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A model of manufacturing sector investment and employment decisions

by

J W Lomax

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CONTENTS

Abstract

This paper examines evidence for dynamic inter-relationships between firms' capital stock and employment decisions using co-integration techniques. Initially, some of the existing literature on inter-relationships in the determination of factor demands is reviewed and it is shown that convex marginal adjustment costs underly such a response pattern. The empirical work undertaken is based on a Cobb-Douglas production function; in addition, it is assumed that firms minimise cost given output. The results obtained prove quite sensitive to the specification of the equilibrium factor demand functions. Where trends in labour productivity are modelled by split time trends and capital market imperfections transmitted by liquidity, some evidence of investment-employment inter-relationships emerges in the dynamic regressions. This outperforms a possible alternative specification in which firms' employment and capital stock decisions are related in the long run.

A model of manufacturing sector investment and employment decisions

I Introduction

In this paper manufacturing firms' aggregate investment and employment decisions are examined and equations estimated using cointegration techniques. The paper covers a number of issues. Its prime focus, however, is to analyse dynamic interactions between firms' investment and employment choices. Most studies have investigated the issue using fairly tight theoretical structures with little attention paid to general econometric and simulation properties. The present work, however, assesses the possibility of such inter-relationships in the context of developing a system which could ultimately be suitable for inclusion in the Bank's econometric model.

Initially, the theory underlying dynamic inter-related adjustment costs is examined. Second, some long-run static factor demand equations are estimated. Plausible long-run equations are required in order to examine inter-relationships between the disequilibrium adjustment processes. A variety of possible influences are considered—demand, relative prices, productivity, utilisation, uncertainty and financial effects. Several possible formulations are proposed. Finally, various dynamic specifications are estimated. Simple error correction and inter-related error correction models are considered.

Results are found to be sensitive to the manner in which trends in labour productivity are treated. If they are assumed to be exogenous, and proxied by split time trends, then considerable evidence of dynamic inter-relationships between investment and employment emerges. Unfortunately, it is impossible to combine this feature with symmetrical relative price effects. On the other hand, if observed productivity improvements are modelled as arising from firms' long-run choices between acquiring additional workers and utilising those workers more intensively, consistent price effects may be derived although at the expense of losing dynamic inter-relationships between factors of production. Overall, it is argued that the 'inter-relationships' model marginally outperforms the 'price symmetry' model.

II The Rationale for Inter-Related Adjustment of Factors of Production

The theoretical rationale for supposing dynamic inter-relationships to exist in the short-run adjustment processes of investment and employment, lies in the existence of adjustment costs. Where factors of production are perfectly variable, factor demands will adjust instantaneously to their levels equilibria. However, given convex marginal adjustment costs, adjustments will be more protracted. By convex adjustment costs it is meant that costs increase more than proportionately with the size of an adjustment. The convexity assumption is critical since neither linear nor concave costs will induce smoothed employment and investment profiles at the level of the individual firm. For example, concave adjustment costs will lead to step changes in factor demands.

How likely are investment and employment to be characterised by convex costs? Several arguments to the opposite effect have been advanced. Nickell (1978) postulates that both employment and investment changes can give rise to a need for reorganisation. However, due to the large fixed costs associated with personnel and training departments, it may be more reasonable to suppose that marginal costs diminish rather than increase with the speed of adjustment. Some elements in implicit contract theory also suggest a degree of volatility in the pattern of employment. For example Hart (1983) suggests that if asymmetric information is available to management and workers, together with risk aversion on the part of the former, in adverse economic circumstances management may cut employment by more than necessary from an efficiency point of view so as to curb wage demands. Furthermore, Frank (1988) argues that firms may use premature excessive layoffs to signal to potential and existing shareholders their future profitability. Similar arguments might also be offered to explain investment behaviour, and clearly suggest a non-smooth adjustment process.

On the other hand, empirically, neither investment nor employment do seem to respond fully and instantaneously to changes in their determinants. One explanation is that in terms of the empirical work on factor demands, at the aggregate level the differences between the predictions of strictly convex, as opposed to linear, adjustment costs tend to disappear. Nevertheless, there are also some possible theoretical arguments which might be invoked. First, the addition to factor services of one employee or unit of capital will tend to be greater the more managerial hours are devoted to his/her/its integration into the workplace. Both are likely to be reduced if the rate of expansion is increased rapidly. Second, an upward sloping cost of finance schedule generated, for example, by limited internal funds together with capital market imperfections, may moderate movements in the demand for both labour and capital. Third, in the context of labour demand, implicit contract theory does not necessarily suggest rapid fluctuations in employment. In a model which takes into account the phenomenon of unemployment benefit, Grossman (1981) shows that employment fluctuations could be smoother than in an economy without such contracts. Moreover, firms may prefer a stable employment path if reputational loss is associated with large redundancy programmes. In particular, in the absence of adequate insurance provisioning, large premia over prevailing wage levels may be required to attract employees in any subsequent cyclical upswing. Finally, with regard to capital expenditure, the most important reason for lagged adjustment stems from the conditions under which capital goods are supplied. Precious (1987) points out that in times of buoyant investment, capacity constraints may emerge in the supplying industry, which will tend to place upward pressure on capital goods prices. Firms may smooth investment in order to moderate such pressures. This argument applies to firms <u>in aggregate</u> as much as to <u>individual</u> entities and therefore has particular force in the present context. The importance of this mechanism will become clearer below.

It is the existence of convex adjustment costs — and in particular inter-relationships between the costs of adjusting different inputs — which opens up the possibility of short-run interactions between factors of production. In particular, firms' factor stock responses to an output or relative prices disturbance will depend on trade-offs between the various adjustment costs characterising each factor of production.

Inter-related factor demand studies

Author	Quasi-fixed factors	Variable factors	Adjustment mechanism	Expectations	Production function	Nature of the short-run relationship between capital and labour
Nadiri and Rosen (1969)	capital labour utilisation hours		exogenous	static	Cobb-Douglas	Capital and labour substitutes in the employmenet equation, but complemen in the capital stock equation. Disequilib term significant hours (just) in the fomer, but not the latter.
Briscoe and Peel (1976)	capital labour utilisation hours		exogenous	static	Cobb-Douglas	Capital and labour complements in capital and labour demand equations. Disequilibrium term very insignificant in both cases.
Mohnen et al (1984)	capital R&D	labour energy	endogenous	static	translog cost-function	Labour is a substitute for capital, which is fixed in the short run.
Morrison and Berndt (1981)	capital white collar labour	energy blue collar labour materials	endogenous	static	translog cost-function	No relationship between capital and white collar labour by assumption. Blue collar labour is a substitute for capital which is fixed in the short run.
Harris (1985)	capital hours utilisation		exogenous	weakly rational	CES	Capital and labour short-run substitute in the employment equation. The disequilibrium term is significant.
Holly and Smith (1986)	capital labour energy		exogenous	static	translog cost-function	Capital and labour substitutes in both equations. Both disequilibrium terms significant.
Shapiro (1986)	capital labour		endogenous	static	Cobb-Douglas	Inter-relationships highly insignificant
Palm and Pfann (1987)	blue collar labour white collar labour		endogenous	rational	quadratic	White collar labour substitute for blue collar labour. Blue collar labour complementary to white collar labour. Both terms significant.

The task of estimating dynamic factor demand models may be approached from two angles — production or cost. Diewert (1971,74) demonstrated that these methods are mirror images of one another. Not only does a production function determine a cost function; in addition, a cost function satisfying certain regularity conditions determines a production function. The advantage of basing the analysis on the cost function is that a more wide-ranging and coherent treatment of adjustment costs may be considered, since these can be entered explicitly into the optimisation process (see Berndt 1981). Thus, the firm simultaneously chooses both the optimal rate of adjustment and optimal factor services. In this type of model the adjustment coefficient varies with the discount rate. Several studies have incorporated such a suggestion into models which abstract from inter-related adjustment costs — see, for example Pindyck and Rotemberg (1983 a, b) and Meese (1980). One which does investigate the issue is Shapiro (1986); however, he finds little evidence of such costs. Berndt and Morrison (1980) and Mohnen et al (1984) consider the relationship between quasi-fixed capital and variable labour, and finds that the latter is typically a substitute for the former in the short term, overshooting its equilibrium level in order to compensate for the sluggish adjustment of the capital stock. Nevertheless, the latter results are of little relevance to the UK since important cultural and institutional differences between labour markets in the two countries exist, and it is reasonably well established that in this country, labour is not variable in the short run. The general model cannot be adapted to consider interactions between two quasi-fixed factors since these are ruled out by assumption. More importantly, however, from the viewpoint of the present work, cost function studies have a crucial drawback since the levels of factor demands are not determined; estimation is carried out on the Euler equations or first order conditions.

An alternative method of considering adjustment costs is to explicitly separate out the determination of the optimal position from the estimation of the adjustment process. This approach is usually, but not always, pursued from the production side. In this context, one simple form of model assumes that agents optimise with respect to a quadratic loss function (see Nickell 1985) allowing for both capital and employment costs.

Writing this in matrix form,

Equation (1) $C = \sum_{s=0}^{\infty} A^s (\lambda' \lambda (X_s - X_{*s})' (X_s - X_{*s}) + \Delta X' \Delta X)$

Where

X is a 2x1 vector of inputs (K, L)
X^* denotes equilibrium levels
X-X^* represents the costs incurred by being away from the optimum position X^*
ΔX represents the costs of adjusting X from the preceding level X_{t-1} to the new level X_t, and Δ is the difference operator
A is a vector of discount factors ($0 \leq A \leq 1$).

This yields the decision rule.

Equation (2) $X = \mu X_{-1} - \mu \lambda \sum_{s=0}^{\infty} (A \mu)^s X^*_s$

Where

μ are given by the roots of the solution to the first order conditions.

Equation (2) is a closed form forward-looking relation. Instead, the equation may be reparameterised into an ECM form. The principles involved may be illustrated as follows. Many economic aggregate quantity variables follow a second order autoregressive process with a unit root. If this process is specified, then the expected values can be generated in terms of current and lagged values and these can be substituted into (2). Thus, if

Equation (3) $X = \beta X_{-1} + (1 - \beta) X_{-2} + \varepsilon$

where ε is white noise.

$$\beta = \begin{pmatrix} \beta_{11} & \beta_{12} \\ \beta_{21} & \beta_{22} \end{pmatrix}$$

with the restrictions $\beta_{12} = \beta_{21} = 0$.

Then, substituting (3) into (2) gives an equation in error correction form:

Equation (4) $\Delta X = \dfrac{(I - \mu)}{I + A\mu \ (I - \beta)} \Delta X^* + (I - \mu) \ (X^* - X)_{-1}$

In which the form of the dynamic inter-relationships is given by the system's first order conditions, and in particular μ. If no inter-related adjustment costs exist, μ is diagonal.

This type of model has been used in a number of empirical applications. Nadiri and Rosen (1969), Briscoe and Peel (1976) and Harris (1985) all approximate cross-disequilibrium effects by including lagged 'other factor' terms in their 'own factor' demand equations. In general, while some evidence is found of employment substituting for capital in the labour demand equation, less indication is found of disequilibrium in employment affecting investment. Moreover some additional problems emerged. Neither relative prices nor scale effects are consistent in the factor demand equations in either Nadiri and Rosen (1969) or Briscoe and Peel (1976). Holly and Smith (1986) estimate a general error correction system based on equation (4), and find strong evidence that capital and labour are short-run substitutes in both factor demand relations. A particular advantage of the multiple error-correction formulation they adopt is that the essence of disequilibrium inter-related dynamic adjustment is clearly specified. In contrast, it is not obvious that simply adding lagged terms of the other inputs to the capital and labour functions in the correct specification for such relationships. In particular, such additions imply a long-run rather than disequilibrium relationship. One problem with applying the Holly and Smith framework in the present context is that is based on a cost function. This paper therefore develops some of their ideas in a model derived from the production-side.

A final important facet of the factor demands literature concerns the incorporation of expectations. Gould (1968) demonstrates that when expectations are non-static, optimal input paths will depend on the entire future course of all the exogenous variables. Several approaches to the formulation and estimation of dynamic factor demand systems under non-static expectations have been suggested—see Prucha and Nadiri (1986) for a survey of a number of such techniques. In this instance, however, a static expectations approach is followed.

In the remaining part of this paper, firms' investment and employment decisions are examined empirically. Initially an overview of historical trends in manufacturing investment and employment is provided. Subsequently equations are estimated using the Granger and Engle two step procedure.(1) The basis of this approach is that the analysis of long-run desired behaviour may be separated out from any short-run movements. Initially, therefore, equilibrium factor demand functions are considered. Subsequently some possible dynamic equations are explored, particularly with a view to discovering inter-relationships in factor demand patterns.

III Historical Trends in Investment and Employment

Manufacturing investment in 1988 was £11½ billion (1985 prices), the highest figure recorded in recent years. It compares with figures of £11 billion in 1979 and £10½ billion in 1973, the respective peaks of the last two business cycles. Since 1983, the trough of the present cycle, investment has grown by 53.5%. This compares with corresponding figures of 21.5% and 22% for the last two cycles. To place these figures in perspective, Chart 1 illustrates the behaviour of the manufacturing investment-output ratio since 1963. The series is clearly volatile and indicates that the 1980 recession was followed by an unusually lengthy period of depressed investment. Nevertheless, no clear trend in the ratio is exhibited over time and the change in its level over the course of the 1980s is not outwith the range of historical experience. This could be interpreted as indicating that no essentially new influences have governed firms' investment decisions over the last decade. Thus, in this sense, investment decisions in the 1980s have been no 'different' from those in any other recent time period.

In contrast to investment, manufacturing employment has declined over time, rising in only eight of the last twenty six years, and even then only by small amounts. Thus, by 1988 it stood at 5¼ million, only 62% of its level in 1963.

(1) Banerjee et al (1986) suggest that the biases in parameter estimates resulting from the two-step procedure may be larger than is the case with a one-step methodology. The work is, however, not conclusive; moreover, the Granger and Engle technique offers an attractive method of implementing the model outlined in this paper, since, once plausible long-run coefficients have been estimated, they may be frozen.

Chart 2 illustrates movements in the employment-output rates over the intervening period. One prominent feature is that the series is obviously less erratic than the equivalent investment ratio. A second, is that the rate of decline is far from uniform. Between 1963 and 1972 the labour-output ratio fell by an annual average of 4.4%. From 1973-1980 virtually no change occurred. However, from 1981-88 the average decrease was 6.9%. These movements have typically been viewed as reflecting the slowdown of productivity in the wake of the 1974 oil price shock and its subsequent recovery in the period since 1979. Several possible reasons for the latter improvement have been propounded, including the following. First it could represent a 'catching up' process with technological leaders (eg Japan and USA). Second, the enhanced productivity performance might be a result of a new era of more harmonious industrial relations. Third, gains may have stemmed from the use of newer vintages of capital equipment due to accelerated scrapping following the 1980 recession. On the other hand, whilst a change in the response of employment to output may have been engendered by new elements in the economic environment, it is also possible that such changes could have been induced by variations in other factors which might appear in the employment function. As will be seen below, it transpires that the analysis of this issue is central to the identification of inter-relationships in the two factor demand equations.

IV Long-Run Analysis of Investment and Employment Decisions

We now move on to the estimation work. Empirically, modelling dynamic inter-relationships in factor adjustment paths is heavily dependent on first determining satisfactory equilibrium equations. This is clear from equation (4). In the present paper, for this purpose, cointegration techniques are used. A set of variables are said to cointegrate when they trend together, with a constant difference, over time. This is determined by reference to certain criteria —Dickey-Fuller, Augmented Dickey-Fuller and Cointegrating Regression Durbin-Watson statistics. For the levels equations to induce a stationary error term, at least two components of the equilibrium vector must be of the same order of integration. Thus, if the dependent variable is I(2), at least one other I(2) variable is required. This is relevant in the present exercise since both capital stock and employment are I(2). Unfortunately, as was found here, in modelling work I(2) dependent variables may create problems since most economic time series are I(1), frequently making it difficult to formulate appropriate relationships.

There are a number of possible sets of theoretical foundations upon which to build an integrated model of corporate behaviour. A desirable property of the framework selected is, however, presumably that the explanatory variables used in the various company sector response functions should be consistent. Accordingly, in the context of the present model, it is preferable that a single theory should underlie both firms' investment and employment decisions.

In the literature, less consensus has been expressed concerning investment behaviour than labour demand decisions. In line with this, a number of capital expenditure models have been proposed; these include the accelerator, cashflow, neoclassical, modified neoclassical (which allows capital to be putty-clay rather than putty-putty) and models based on Tobin's Q. However, neither surveys by Clarke (1979) nor Jenkinson (1981), for example, provide compelling evidence in favour of any one hypothesis. Thus, some flexibility in choosing an appropriate modelling framework exists. In contrast, with regard to employment models, firms have nearly always been treated as minimising costs given output (a variant of the neoclassical story), stemming from work by Brechling (1965) and Ball and St Cyr (1966). In this paper, since we are dealing with a joint model of investment and employment, the last approach is initially selected, although it does prove necessary to make extensions to the simple version of the theory. The essential difference between a profit maximising and cost minimising firm is that whereas the former adjusts employment, capital and output in response to changes in exogenously given input and output prices, the latter varies its inputs so as to minimise its production costs following changes in the exogenously given input prices and output level. The decisive advantage of adopting the latter theoretical framework as a basis for the econometric analysis is that it allows a role for the level of demand in determining factor quantities, a feature which is heavily supported in the existing empirical work. Many commentators have argued that although the level of demand might appropriately be treated as exogenous, output remains a decision variable since firms can hold inventories. Moreover, and in any case, output will not be synomous with demand if firms are constrained by existing capacity limitation. As a possible alternative, a quantitative index of the responses to question seven in the CBI Industrial Trends Survey ('What has been the trend over the past four months with regard to the volume of total new orders') was used as a proxy for demand in the empirical work.(1) However, the results obtained were less satisfactory than when output itself was used as a regressor.

The long-run optimal factor demand equations for a cost minimising firm are derived as follows. Assume, that technology is Cobb-Douglas;(2) then the production function is given by

Equation (5) $Q_t = Ae^{\sigma t}K_t^{\alpha}L_t^{\beta}$

Where,

Q_t = output at time

t = technological progress

K_t = capital stock at time t

L_t = employment at time t

The static factor demand functions are of the following form,

Equation (6) $ln\ K_t^{*} = k_1 - \frac{\sigma}{\alpha+\beta}t + \frac{\beta}{\alpha+\beta}\ ln\ \frac{w_t}{c_t} + \frac{1}{\alpha+\beta}\ ln\ Q_t$

and

Equation (7) $ln\ L_t^{*} = k_2 - \frac{\sigma}{\alpha+\beta}t - \frac{\alpha}{\alpha+\beta}\ ln\ \frac{w_t}{c_t} + \frac{1}{\alpha+\beta}\ ln\ Q_t$ (3)

Where

w_t = the nominal wage rate at time t

c_t = the nominal user cost of capital at time t

A major problem with implementing such a model lies in appropriately specifying the relative price term and, in particular, the user cost of capital. Wallis (1987) argues that the measure derived by Kelly and Owen (1985) represents the most satisfactory of the proxies currently used by the major modelling groups and, therefore, it is used in the present exercise. The user cost of capital (or the opportunity cost of employing a unit of physical capital for one period) can be defined as the purchase price plus the return foregone on alternative investment less the price which could be obtained from selling the asset at the end of the period (after allowing for depreciation). The definition of the user cost of capital may be written as follows;

Equation (8) $\frac{1 - pvic}{1 - (tryc/100)} \times pifo \times (\rho + \delta - 0.5 \times \Delta pifoe)$

(1) Output can instead be instrumented although it was found that this led to little change in either the regression estimates or the equation diagnostics.

(2) Other production functions, for example those embodying a constant or variable elasticity of substitution, clearly incorporate a more flexible pattern of technology however the analysis becomes less tractable.

(3) In the applied work it was found that entering the factor price ratio into the two factor demand equations induced a superior performance to introducing the wage rate and the user cost of capital separately.

The first part of the expression, ((1-*pvic*)/(1-*tryc*/100)), indicates that the higher the tax rate (*tryc*/100), the more valuable the present value of investment allowances (*pvic*). The second component (*pifo*) defines the purchase price of new capital equipment. The third element of the equation adds the depreciation rate (δ) to the nominal rate of return forgone on alternative investments (ρ) and deducts the expected nominal realisable gain on capital goods, represented by half the gain on new investment equipment (0.5 x pifoe).[1]

The formulation of ρ is the most complex element within the composite term and its computation involves weighting together the marginal costs of different sources of finance (debt, new equity and retentions) where each marginal cost is calculated taking into account the tax system and on the assumption that companies must provide a return on each source of funds equal to the opportunity cost for the supplier, allowing for a constant risk premium.

In equation (8) the less than unit coefficient on Δ *pifoe* is clearly contentious.[2] An important disadvantage of measuring the user cost in the manner described lies in the proportionality assumed between a change in the predicted price of new capital and the realisable gain on existing goods which is clearly arbitrary, as indeed is the coefficient of 0.5. In this context, the decisive attribute of the formulation adopted is empirical. Taking full account of inflationary expectations causes problems in the model, for unless the rate of depreciation plus the risk premium (defined within ρ) is set rather high, the user cost may become negative, with the implication that firms should expand their capital stock infinitely.

At the outset of the empirical analysis it should be mentioned that a satisfactory cointegrating vector for capital stock proved extremely elusive. The most acceptable equation obtained was based on the assumption that firms are employment (and perhaps also capital) constrained, and hence that equations (6) and (7) are targets which may never actually be obtained (see Davidson and Hall 1989). Accordingly, employment should be included in the capital stock equation and vice versa (very similar, it should be noted, to the specification used by Nadiri and Rosen (1969) in their empirical study). Whilst at first blush representing a rather strange notion of equilibrium, it is not inconsistent with its interpretation in the present application:

> 'the term equilibrium has many meanings in economics and its use in the cointegration literature is rather different from most definitions of equilibrium. Within the cointegration literature all that is meant by equilibrium is that it is an observed relationship which has, on average, been maintained by a set of variables for a long period. It implies none of the usual theoretical implications of market clearing or full employment and neither does it imply that the system is at rest'. (Hall and Henry 1988).[3]

Without at this stage going into the justification for all of the variables included in the system, Table 1 shows a possible system estimated by three stage least squares. The independent variables used were determined after a wide ranging search over the set of candidate regressors described below. Even so, equations (1.1) and (1.2) at best only marginally satisfy the standard cointegration criteria. Furthermore, the relative price term in the employment equation is incorrectly signed. Equally, the interpretation of the 'other factor' terms is ambiguous since these pick up trends in productivity in addition to factor market rationing considerations. Nevertheless, overall the results are quite suggestive since both variables enter the levels equations very significantly with the appropriate sign. Moreover, even marginally satisfactory cointegrating vectors for capital stock cannot be obtained unless possible employment constraints are taken into consideration.

An alternative interpretation of the difficulties involved in deriving a suitable cointegrating vector for the capital stock is that the dependent variable takes an extremely long while to adjust to its long-term level and that a much

(1) The expected capital gains term embodies an extrapolative expectations assumption in that future price changes emulate those in the recent past.

(2) It was decided not to estimate the coefficient in order to avoid the use of non-linear estimation techniques.

(3) Page 53.

longer run of data would be required to identify the equilibrium relationship. In line with this argument, the equation can be reparameterised as an investment relation (see Bean 1979).

First, define the capital stock to be that quantity of capital which the firm wishes to use in long-run equilibrium at constant prices (or assuming static expectations). Since net investment must be zero at such an equilibrium, investment can only be for replacement purposes. The desired capital stock K^* requires a level of replacement ZK^* to maintain itself and hence equilibrium investment is given by ZK^*

Equation (9) $I_t^* = ZK_t^*$

where

I_t = gross investment at time t
Z = depreciation rate (proportional to the existing captial stock)

Substituting (6) into (9), we obtain

Equation (10) $ln\ I_t^* = z + k_1 - \frac{\sigma}{\alpha+\beta} t + \frac{\beta}{\alpha+\beta}\ ln \frac{w_t}{c_t} + \frac{1}{\alpha+\beta}\ ln\ Q_t$

Difficulties with such a formulation arise in circumstances in which expectations are non-static. This may be illustrated as follows. Suppose output rises or the rate of interest falls; given supply constraints, the price of capital goods is immediately forced up by investment demand (*pifo* in equation (8)), reflecting higher discounted profits. However, rather than remain constant, prices fall thereafter (which should be transmitted by Δ*pifoe*) as supply increases. The latter development tends to increase the cost of capital, thereby smoothing the response of both expected and unexpected changes in the economic environment. Such influences are however extremely difficult to capture directly in an empirical study; thus here, as already pointed out, static expectations are assumed, and tendencies towards smoothing transmitted by the various lags incorporated in the dynamic equation.

More widely, it should be emphasized that equation (10) does not indicate that the economy is stationary. Instead, and in precisely the same way as more traditional investment equations, the dynamics (eg the accelerator effects) are transmitted, but by the second stage regressions. Clearly, the model implies a distinction between replacement and new investment, with an equilibrium relation only specified for the former. In fact, however, if capital is partly putty-clay rather than putty-putty the dichotomy breaks down. Bischoff (1971) for example, argues that since only new rather than existing capital goods can be modified in response to a change in relative prices, new investment should be a function of the levels rather than the differences of the input price terms. The output response would remain unchanged.

Equations (2.1) and (3.1) illustrate the results of implementing (7) and (10) empirically, with deterministic time trends used to capture technological progress. These do not provide an explanation of movements in technical change but they have generally been seen as a satisfactory method of measuring such a process (see Henry 1981); they are, therefore capable of encapsulating changes in productivity growth of the type discussed in section three. This procedure works satisfactorily for the investment equation which appears to cointegrate with (see (2.1)) or without (see (2.4)) the inclusion of a time trend. Both regressions outperform the employment constrained capital stock equation. The employment equation is however, more problematic. Not surprisingly, given observed trends in output per head coupled with the fact that employment is I(2), the regression fails to cointegrate when a single trend is incorporated (3.1). Significant improvements can, however, be obtained when three split trends are used (3.2). Nevertheless, although satisfying the usual cointegration criteria, a number of problems surround the model as set out here. One drawback is that whereas investment is characterised by decreasing returns to scale, employment faces increasing returns. There are two ways of obtaining greater consistency. First the elimination of the intercept from the investment equation (2.2) reduces the co-efficient on output from 1.28 to 0.78 thereby ensuring overall increasing returns. Second, the output parameter can be restricted to unity in both factor demand equations (2.3) and (3.3). The latter restriction is imposed in the remaining empirical results presented here for a number of reasons. Long-run increasing returns to scale are difficult to reconcile with the standard competitive model. Furthermore the implied transformation of the dependent variables (to the labour-output and investment-output ratios respectively) makes both I(1). In addition, in the second stage regressions it was found that there were improvements in terms of goodness of fit.

A further problem with equations (2.1) and (3.1) is that the signs on the relative price terms are inconsistent. This result echoes those of Nadiri and Rosen (1969) and Briscoe and Peel (1976). Since this situation is not rectified by the above manipulations (see (3.3)) a likely interpretation is that in the employment equation the split time trends are colinear with relative prices, which results in the latter being wrongly signed.(1) One solution is to eliminate the price term (equation (3.16)) which produces a relation which appears to cointegrate quite well. An alternative line of approach is to experiment with extended specifications of the employment function. Several potential alternative influences on employment have been discussed in the literature, including utilisation, uncertainty and financial effects. These are considered below and their impact on investment as well as labour demand evaluated.

Utilisation: one possible explanation of recent trends in employment is that improvements in observed productivity have essentially been a reflection of a change in firms' long-run (ie non-cyclical) choices between factor service flows and stocks. A number of possible reasons could be responsible for this development. First, some researchers have examined the role of relative prices in inducing firms to substitute overtime for employees (see for example papers by Santamaki, and Konig and Pohlmeier in Hart (1988)). The direct empirical application of such models is, however, difficult since quarterly data on overtime earnings is not available. Second, movements in hours could be related to secular changes in productivity. Thus, in the 1980s firms could have expanded overtime rather than raising employment as a means of gaining flexibility and therefore improving productivity. Third, changes in hours worked could be transmitting errors in forecasting output (see Darby and Wren-Lewis (1988)). Thus, to the extent that firms' output expectations were biased downwards in the 1980s, hires were lower, and hours greater than might have been anticipated on the basis of pre-existing historical trends. Similar results would obtain in circumstances in which the growth of output was regarded as transitory.

Bearing these arguments in mind, two variables which may usefully be entered into the employment equations are average hours (3.4) and normal hours (3.5). The former exhibits a negative sign; as such, therefore, it cannot simply be transmitting a merely short-term influence, but instead a long-term behavioural trait. In contrast, a positive sign could indicate that hours were acting as a proxy for cyclical demand conditions, which would imply that the employment dynamics were being illegitimately modelled in the long-run levels equation. The important role of normal hours (bearing a positively signed coefficient) in long-run equations further suggests that movements in hours may be an important determinant of equilibrium employment. In both cases, the regressions exhibit cointegration properties which are on the margin of acceptability, contain a negatively signed relative price term and only a single time trend. In forecasting terms, it could be argued that the incorporation of a single trend is an advance on equation (3.3) since it is difficult to place faith in the extrapolated values of a trend which exhibits two breaks over the sample period. Overall, the equation incorporating average hours is preferable to that involving normal hours since it has a lower standard error, coupled with higher Durbin-Watson, Dickey-Fuller and Augmented Dickey-Fuller statistics.

(1) Another factor possibly responsible is that the deterministic trends fail to satisfactorily capture technological progress. In other words, technology has not advanced at a constant rate over time and accordingly time trends are too smooth to represent the underlying process. In line with this argument, Harvey et al (1986) suggest that a stochastic time trend is a more appropriate proxy. However, stochastic trends cannot be estimated by maximum likelihood methods as part of the equilibrium vector since dynamic adjustments are a so picked up: accordingly, the fit is excessively tight leading to insignificant error correction terms in the second stage regressions.

Uncertainty: It is unlikely that the demands for quasi-fixed factors of production are determined solely by the levels of output and relative prices; where firms are uncertain about their likely future levels, the variances of the forcing variables as well as their actual values might influence factor demands.

These variances are unknown; however, they were proxied here by equation (11).

Equation (11) $var\ (x) = (x - \frac{1}{4}\sum_{i=0}^{3} x_i)^2$

where x = output, relative prices.

Our priors concerning the effect of uncertainty on investment and employment are as follows. As regards investment, if such expenditure is irreversible and future demand or cost conditions uncertain, these moves involve the exercising of an option. Uncertainty raises the value of firms' investment options (ie options to invest at any time in the future) and thus the opportunity cost of investing at any given moment of time (see Pindyck 1988). Thus, we would expect the proxies for the variances of both output and relative prices to enter the capital expenditure equation with a negative sign, which they do — see equation (2.7). Since firms are less willing to invest (scrap) in the face of relative price uncertainty they must correspondingly be less willing to fire (hire) labour; thus the proxy for the variance of relative prices could also, be expected to exhibit a negative sign in the employment equation, an expectation which is indeed met (see (3.11)). The response of employment to output uncertainty is less clearcut. On the one hand firms might choose to hoard labour in order to cater for periods of buoyant output. Accordingly, lower than expected labour demand on the 1980s could be a reflection of the greater degree of certainty concerning trends in the product market. Alternatively as with investment, uncertainty might increase the value of firms options, although in this case its employment options. In these circumstances firms would meet output either by selling from stocks or increasing hours and plant utilisation. In equation (3.10) it can be seen that the proxy for the variance of output enters the employment equation with a negative sign supporting the second argument. However, whilst the variance proxies may be introduced into the two factor demand equations with plausible signs, in both instances they induce some deterioration in the criteria used to test for cointegration.

Financial influences: Various researchers (for example, Wadwhani (1984) and Wren-Lewis (1984) have suggested that financial effects may exert a major influence on factor demands by impinging on cashflow. The rationale for including such variables in factor demand equations is partly that the level of cashflow not only helps to determine the quantity of internal funds available for acquiring factors of production, but it may also influence the cost and level of finance which external sources are prepared to provide. In addition such variables may reflect information concerning expected demand not captured by the output term. Following these arguments, a wide range of financial variables including some interest rate terms, the share of industrial and commercial companies' (ICCs') profits in national income, their net liquidity ratio and net income gearing were entered into both equations With regard to interest rates, both real and nominal representations were included; in both instances long-term rates exercised a greater influence than short-term rates. The inclusion of the real term helps to explain both equilibrium employment and investment—see equations (2.9) and (3.12) respectively. The relative price term in the investment equation does, however, change signs. Nominal rates may be entered into both equations without perversely affecting relative prices in the investment demand function ((2.10) and (3.13)). Of the other cashflow variables considered, all enter the investment equation with the expected sign (positive in the case of profit share (2.5), the net liquidity ratio (2.6), negative for income gearing (2.15)). However, only net liquidity (3.8) may be introduced into the employment equation with the appropriate sign. Of the latter two equations only that incorporating net liquidity fulfills the normal cointegration requirements.

This concludes the discussion of the long-run levels relationships. Some choice between the equations considered is, however, clearly required before the dynamics can be modelled. Two candidate employment relations emerge—equation (3.16) including output together with the split time trends is one possibility. An alternative is

(3.8) which contains output, relative prices, liquidity and average hours. The essential difference between these specifications is that in the latter the rapid growth rates in actual productivity observed recently can be explained without reference to a supply-side miracle. Equation (3.16) produces a somewhat higher ADF, although (3.8) could be regarded as more appropriate from a theoretical viewpoint, in the sense that it contains a relative price effect consistent with that in the investment equation. With regard to the latter function, (2.6) was regarded as dominating other possible formulations. This contains output, relative prices and the liquidity ratio. All of the investment equations in Table 1 dominate the employment constrained capital stock equation (1.2).[1] Some dynamic specifications based on the long-run relations identified here are examined in the next section.

V Dynamic Equations

The final section of the paper is concerned with estimating satisfactory dynamic equations. To this end, the residuals from the long-run equations were entered into the system of dynamic equations implied by (4).

Equation (12) $[1-\theta(L)]\begin{bmatrix}\Delta_e \\ \Delta i\end{bmatrix} = \Phi(L)\begin{bmatrix}\Delta_e^{\bullet} \\ \Delta i^{\bullet}\end{bmatrix} + \mu\begin{bmatrix}e \dot{-} e \\ i \dot{-} i\end{bmatrix}_{-1}$

Where $\theta(L) = \begin{bmatrix}\theta_{11} & \theta_{12} \\ \theta_{21} & \theta_{22}\end{bmatrix}$ $\Phi(L) = \begin{bmatrix}\Phi_{11} & \Phi_{12} \\ \Phi_{21} & \Phi_{22}\end{bmatrix}$

and $\mu(L) = \begin{bmatrix}\mu_{11} & \mu_{12} \\ \mu_{21} & \mu_{22}\end{bmatrix}$

The analysis is conducted at two levels. First simple error correction models are estimated in which the parameter matrices in equation (12) are assumed diagonal. Second dynamic inter-relationships between the two equations are considered.

A general to specific modelling estimation strategy was used, with initially ninth order lags on both output and the respective dependent variables considered. Even with a fairly large data sample of almost 80 observations, this prevented the simultaneous consideration of long lags on the other variables in the respective cointegrating vectors. These are considered subsequently. In each set of dynamic equations, it was also recognised that there may be certain variables which whilst not conditioning equilibrium factor demands, nevertheless modify the path to equilibrium. In this context, a number of additional variables were also introduced. There is clearly a danger of omitted variables biasing coefficient estimates. However, to the extent that movements between output and the other explanatory variables have not been highly correlated, it is hoped that the likelihood is small.

VI Simple Error Correction Factor Demand Model

In this section, searches are reported based on long-run equations (2.6) and (3.8). Results are not, however, sensitive to the particular formulation of the employment relation, since the dynamics are similar when (3.16) is incorporated as a long-run solution. Table 4 illustrates the first part of the process of obtaining a satisfactory dynamic investment equation. Equation (4.5) containing the second and third lags on the change in output, the dependent variable lagged four and six periods and the disequilibrium term provides one suitable specification in that a broad range of econometric tests are passed and an appropriate dynamic structure retained. The dynamics characterising the

(1) In addition, it was found that in dynamic equations embodying 1.2 as the long-run solution, the error correction term was insignificant.

equation may be further enriched by augmenting the equation with the dependent variable lagged either five (4.3) or three periods (4.4); in both cases, although not significant, the coefficients exhibit t statistics of 1.5 or more. Once additional regressors were considered, it was found that including the third lag (4.4) provided the better of the two possible formulations. Charts 3, 4 and 5 illustrate the responses of equation (4.4) to 1% shocks to output, relative prices and the liquidity ratio. The function is clearly much more sensitive to output than to either of the financial variables. The response to output is of a typical accelerator mode, with investment overshooting its long-run value in the time periods following the peturbation.

Table 5 considers some possible extensions to the simple dynamic model described above. One variable which figures prominently is a dummy variable (dd_{-3}) picking up timing effects from the 1984 changes in the rules applying to corporation tax (6.1). Changes in the nominal interest rate (6.2) make little additional contribution. Nor was it possible to enter either relative prices or liquidity into dynamic investment equations in difference form significantly.

It has also been suggested that capacity utilisation might be an important determinant of investment. Bean (1979) argues that this can be interpreted as an 'integral control mechanism'; incomplete short-run adjustments to changes in output or unforseen errors might lead to an almost permanently lower capital stock. A mechanism could therefore be required which allows behaviour to adjust to cumulated past errors. Accordingly, several proxies for the change in capacity utilisation were entered into the dynamic equation. Responses to the CBI trends survey question 4 ('Is your present level of output below capacity?') both in their raw form and transformed to yield a quantitative index were used as regressors, as was the ratio of current to trend output. None proved significant, and the results are not reported here.

The search for a suitable dynamic employment equation proceeded along similar lines. The short-term adjustment process is clearly considerably less complex than is the case with investment, and in the initial investigation (see Table 6), the most suitable specification appeared to be (6.4) which contains current and lagged output, the dependent variable and the error correction term. Charts 6 to 9 show the response of equation (6.4) to output, relative prices, liquidity and average hours. Employment responds to output a little more slowly than does investment, moving half way to its long- run level within a year. In common with investment, however, it is much less responsive to financial than to real shocks. Finally, Chart 9 illustrates the powerful effects of increases in average hours in reducing employment.

Table 7 considers some possible extensions to the simple dynamic employment equation. The first difference of hours exhibits a negative sign (8.1) which does not seem plausible, since, a priori, an increase in the utilisation rate might in the short run be expected to exert a positive influence on employment. Both the long-run and short-run nominal interest rates could, however, be included (8.3), presumably transmitting cashflow influences.

VII Inter-Related Disequilibrium Factor Demand Model

In order to capture disequilibrium inter-related factor demand effects, the residuals from both of the investment and employment equilibrium vectors were entered into the two dynamic factor demand functions in the manner suggested by equation 12.(1) The cross disequilibrium effects considered here clearly differ slightly from those in Nadiri and Rosen's (1969) specification, since the relationship formulated is between investment and employment rather than capital stock and employment. In part this specification is suggested by the statistical properties of the data. Nevertheless, at a practical level, it may make more sense to envisage a relationship between investment and

(1) For both factor demands, the possibility that the speed of adjustment in one factor input might influence adjustment in the other input was also considered. Although changes in employment do appear to influence investment, they are collinear with output. Since eliminating output terms results in a less plausible overall dynamic structure such cross-terms are better excluded.

employment, since their adjustment times exhibit a greater degree of similarity (capital stock adjusts very slowly) and thus the scope for dynamic inter-relationships is correspondingly increased.

In contrast to the simple model discussed above, the identification of significant disequilibrium error-correction terms (and, in particular inter-related effects) proved sensitive to the specification of the employment equation. Cross disequilibrium effects cannot be observed in equations based on (3.8) which includes hours in its long-run solution ((8.1), (8.2), (9.1), (9.2)). However, where the more traditional specification of conditioning employment on split time trends is implemented (3.16), fairly strong inter-related adjustment processes are evident, with capital and labour acting as short-term substitutes. Even within this context, however, it can be seen that the cross disequilibrium effects are colinear with other parts of the dynamic adjustment process. Thus, if the lag structure obtained earlier is retained, the cross disequilibrium terms continue to be insignificant, although only marginally so in the case of investment. Nevertheless, when some of the output terms are eliminated, the t statistics on the two cross error correction terms improve to 2.19 and 1.93 respectively. The loss of the demand variables scarcely affects the explanatory power of either equation, perhaps not surprisingly in the case of investment since the eliminated term is insignificant.

The advantages of including cross disequilibrium effects are most decisive in the case of the investment function, since both within-sample and forecasting performance are enhanced. Equation standard error is lower than in any regression which excludes the cross-term, similarly the PC RMSE statistic is lower than that obtaining in alternative specifications. As regards the employment equation, the benefits are less clearcut. Standard error rises a little to 0.0031 compared with 0.0028 for the best simple error correction formulations identified (see, for example, (6.4)). However, the summary forecast statistics indicate some improvement in predictive performance.

VIII Concluding Remarks

This paper has presented the results of an exercise in modelling firms' investment and employment decisions, with a particular emphasis on evaluating possible dynamic inter-relationships in the process of adjustment towards long-run equilibrium. Some recent studies have incorporated such effects using a cost-function approach. Although such methods offer a coherent and thoroughgoing treatment of adjustment costs, an important drawback is that the levels of factor demands are not determined. Therefore, in this paper a production function based model is specified. Estimation was undertaken using cointegration techniques.

The long-run equations for both labour and investment demand were broadly based on the hypothesis that firms minimise costs given output. The crucial problem underlying the model lay in identifying the source of observed labour productivity gains. In some senses, the paper raises more questions than it answers, since it shows that such movements may be treated in several ways, two of which were examined in detail. First, they could be regarded as stemming from exogenous changes in technical progress and proxied by split time trends. Second, observed improvements may have resulted from alterations in labour utilisation rates. Diagnostics from the employment levels equations indicate that a slight preference for the former could be justified: however, some theoretical consistency is lost since it is not possible to incorporate symmetrical relative price effects within such a schema. In modelling the dynamics, therefore, specifications based on both long-run solutions were examined. The differences were, in fact, crucial since evidence of dynamic inter-relationships between the adjustment processes of investment and employment proved sensitive to the specification of the long-run employment equation. Nevertheless, where trends in productivity were treated as exogenous, considerable signs of cross disequilibrium effects emerge, with capital and labour acting as short-run substitutes. These concepts were incorporated into a model which has attractive overall econometric and dynamic properties.

Table 1: Capital and Employment Constrained Factor Demand Equations

Equation 1.1

$$le = 27.0 + 1.0\, lo + 0.055\, lrelp - 3.19\, lhmf + 1.45\, liq - 1.32\, lk$$

SEE = 0.045
DW = 0.57
DF = -3.67
ADF = -2.86

Equation 1.2

$$lk = 17.61 + 1.0\, lo + 0.0066\, lrelp + 1.06\, liq - 2.7\, lhmf - 0.56\, le$$

SEE = 0.029
DW = 0.83
DF = -4.84
ADF = -3.03

Instruments

lo, lo(-1), lo(-2), lk(-1), lk(-2), le(-1), le(-2), lrelp, lhmf, liq

Smpl 67:1 86:4

Table 2: Investment— Long-Run Relations

	2.1	2.2	2.3	2.4	2.5	2.6	2.7	2.8	2.9	2.10	2.11	2.12	2.13	2.14	2.15
c	-4.69		-2.11	-2.21	-1.79	-2.19	-2.23	-2.23	-2.6	-2.3	-2.3	-2.2	-2.2	-2.1	-2.3
lo	1.28	0.78	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
lrelp	0.0005	0.032	0.023	0.034	0.048	0.034	0.043	0.042	-0.013	0.03	0.03	0.43	0.028	0.0347	0.0298
time	-0.00108	-0.0002	-0.0004												
prof					0.25										
liq						0.24					0.011	0.4			
varlo							-7.11								
varlu							-0.049	-0.049				-0.49			
lrukg									-0.28	-0.052	-0.052				-0.052
lreal									-100.0						
lcaput													0.42		
ng															-0.0437
SEE	0.09	0.094	0.091	0.092	0.087	0.091	0.089	0.086	0.087	0.09	0.091	0.089	0.089	0.09	0.09
DW	0.38	0.31	0.34	0.34	0.39	0.35	0.42	0.40	0.4	0.36	0.36	0.4	0.35	0.37	0.36
DF	-2.83	-2.6	-2.68	-2.58	-2.91	-2.71	-2.91	-2.85	-2.89	-2.71	-2.72	-2.89	-2.62	-2.77	-2.71
ADF	-3.62	-4.03	-3.83	-3.84	-3.18	-3.87	-3.49	-3.63	-4.06	-4.0	-4.0	-3.79	-3.72	-3.82	-4.0
Smpl	67:1	86:4													

Table 3: Employment—Long-Run Relations

	3.1	3.2	3.3	3.4	3.5	3.6	3.7	3.8	3.9	3.10	3.11	3.12	3.13	3.14	3.15	3.16
c	4.08	4.42	-0.464	7.63	-18.11	-1.27	7.39	7.29	7.41	9.66	7.85	7.72	0.01	7.56	-25.7	-0.266
lo	0.541	0.49	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
lrelp	0.006	0.035	0.0457	-0.0424	-0.037	-0.043	-0.042	-0.025	-0.043	-0.032	-0.032	-0.0669	-0.026	-0.013	-0.026	
time	-0.006	-0.006	-0.0094	-0.0095	-0.006	-0.009	-0.01	-0.009	-0.00096	-0.0093	-0.0093	-0.01	-0.009	-0.009	-0.0046	-0.009
timel		0.00588	0.0124													0.0087
time2		-0.011	-0.014													-0.012
prof							-0.0127									
liq								0.7					0.74	0.76		
ng									0.0053							
varlo										-1.12						
varlu										-0.13	-0.13			-0.15		
lrukg												-0.07	0.019		-0.081	
lreal												-34.3				
lhmf				-2.02		-1.59	-1.93	-1.96	-1.97	-2.12	-2.1	-2.04	-1.87	-2.05		
nhn					4.85	1.96									6.81	
SEE	0.04	0.017	0.028	0.0294	0.036	0.028	0.029	0.027	0.03	0.029	0.029	0.028	0.028	0.027	0.035	0.03
DW	0.09	0.51	0.59	0.57	0.36	0.49	0.57	0.61	0.56	0.63	0.63	0.68	0.59	0.7	0.37	0.46
DF	-0.8	-3.31	-3.72	-3.55	-2.83	-3.35	-3.54	-3.75	-3.52	-3.65	-3.64	-3.92	-3.75	-3.98	-2.78	-3.23
ADF	-1.51	-3.55	-3.33	-2.94	-2.87	-3.37	-2.89	-3.30	-2.96	-2.54	-2.53	-2.96	-3.39	-2.82	-3.06	-3.51
Smpl	67:1	86:4														

Table 4: Dynamic Investment Equations

	4.1	4.2	4.3	4.4	4.5
c	-0.00289	-0.00254	-0.00213	-0.00209	-0.00194
	(0.624)	(0.547)	(0.46)	(0.45)	(0.42)
Δlo_{-1}	0.255	0.18			
	(1.07)	(0.78)			
Δlo_{-2}	0.621	0.55	0.597	0.555	0.616
	(2.6)	(2.5)	(2.77)	(2.52)	(2.83)
Δlo_{-3}	0.701	0.61	0.702	0.619	0.702
	(2.81)	(2.77)	(3.33)	(2.83)	(3.29)
Δlo_{-4}	0.103				
	(0.4)				
Δli_{-1}	-0.193				
	(1.64)				
Δli_{-2}	0.0568				
	(0.5)				
Δli_{-3}	0.139	0.129		0.156	
	(1.25)	(1.22)		(1.55)	
Δli_{-4}	0.24	0.249	0.244	0.239	0.224
	(2.23)	(2.37)	(2.33)	(2.28)	(2.12)
Δli_{-5}	0.163	0.168	0.187		
	(1.44)	(1.5)	(1.69)		
Δli_{-6}	0.25	0.289	0.304	0.262	0.273
	(2.24)	(2.64)	(2.78)	(2.42)	(2.51)
$(i - i^*)_{-1}$	-0.308	-0.341	-0.34	-0.309	-0.28
	(3.95)	(4.57)	(4.84)	(4.84)	(4.57)
R^2	0.48	0.45	0.43	0.43	0.41
SEE	0.041	0.041	0.041	0.041	0.041
DW	1.97	2.29	2.23	2.33	2.34
LM(8)	8.7	10.93	8.16	12.34	8.97
LM(4)	4.01	7.15	3.85	7.35	4.54
ARCH(1)	0.9	1.63	0.8	1.55	1.54
$\chi^2(8)$	15.2	14.2	14.2	14.6	14.0
PC RMSE	1108	1595	1804	1661	1746
Smpl	67:2	86:4			

Table 5: Extensions to the Dynamic Investment Equation

	5.1	5.2
c	-0.00215	-0.00189
	(0.5)	(0.448)
$\Delta\, lo_{-2}$	0.569	0.537
	(2.82)	(2.65)
$\Delta\, lo_{-3}$	0.632	0.673
	(3.15)	(3.31)
$\Delta\, li_{-3}$	0.157	
	(1.63)	
$\Delta\, li_{-4}$	0.234	0.239
	(2.43)	(2.5)
$\Delta\, li_{-6}$	0.285	0.276
	(2.86)	(2.78)
$\Delta\, lr_{-4}$		-0.079
		(0.98)
dd_{-3}	0.103	0.102
	(3.86)	(3.8)
$(i - i^{*})_{-1}$	-0.295	-0.285
	(5.04)	(4.82)
R^2	0.526	0.53
SEE	0.0376	0.0374
DW	2.28	2.34
LM(8)	8.1	9.5
LM(4)	4.16	4.98
ARCH(1)	0.71	1.45
$\chi^2(8)$	17.6	17.2
PC RMSE	1728	1952
Smpl	67:2	86:4

Table 6: Dynamic Employment Equations

	6.1	6.2	6.3	6.4
c	-0.0015	-0.00185	-0.00175	-0.00178
	(2.56)	(3.94)	(4.14)	(4.19)
$\Delta\, lo$	0.0754	0.0762	0.0749	0.0681
	(4.25)	(4.5)	(4.5)	(4.3)
$\Delta\, lo_{-1}$	0.062	0.062	0.058	0.0504
	(2.87)	(3.08)	(3.15)	(2.88)
$\Delta\, lo_{-2}$	0.00594	0.01		
	(0.26)	(0.51)		
$\Delta\, lo_{-3}$	-0.0187			
	(0.88)			
$\Delta\, lo_{-4}$	-0.136			
	(0.74)			
$\Delta\, le_{-1}$	0.657	0.642	0.67	0.745
	(5.69)	(7.01)	(9.18)	(17.66)
$\Delta\, le_{-2}$	0.024			
	(0.19)			
$\Delta\, le_{-3}$	0.101	0.1	0.085	
	(0.83)	(1.36)	(1.27)	
$\Delta\, le_{-4}$	0.0102			
	(0.104)			
$(e - e^{*})_{-1}$	-0.0634	-0.0595	-0.0613	-0.0563
	(3.89)	(2.8)	(4.03)	(3.81)
R^2	0.9	0.89	0.89	0.89
SEE	0.0029	0.0028	0.0028	0.0028
DW	2.08	2.02	2.08	2.17
LM(8)	6.39	5.69	6.15	6.49
LM(4)	1.17	0.56	0.49	1.13
ARCH(1)	0.26	0.16	0.223	0.087
$\chi^2(8)$	7.82	7.9	7.8	6.76
PC RMSE	462	444	459	434
Smpl	67:2	86:4		

Table 7: Extensions to the Dynamic Employment Equation

	7.1	7.2	7.3
c	-0.0026	0.00234	-0.00236
	(5.1)	(4.5)	(4.5)
$\Delta\, lo$	0.103	0.0945	0.093
	(6.58)	(5.92)	(5.9)
$\Delta\, lo_{-1}$	0.054	0.0514	0.0493
	(2.98)	(2.81)	(2.73)
$\Delta\, le_{-1}$	0.63	0.664	0.65
	(10.1)	(10.42)	(10.3)
$\Delta\, lhmf_{-3}$	-0.04	-0.026	
	(1.45)	(0.94)	
$\Delta\, sr_{-2}$		-0.0049	-0.0099
		(1.53)	(1.56)
$\Delta\, lrelp$		-0.00244	
		(1.14)	
$\Delta\, lnkg_{-4}$		-0.00953	-0.00492
		(1.53)	(1.60)
$(e - e^*)_{-1}$	-0.513	-0.047	-0.0516
	(3.12)	(2.68)	(3.09)
R^2	0.89	0.89	0.89
SEE	0.0029	0.0029	0.0029
DW	2.14	2.11	2.07
LM(8)	5.99	9.14	7.72
LM(4)	0.99	3.52	1.9
ARCH(1)	0.045	0.16	0.012
$\chi^2(8)$	7.78	8.32	8.64
PC RMSE	467	415	423
Smple	67:2	86:4	

Table 8: Investment; Disequilibrium Inter-Related Factor Demand Model

	8.1(1)	8.2(1)	8.3(2)	8.4(2)
c	-0.00218	-0.00107	-0.00142	-0.00122
	(0.51)	(0.23)	(0.4)	(0.3)
Δlo_{-2}	0.578	—	0.38	0.388
	(2.77)		(1.68)	(1.7)
Δlo_{-3}	0.639	0.71	0.464	0.493
	(3.11)	(3.32)	(2.13)	(2.78)
Δli_{-3}	0.16	—	0.112	—
	(1.62)		(1.14)	
Δli_{-4}	0.233	0.243	0.185	0.167
	(2.4)	(2.4)	(1.87)	(1.71)
Δli_{-6}	0.285	0.26	0.286	0.294
	(2.84)	(2.46)	(2.92)	(3.0)
dd_{-3}	0.1	0.1	0.1	0.1
	(3.77)	(3.62)	(3.99)	(3.99)
$(i - i^*)_{-1}$	-0.3	-0.26	-0.28	-0.262
	(4.29)	(3.68)	(4.9)	(4.77)
$(e - e^*)_{-1}$	-0.04	-0.2	-0.36	-0.417
	(0.18)	(0.9)	(1.84)	(2.19)
R^2	0.52	0.45	0.55	0.54
SEE	0.038	0.04	0.037	0.037
DW	2.27	2.22	2.41	2.43
LM(8)	8.32	13.3	10.1	12.3
LM(4)	4.18	10.4	5.82	7.2
ARCH(1)	0.57	5.6	2.06	2.74
$\chi^2(8)$	17.4	19.2	18.9	18.8
PC RMSE	1764	2070	1588	1624

(1) Disequilibrium terms based on 2.6 and 3.8.

(2) Disequilibrium terms based on 2.6 and 3.7.

Smple 67:2 86:4

Table 9: Employment; Disequilibrium Inter-Related Factor Demand Model

	9.1(1)	9.2(1)	9.3(2)	9.4(2)
c	-0.0019	-0.00146	-0.002	-0.002
	(4.08)	(3.28)	(3.95)	(3.7)
$\Delta\, lo$	0.0707	0.065	0.099	0.103
	(4.39)	(3.92)	(5.55)	(5.6)
$\Delta\, lo_{-1}$	0.0485		0.053	
	(2.68)		(2.63)	
$\Delta\, le_{-1}$	0.724	0.771	0.67	0.666
	(15.3)	(16.9)	(9.04)	(8.63)
$(e - e^{*})_{-1}$	-0.067	-0.0767	-0.042	-0.0646
	(3.68)	(4.14)	(1.9)	(3.0)
$(i - i^{*})_{-1}$	0.0043	0.0012	-0.0045	-0.0083
	(0.85)	(0.23)	(1.03)	(1.93)
R^2	0.89	0.88	0.88	0.87
SEE	0.0029	0.003	0.003	0.0031
DW	2.10	2.15	2.05	2.01
LM(8)	6.83	4.83	4.84	6.19
LM(4)	1.21	2.58	0.98	3.07
ARCH(1)	0.0006	0.0016	0.3	0.8
$\chi^2(8)$	6.6	4.29	6.93	5.69
PC RMSE	418	362	420	337

(1) Disequilibrium terms based on 2.6 and 3.8.

(2) Disequilibrium terms based on 2.6 and 3.7.

Smple 67:2 86:4

Chart 1
Investment - Output ratio (1985 prices)

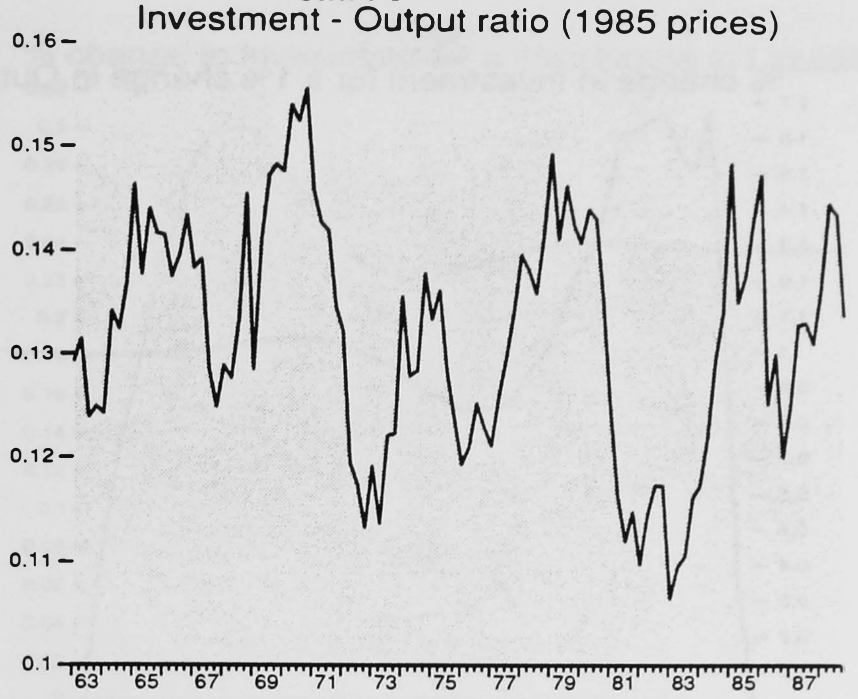


Chart 2
Employment - Output ratio (man/£ mn (1985 prices))

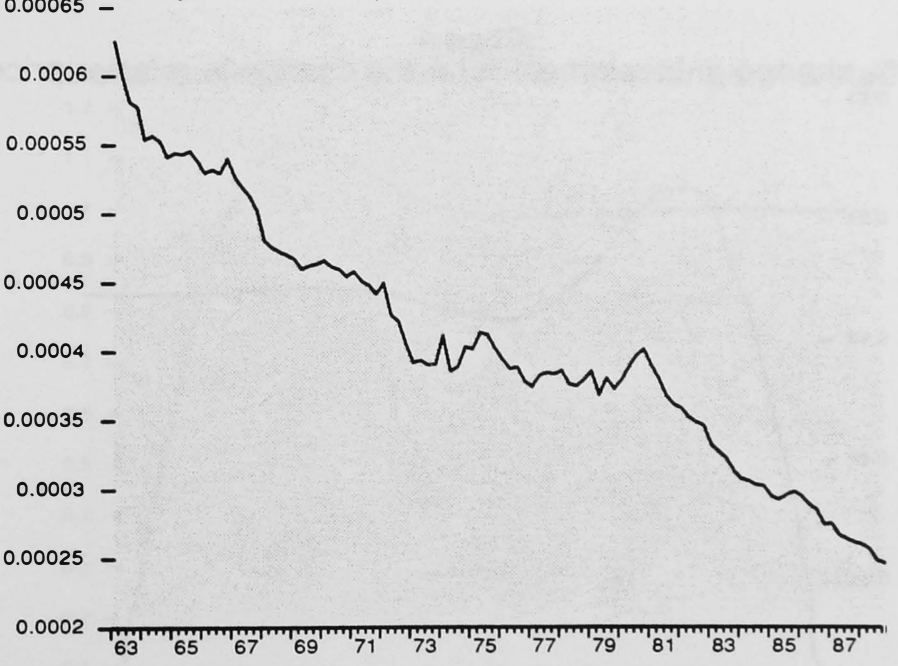


Chart 3
% change in Investment for a 1% change in Output

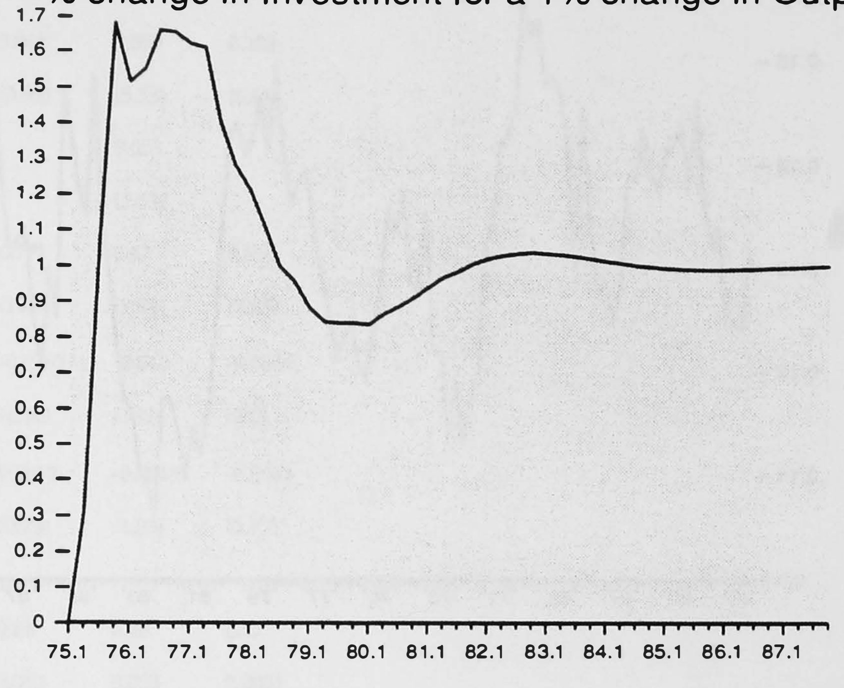


Chart 4
% change in Investment for a 1% change in relative prices

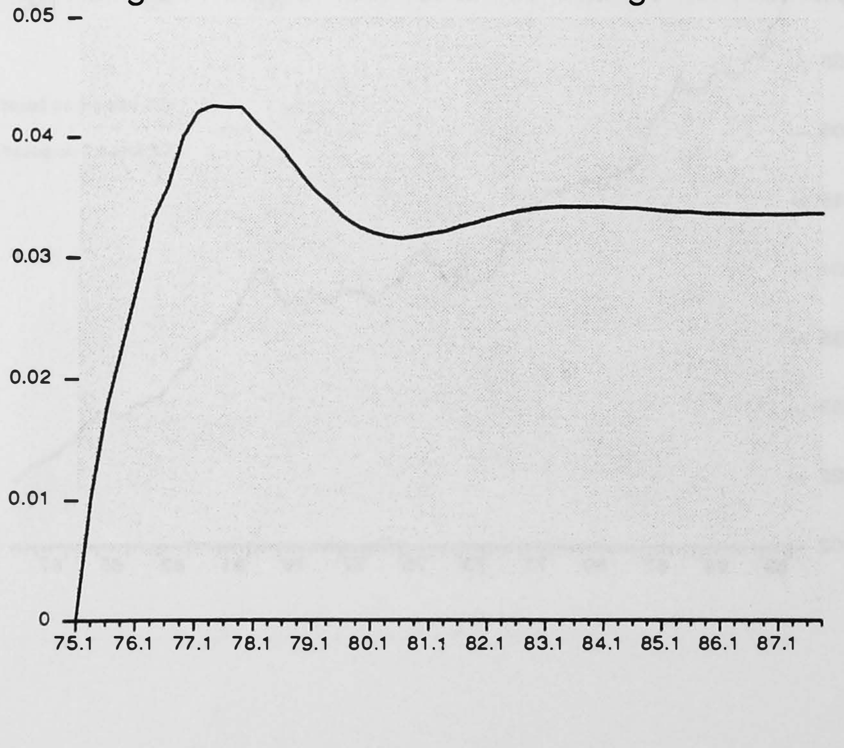


Chart 5
% change in Investment for a 1% change in Liquidity

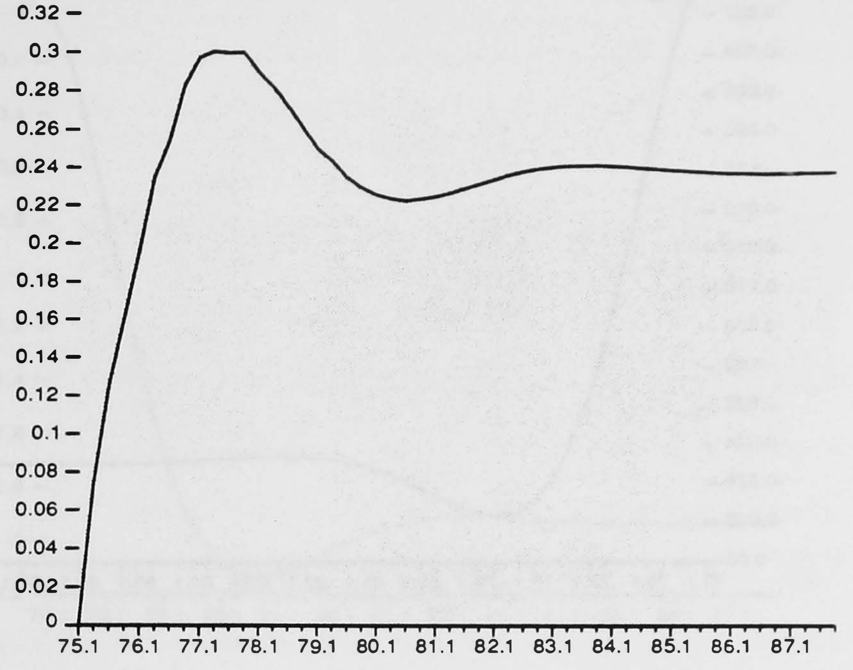


Chart 6
% change in Employment for a 1% change in Output

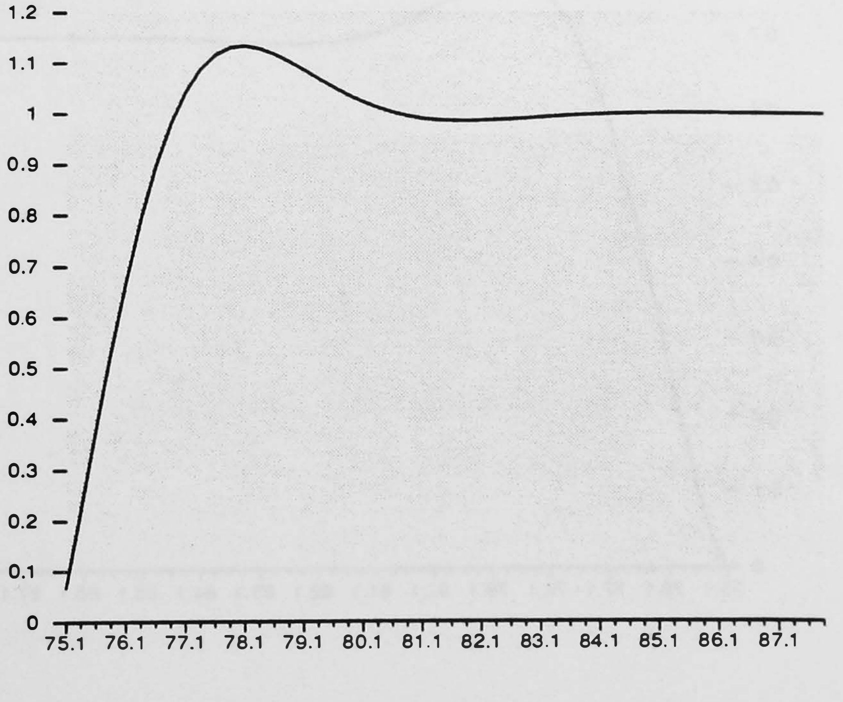


Chart 7
% change in Employment for a 1% change in relative prices

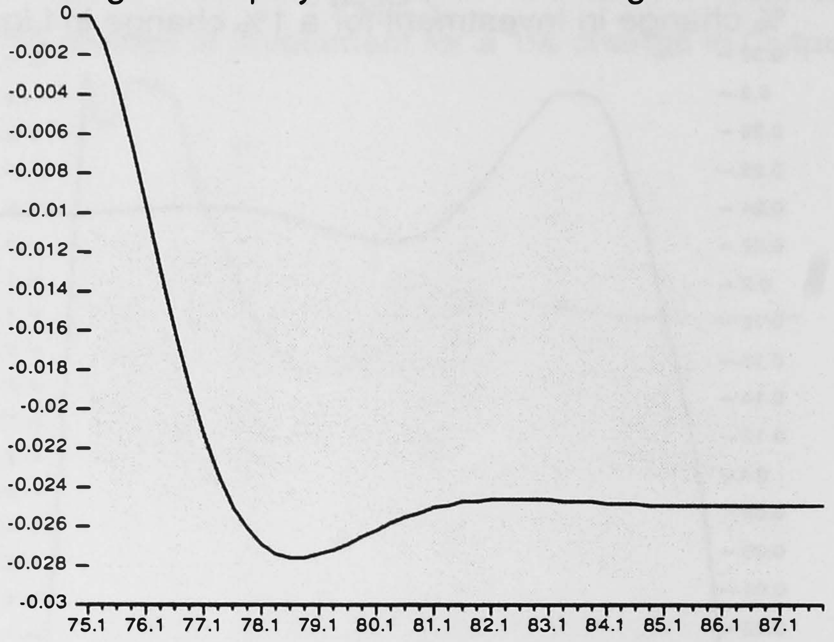


Chart 8
% change in Employment for a 1% change in Liquidity

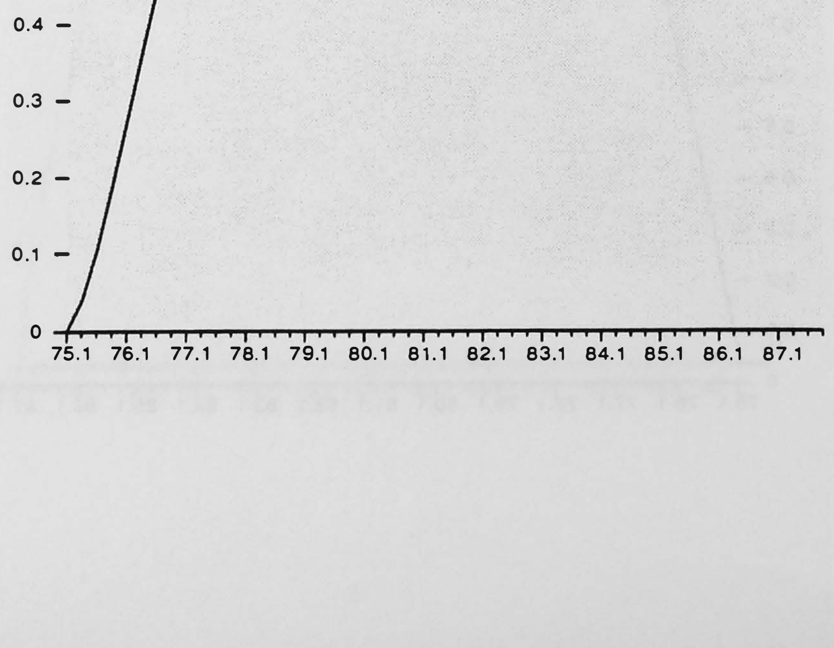
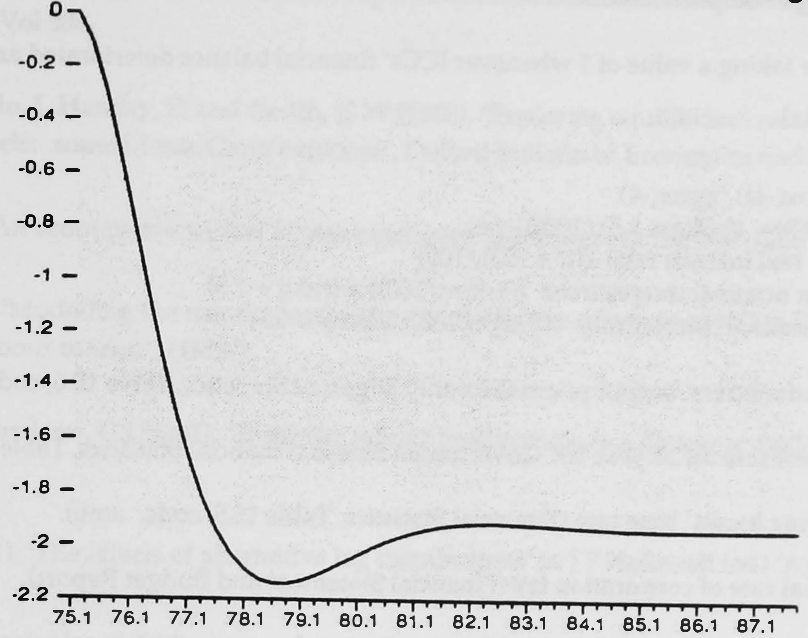


Chart 9
% change in Employment for a 1% change in average hours



Data Definitions

Variables transformed into logs in the estimation work are underlined.

dd — dummy variable taking a value of 1 in the second quarter of 1984 and 0 otherwise to take account of the change in rules applying to corporation tax.

dum1 — dummy variable taking a value of 1 whenever ICCs' financial balance deteriorated and 0 otherwise.

Interest rate terms:

pe = (ppox - ppox(-4))/ppox(-4)
lr = ((1 - tryc/100)) + ((rukg + 1.5)/100)) - pe
lreal = long-run real interest rate: ((lr x 100)/100)
lrukg = long-run nominal interest rate: ((1-tryc/100)) x (rukg + 1.5)
sr = short-run nominal interest rate: ((1-tryc/100)) x (rcbr + 1.5)

ppox — manufacturers' output prices (Monthly Digest of Statistics, Table 18.6, code: dzcw).

rukg — interest rate on 20-year UK Government Stocks (Financial Statistics, Table 13.5, code: ajlx).

rcbr — clearing banks' base rate (Financial Statistics, Table 13.5, code: amij).

tryc — annual rate of corporation tax (Financial Statement and Budget Report).

lcaput — capacity utilisation: proxied by the ratio of current to trend output which is calcuated as

$$lo(-1) - \left(\frac{1}{9} \sum_{i=2}^{10} lo_{-i} \right)$$

lhmf — average hours worked per operative in manufacturing (Department of Employment Gazette, Table 1.12).

li — manufacturing investment (British Business, Table 3).

liq — ICCs' net liquidity: calculated a nlqr+1 (nlqr drawn from Bank of England's companies sector database).

lk — capital stock in the manufacturing sector computed from figures in Table 11.10 in the Blue Book and interpolated to give quarterly data.

lo — manufacturing production (Economic Trends, Table 16, code: dvis).

lrelp — relative prices of capital and labour (Kelly and Owen (1985)).

ng — ICCs' net income gearing (Bank of England's company sector database).

nhn — normal hours worked per operative in manufacturing (annual observations obtained from the September issue of the Labour Research Department Bargaining Report and interpolated to give quarterly data).

prof — ICCs' share of profits in GDP (Economic Trends, Table A3, code: cial/djal).

varo — proxy for the variance of output constructed using equation (14).

varlu — proxy for the variance of relative prices constructed using equation (14).

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