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## **Production Constraints and the NAIRU**

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### **Abstract:**

This paper argues that the production constraints in the basic NAIRU model should be distinguished by type: capital constraints and labour constraints. It notes the failure to incorporate this phenomenon in standard macro models. Using panel data for UK manufacturing over eighty quarters it is shown that capital constraints became relatively more important during the 1980s as industry failed to match the increase in labour flexibility with rising capital investment.

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# Production Constraints and the NAIRU

## *Introduction*

There has been a growing literature in recent years that attempts to model directly the time variation that may exist in the NAIRU. Notable contributions to this literature include Ball and Mankiw (2002), Staiger, Stock and Watson (2001) and Gordon (1998). These papers attempt to identify the time variation in the NAIRU by making a simple a-theoretical decomposition. Specifically, Staiger *et.al* and Gordon both assume that the NAIRU is a random walk while the other shocks affecting unemployment are stationary and thus they extract the non-stationary component and regard this as the NAIRU. Ball and Mankiw on the other hand apply a simple Hodrick-Prescott filter which again amounts to extracting the trend component of unemployment but in a slightly different way. Our contribution addresses the same issue but from a more theoretical perspective. In particular, we advance a theory of why the NAIRU in the UK may have experienced a structural break during the 1980s.

Following the authors cited above we too relax the assumption that the NAIRU is time invariant. Our rationale, however, is more radical than the existing literature. Whereas the traditional NAIRU model focuses on the single factor labour in driving the output gap, we widen the scope to include capital constraints on production. This broader approach has found some support in the literature (Ceccetti 1995) but the implications for the NAIRU model have not been fully developed as of now. One important point that follows from a consideration of multiple input constraints is that time variation in the NAIRU can be induced by a structural shift in the relationship between these constraints.

The rationale behind an exclusive focus on labour constraints in the literature arises from the (often implicit) assumption that factor substitution allows full employment to be reached with any capital stock. Under these conditions, the availability of labour does indeed determine whether firms have the capacity to meet the current level of demand and the size of the capital stock exercises its influence primarily via the marginal product of labour which determines the feasible [path of real wages. However, insofar as

opportunities for capital substitution are limited, e.g. much of manufacturing industry, productive potential may be constrained independently by capital and labour constraints. Survey evidence (see the data appendix for source) shows a low correlation between perceived labour constraints and capital constraints in manufacturing with an average correlation coefficient of about 0.5 using quarterly data in the decade up to 2006. It has also been demonstrated that perceived capital shortage is surprisingly persistent. Using the methods in Clements and Hendry (1998) with the same data source, it has been shown that perceived capital shortage in the ten major sectors of manufacturing are predictable up to ten quarters ahead (Driver and Meade 2001).

The structure of the paper is as follows. Section 1 below advances a rationale for expecting a structural break to have occurred between labour and capital constraints in the UK in the 1980s. In Section 2 we develop a formal model where the output gap in the economy reflects both the constraints on labour supply and capital shortages. Section 3 describes the data and tests for structural breaks between the constraint series. We use a panel data set of business survey data for individual industries in the UK and particularly make use of unique (CBI) estimates of labour, capital and total output constraints in the economy at a sectoral level. The results, discussed in Section 4 confirm the existence of the hypothesised structural break. The implications are discussed in the concluding sections.

### ***1. Shareholder value and increased capital constraints***

There may be several reasons for expecting structural breaks in the relationship between labour and capital constraints. Immigration and changes in labour participation rates are possible candidates, though we would expect these to be more characterised by slow moving trends. Perhaps the most important reason for a sharp break in respect of capital constraints is the increased emphasis on shareholder value that shifted managerial behaviour in shareholder-oriented economies in the 1980s.

Following financial deregulation in the US and elsewhere at that time, managerial autonomy was circumscribed by greater pressure from investors resulting in stringent profitability requirements in capital investment appraisal and a greater tendency to return capital to shareholders. In countries characterised by a reliance on equity finance there

was, from the 1980s, an increased managerial focus on short-term performance (Nolan 2002). This was fuelled partly by a defensive reaction to takeovers and partly by the degree to which managerial compensation was increasingly linked to the current share price. Some have also argued that the increased gearing that accompanied this phenomenon reduced free cash flow and managerial autonomy. Whether this was the case or not, the obligation to pay future debt will have focused attention on the scope for cost-cutting and the elimination of excess capacity.

The effect of these processes on capital investment in Anglo-American economies is controversial (Shleifer and Vishny 1997; Stockhammer 2004) but one view is that that they contained capital expenditure and reduced the degree of slack in capital stock use. It has been argued that the “ultimate purpose “ of the restructuring of the 1980’s was to improve performance by “reducing investment...” (Donaldson 1994). This is underscored in writings such as Jensen (1997) where it is claimed that widespread overcapacity was partly eliminated in the 1980s. The retrospective conclusion also appears to be that increased institutional investment “helped to eliminate excess capacity” (Holmstrom and Kaplan 2001, p.122). For the case of the UK, there is also evidence of an upward shift in manufacturing capacity utilisation from the mid 1980s, suggesting a more cautious capital investment stance or a greater tendency to retire surplus capital (Driver and Shepherd 2005).

There is, therefore, plausible theory and some empirical support for expecting structural breaks in the relationship between labour and capital constraints though this has not been addressed in the existing theory. Some authors do give attention to the distinction between labour and capital constraints but these are exceptions.<sup>1</sup> For the most part the standard theory tends to eliminate the role of capital from the NAIRU completely, often explicitly so, concentrating instead on the role of the labour market and labour market institutions (Belot and Van Ours 2004).

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<sup>1</sup> We include here Rowthorn (1995); Malinvaud (1977); Arestis and Biefang-Frisancho Mariscal (2000); Malley and Moutos (2001); and Arestis and Sawyer (2005). There has also been some discussion of the role of capacity utilisation in the determination of macroeconomic pricing pressure -see Wolfgang and Gordon (1993), Cecchetti (1995), Corrado and Matthey (1997) and Kennedy (1998).

## 2. The NAIRU with capital and labour constraints

The standard NAIRU model may be represented (without dynamics or error terms) as:<sup>2</sup>

$$\begin{aligned} p_t - w_t^e &= b_0 - b_1 u_t^k \\ w_t - p_t^e &= g_0 - g_1 u_t^l \end{aligned} \quad \dots(1)$$

where  $p$  is output price,  $w$  is nominal wage,  $u^k$  is plant capacity slack,  $u^l$  is unemployment and superscript  $e$  represents expectations. We are of course abstracting from a number of other factors, which may also affect the NAIRU in the real world. These would include such things as the tax and benefit system, union strength and the legal bargaining framework in the labour market amongst others, these are all assumed to be part of the two constant terms above ( $b_0$   $g_0$ ). The inclusion of these terms in the constants will not affect our investigation of the implications of the production constraints as we pursue a direct analysis of the constraint relationship rather than estimating a conventional wage equation which would be severely affected by an omitted variable problem. We are not therefore denying the importance of these other factors but rather we are focusing more directly than usual on the constraint issue.

Consider first the labour market constraint. Although the standard model would, as above, often be simply written with unemployment it should more correctly be a general measure of labour market disequilibrium, maybe the deviation of actual unemployment from the NAIRU or a direct measure (as we will use). Similarly  $u^k$  is a measure of the constraints facing the firm on the capital side and it is this factor that affects the firms pricing behaviour in the bargain. An equilibrium solution to equation (1), where actual and expected values are equal implies a relationship between the cyclical variables  $u_t^l$  and  $u_t^k$ . These variables may be represented in standard form as a sum of  $J$  frequency components:

$$\log u_t^i = \sum_{j=1}^J [\alpha_j^i \cos \lambda_j^i t + \beta_j^i \sin \lambda_j^i t] + \log \varphi_t^i \quad \dots(2)$$

where  $i = l, c$  and  $\varphi_t^i$  is a scale factor.

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<sup>2</sup> The equation system is sometimes written to include productivity variables but the coefficients on these are generally constrained so that they do not enter the equilibrium solution.

The variables  $u_t^l$  and  $u_t^k$  may differ in phase, amplitude and regularity. As our concern here is with long-run solutions, we focus on the case where the levels of the series differ by a multiple that is subject to a random break. Thus:

$$\alpha_j^i = \alpha; \beta_j^i = \beta \text{ for } i = l, k \text{ and for all } j$$

$$\text{and } \log \varphi_t^c = \log \eta_t + \log \varphi_t^l$$

where  $\eta_t \geq 0$  and

$$\eta_t = \eta_0 \text{ for } t < t_b$$

$$\eta_t = \eta_0 + \delta \eta_0 \text{ for } t \geq t_b$$

and where  $t_b$  is the time of a random shift break in the relationship between  $u_t^l$  and  $u_t^k$

Thus, the initial state has  $u_t^k / u_t^l = \eta_0$  and the NAIRU may be expressed as:

$$u^* = (b_0 + g_0) / (b_1 \eta_0 + g_1) \quad \dots(3)$$

Clearly, the bigger the relative degree of plant capacity slack, the lower the NAIRU. To see the response of the NAIRU to a change in  $\eta_0$ , we may differentiate  $\log u^*$  with respect to  $\eta_0$  to obtain a semi-elasticity:

$$\partial \log u^* / \partial \eta_0 = -b_1 / (b_1 \eta_0 + g_1) \quad \dots(4)$$

Where the adjustment coefficients of price and wages are approximately equal, we have  $b_1 \approx g_1$  giving:

$$\partial \log u^* \approx -\partial \eta_0 / (1 + \eta_0) \quad \dots(5)$$

Almost invariably the practice in the literature is to impose the restriction  $\eta_t = 1$  for all  $t$  so that there is no distinction drawn between the two cyclical measures of unemployment and plant capacity slack. It is somewhat surprising that these variables are conflated because they correspond to two different sets of literatures. The unemployment variable relates to the labour market literature on the Phillips curve (See

for example Blanchard and Katz 1977 for a survey), or the “wage curve” that is said to underpin the labour supply function (Blanchflower and Oswald 1994). The indicator of capacity slack refers to the literature on mark-up pricing and its cyclical or anti-cyclical behaviour (Bloch and Olive 2001, Small 1998, Lee 1993) that determines the labour demand equation in the NAIRU model.

To motivate the empirical work that follows we may note that discontinuities between the two cyclical measures can have reasonably large effects. For example, a 10% increase in  $\eta_0$  from an initial value of unity would increase the NAIRU to 1.05 of its value while a 50% increase in  $\eta_0$  would raise the NAIRU by a quarter. In the next section we show how it is possible empirically to test for breaks between the cyclical variables.

### **3. Data and Estimation**

As argued above the standard model of the NAIRU yields a relationship between labour and capital constraints, which, for stable parameters (which includes a range of other factors that may affect the NAIRU) will give rise to a constant NAIRU. But if there are breaks in these parameters then the NAIRU will itself break. In this section we evaluate the stability of the relationship between the constraints in the economy.

The variables  $u_t^l$  and  $u_t^k$  in the previous section may be proxied in a number of ways. Here we propose to measure them (inversely) by indicators of skilled labour constraint and by plant capacity constraints. We investigate the degree of labour constraint and capital constraint in a large set of UK manufacturing industries over a long data period using panel methods. We use panel data on three key variables defined as:<sup>3</sup>

CU capacity utilisation

LC labour constraints

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<sup>3</sup> See the data appendix for exact definitions. The use of the manufacturing sector seems apposite as it shares the characteristics of the “primary” sector that the NAIRU model was originally designed for (Layard, Nickell and Jackman 1991).



## KC capital constraints

Our primary interest is to look for structural shifts in the way labour and capital constraints affect capacity utilisation. We are therefore searching for a structural break at some unknown point in the sample in a panel data context. Moreover the issue is to find a specific break in the relationship between capacity utilisation and either labour constraints or capital constraints so we are concerned with a parameter shift in this relationship rather than the more usual mean shift. To derive reliable estimates of these breaks it is also important to have a model, which is in all other respects a good description of the data. So the model must be reasonably rich in terms of both dynamic specification and its use of other explanatory effects. As is well known dynamic panel data models can often lead to biased parameter estimates and so we will employ the Generalised Methods of Moments estimator for dynamic panel data models developed by Arellano and Bond (1991). The problem then is to test for a structural break in the parameters at some unknown break point. The basic methodology we use rests on Andrews (1993) who defines the asymptotic distribution theory of sequential structural break tests. We are extending this framework into the GMM panel data estimators noted above. Similar techniques which extend the testing to the case of non-stationarity include Zivot and Andrews (1992) and Banerjee, Lumsdaine and Stock (1992) although our case is a little simpler as non-stationarity is not an issue here. These techniques conventionally use a sequential dummy variable approach *i.e.* a sequence of full sample estimates are undertaken where a constant shift is allowed for through a zero-one dummy and the timing of the shift in the dummy is sequentially moved through the complete sample. Formal tests of the structural break are then conducted by taking supremum of a relevant test statistic ( in our case the largest 't' statistic) observed in the sample and this then indicates both the significance of the break and its timing. The tests

are generally non-standard ones due to the presence of a structural break parameter in the alternative, which is not present under the null. Andrews (1993) tabulates appropriate asymptotic critical values for this test. These critical values vary with the proportion of the sample which is being searched over, and are strictly undefined if the whole sample is being used for the structural break test. We will search over a range that excludes the first and last 10% of the observations. The appropriate 5% critical value for a 't' distributed Wald test is then approximately 3. In our application we have chosen to interact the dummy variable with the labour and capital constraint variables. This then implies a sequence of shifting parameter values on the two constraints and we can graph both the implied total parameter value and the associated 't' statistic based on robust standard errors (Arellano1987) for the break point.

In order to ensure a sufficiently rich model we run a dynamic two-way fixed effects panel with CU as the dependent variable and with the sequential dummy variables interacted for both LC and KC. In addition to control for any general cyclical effects we include the growth rate of the aggregate economy. This model is then run sequentially, updating the time dummy for each run.

The exact specification for the panel estimation is:

$$\begin{aligned}
 CU_{i,t} = & \beta_0 + \beta_1 CU_{i,t-1} + \beta_2 LC_{i,t} + \beta_3 KC_{i,t} + \beta_4 LCDUM_{i,t} \\
 & + \beta_5 KCDUM_{i,t} + \beta_6 DUK_{t-1} + e_i + u_t + e_{i,t}
 \end{aligned}
 \tag{6}$$

where the labour and capital constraint time dummy interactive terms are termed respectively as LCDUM, KCDUM and where DUK is the change in the log of UK GDP.  $e_i$  is the industry specific effect while  $u_t$  is the time specific effect and  $e_{it}$  is the residual.

The sample period is 1978Q1 to 1998Q4 and the panel is unbalanced, the longest time series comprises 84 observations, there are 48 industries covered and the total sample size is 3,800 observations.

#### **4. Results**

The coefficients on KC and LC are 0.4 (robust  $t=14.2$ ) and 0,17 (robust  $t=3.75$ ) when the model is run without sequential dummies. This is not surprising as previous studies by CBI data managers have suggested that the utilisation variable primarily reflects the incidence of plant constraints (Junankar 1990). The model is reasonably well specified showing no signs of serial correlation and the instrument set is accepted by the Sargan test of instrument validity.

We now turn to the main results, the investigation of the possibility of a structural break. We performed a sequence of 84 regressions where the interacting dummy variables were switched on at every possible break point. The graphs of the basic coefficients with and without the dummy effect included are shown in Figure 1. The significance of the dummy effects are given in Figure 2 for both LC and KC.

The interpretation of these graphs needs some explanation. The sequential estimation takes place many times over, with the interacting dummy variables switching on at every possible point in time. We then use the  $t$  statistics in figure 2 to judge the most likely break point, this is detected by selecting the largest  $t$  value over the whole sample. This occurs in 1987 for Labour and 1982 for capital. To judge whether this is a significant structural break we note that the appropriate critical value is roughly 3 and we can see that both of the maximum  $t$  stats exceed this value. However we know that the test does not perform well at periods close to the end of the sample and so we have

some doubts about its reliability for the timing of a capital break, which occurs very close to the beginning of the sample. Figure 1 then shows the value of the coefficient for labour and capital,  $(\beta_2, \beta_3)$ , these coefficients are always derived over the whole sample but are changing over time as the interacting dummy terms are switching on sequentially. Figure 1 also shows the combined effect of the variable with the interacting dummy effect  $(\beta_2 + \beta_4; \beta_3 + \beta_5)$ , which is the total effect of the variable in the equation estimated for each possible break point. The difference between each pair of lines then shows the size of the break assuming the break occurs at that point in time.

Focusing first on the LC variable, the coefficient on the dummy becomes negative and significant some time after the start of 1985 with a maximum t-value occurring in 1987Q2. The results of the KC variable are different. As noted earlier, there is some indication of positive t-statistics on the dummy in the early years but these must be treated with caution given that the coefficients on the dummy here are estimated with a small number of observations. Figure 1 shows that there was a rise in the combined capital constraint plus dummy effect from the late 1980s.

Overall the results are consistent with a fall in the effect of LC in the latter half of the period and stable or slightly rising effect of KC. From Chart 1 it can be seen that the changes were concentrated in the 1980s. This is consistent with the view that UK manufacturing adopted a tighter “capacity stance” as industry recovered from the effects of the 1980s recession. At the same time labour constraints were reduced in importance, presumably reflecting the effects of legislation and company practices in removing restrictions.

The general picture that emerges is of a failure to capitalise on improved labour practices by complementing them with rising capital investment sufficient to contain capital constraints on output. Rather, the opposite seemed to happen as capital constraints began to bite more severely in the 1980s. A number of plausible patterns may be advanced for this. First, the labour market reforms, while increasing profitability, were accompanied by higher macroeconomic uncertainty and increased industry-level uncertainty due to the changing composition of demand in the economy that was in turn driven by a change in income distribution. Secondly, the increased attention to cost efficiency that accompanied the reforms created an ambiguous climate for growth (Chandler 1994; Stockhammer 2004)<sup>4</sup>.

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<sup>4</sup> . This focus on cost reduction reflected in part the increased power and influence of institutional investors and the erosion of managerialism . See also the discussion in Holmstrom and Kaplan (2001) in respect of the US economy.

## **5. Implications for the NAIRU**

The implications for the NAIRU of the findings in Section 3 are quite straightforward. A structural break in the relationship between the constraints has been identified and this in itself is sufficient to introduce time-variation in the NAIRU. We find that the ratio of the capital coefficients to the labour coefficient (taking account of the time dummy effect) more than doubled from the mid to the late 1980s to the late 1990s. In the simple model of Section 2 that would have increased the NAIRU substantially unless mediated by other reforms. It seems surprising that the sensitivity of NAIRU estimates to such a plausible phenomenon as a structural break between factor constraints has not emerged so far in the theoretical literature.

In some respects our conclusions and implications are similar to those of other authors, cited in the introduction, who have addressed the question of a time-varying NAIRU. Certainly, our approach shares with other recent treatments a concern with productivity variables that were omitted from earlier models (Layard, Nickell and Jackman 1991). Productivity variables will affect the NAIRU in the standard theory only if the labour share is affected by investment or if there is a lag in the adjustment of real wage to productivity. The latter issue has formed the centrepiece of recent critiques of standard NAIRU theory (Ball and Moffet 2001; Ball and Mankiw 2002).<sup>5</sup> The underlying argument here relies on sluggish wage adjustment to higher productivity growth. If the equations in (1) are differentially affected by productivity growth, say because the outside wage is linked to productivity or more generally because of unspecified “real wage resistance”,

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<sup>5</sup> Until recently, these issues have been sidelined in the literature. The former effect was generally circumvented in the standard model by using a Cobb-Douglas Production function: see Rowthorn (1999) for a critique. The importance of productivity growth was noted in Dreze and Sneessons (1995).

then the numerator of (3) contains a term in productivity growth and the NAIRU itself will be negatively related to that growth.<sup>6</sup>

While accepting that wage adjustment lags can help to explain time-variation in the NAIRUs, we have in this paper pursued a distinct productivity-related approach to explain why the UK NAIRU may not have responded as hoped to the labour market reforms of the 1980s. Our account is based on an observed break in the balance of capital and labour constraints in UK manufacturing, reflecting perhaps the shock of increased financial discipline during the 1980s. Whereas authors such as Ball and Moffet analyse effects occurring through the wage equation, we focus on effects occurring through the price mark-up on wages. In essence, we suggest that weak capital investment in the UK, or tighter capacity utilisation, may have contributed to maintaining equilibrium unemployment higher than necessary.<sup>7</sup>

Finally, we may note that our contribution provides another explanation for expecting hysteresis in the NAIRU. A number of explanations for persistence in the NAIRU have been discussed in the literature e.g. insider-outsider models; models based on the atrophying skills of the unemployed and more recently the interaction of shocks and institutions (Blanchard and Wolfers 2001). Empirically there is strong support for

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<sup>6</sup> OECD studies have tended to find lagged wage adjustment for European countries but not for the US. However, recent empirical results for the United States seem to confirm that ‘changes in productivity growth appear to shift the inflation-unemployment tradeoff... In the future, (macroeconomists) should expand their scope to build and test models of inflation, unemployment and productivity’ (Ball and Mankiw 2002).

<sup>7</sup> While the US also experienced a pruning of excess capacity in the 1980s this appears to have been compensated by new entry, unlike the experience in the UK (Holmstrom and Kaplan 2001; Driver and Shepherd 2005)

persistence, especially in some European countries.<sup>8</sup> Our contribution provides another explanation for this, given that a break in the NAIRU is easily conflated with a unit root.

## **6. Conclusions**

Our focus in this paper has been quite specific. Rather than estimating and testing a model based on the NAIRU framework that would be subject to several criticisms (Pichelmann and Schuh 1997; Akerlof 2002) we have chosen a more direct test on one of the maintained hypotheses of the theory viz. that the same cyclical variable can be used in the pricing and the wage equations. We find evidence for a structural break between these cyclical series over the period studied in line with a priori beliefs on the role of managerial incentives and corporate behaviour in reducing available slack in the capital stock.

As shown in the paper, the NAIRU is affected by the relationship between the degrees of slack in the supply of labour and capital. A rising relative influence of capital constraints can offset a potential fall in the NAIRU caused by increased labour market flexibility. We find that the ratio of the capital coefficients to the labour coefficient (taking account of the time dummy effect) more than doubled from the mid-1980s to the late 1990s. This is quite a sizeable shift and thus any attempt to base policy on a NAIRU estimated simply from unemployment or other index of labour market tightness may be more than usually misguided.

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<sup>8</sup> Using a standard ADF test, stationarity in the NAIRU is accepted at 10% only for the US, Finland and Sweden. Using a test that individually tests the null of non-stationarity in the SURE framework, hysteresis is still found in half the countries studied. (Camarero and Tamarit 2004).



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Figure 1: Sequential coefficients on KC and LC

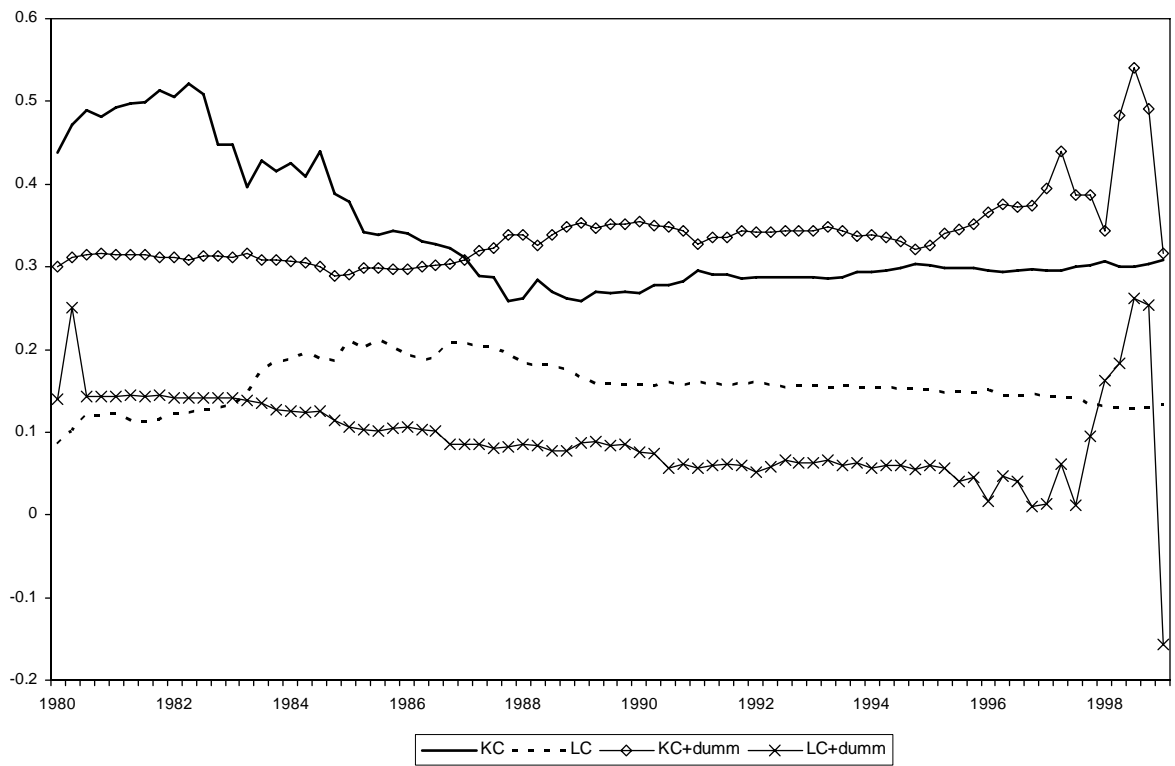
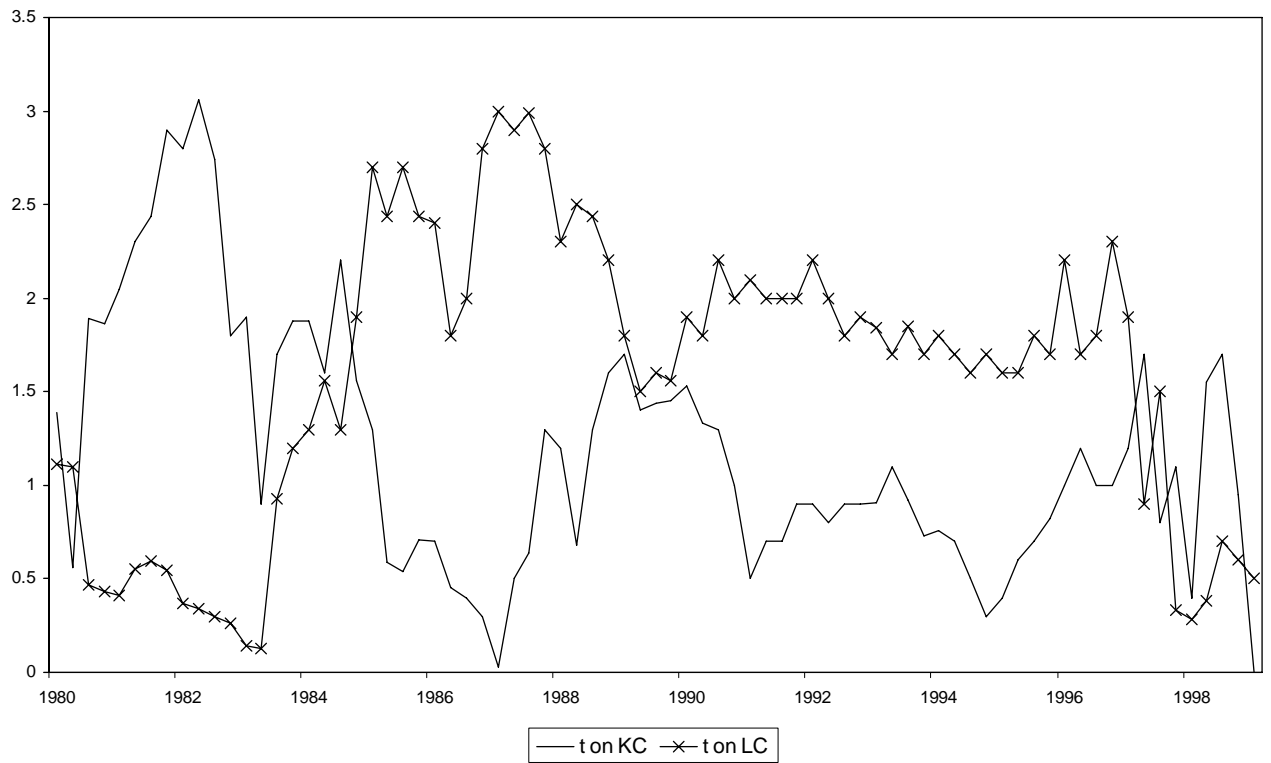


Figure 2: Absolute 't' Statistics on the sequential breaks in KC and LC



## Data Appendix

Most of the data used comes from the survey questions designed by the Confederation of British Industries (CBI). This survey has an excellent reputation, having run continuously since 1958. It feeds into the EU official data series and it is regularly used in academic and policy studies. The sample size is large with over 1000 returns, quarterly (European Commission 1997)

The CBI variables are defined as follows:

*LCU* is the percentage of respondents replying “NO” to the question “are you working below a satisfactory full rate of operation” (Q4B).

*LC and KC* are the percentage replies “Skilled labour” and “plant capacity” to the question “What factors are likely to limit your output over the next four month”(Q14B and Q14D)

The DUK variable is taken from the UK National Accounts