# Real Options - Delay or Pre-Emption: Do Industrial Characteristics Matter?

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## ABSTRACT

This paper presents an empirical study of the channels of influence from uncertainty to fixed investment suggested by real options theory. Using panel data from the Confederation of British Industry (CBI) Industrial Trends Survey, we report OLS estimates of the impact of uncertainty on investment where the regressors are augmented by cross-sectional averages of the dependent variable and of the individual specific regressors, as recently suggested by Pesaran (2006). The cross-industry pattern of results is checked for consistency with the pattern predicted by real options theory, using a specially constructed data set of industrial characteristics. We find that irreversibility is able to predict the pattern detected, but only when combined with a measure of the information advantage of delay. There is also evidence for expansion options effects; industries with high R&D and advertising intensities tend to have positive uncertainty effects.



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# 1 Introduction

Theoretical developments over several decades have highlighted the potential significance of uncertainty for capital investment decisions. A standard argument is that uncertainty should raise the amount of investment because of the likely convexity of marginal profit in the uncertain variable working through Jensen's inequality (Abel 1983). However, traditional convexity models are subject to the critique that they often ignore irreversibility and the timing decision associated with a project. Real options theory provides one explanation for a delayed response under uncertainty to signals that would cause entry or exit in a frictionless world. In this paper we investigate the empirical validity of this approach.

In real options theory, the trigger values for irreversible investment or disinvestment are respectively above and below the corresponding Marshallian values (variable cost plus the servicing of sunk cost of entry or exit) under uncertainty, as long as information arrives stochastically over time and waiting is not too costly. Models of the relationship of adjustment speed to uncertainty for irreversible investment are developed in Brennan and Schwartz (1985), McDonald and Siegel (1986), and Dixit and Pindyk (1994). A similar approach, reconciling the theory with standard q-theory of investment, is developed in Abel and Eberly (1994) where it is shown that the extent of the zone of inaction with respect to the forcing variable depends on the level of uncertainty; furthermore, activity outside the zone of inaction is slowed by heightened uncertainty. While most of the literature is concerned with the option to wait, and its effect on delaying investment, under some circumstances, increased uncertainty can accelerate project development, particularly where there is a time to build or where first mover advantages are significant (Bar-Ilan and Strange 1996; Weeds 2002; Folta and O'Brien 2004). The theoretical rationale for this ambiguity in the real option effect is explained in Abel *et al* (1996) where the effect of irreversibility (no downward adjustment) is allied with lack of expandability (no upward adjustment). Thus, the firm's options consist of a set of both call options and put options[1]. Much of the empirical literature finds a negative relationship between uncertainty and investment. Indeed, this has become something of a stylized fact. Many of these studies report results for *aggregate* investment. However, in this contribution we find that there is considerable heterogeneity in the response of investment to uncertainty across industries.

The main aim of this paper is to exploit the observed heterogeneity across industries in order to examine the relevance of real options in explaining the pattern. The method we adopt is first to establish estimates of both the sign and the magnitude of the impact of uncertainty on investment for each industry. We then use measures of industry characteristics – as suggested by real options theory – to explain the pattern observed. In Section 2 we discuss real options models of investment and the implications for investment decisions under uncertainty. Section 3 introduces the basic investment model used in the paper and reports the results of estimating the model with indicators of uncertainty. Section 4 assesses whether the cross-sectional pattern of uncertainty coefficients can be reconciled with the theory discussed in Section 3. Section 5 concludes.

# 2 The Theoretical Effect of Uncertainty on Investment Demand

Theory suggests a number of possible channels of influence running from uncertainty to investment. In this section we focus on two opposing influences predicted by real options theory (Trigeorgis 2003).

[1] Few studies have examined the combined effects of call and put otpions. Exceptions include Bulan (2005), who interprets irreversibility as a measure of the difference between the value of call options and put options, and Shaanan (2005), who recognises the issue but abstracts from it in estimation.

## 2.1 Deferment options and convexity

The basic "real options" approach stresses an additional cost to investment which attaches to any early exercise of an option to invest. By deferring the project and keeping the option open, costly mistakes may be avoided (Dixit and Pindyck 1994). The idea is very general: because of proprietary assets in knowledge, competences, or spare land, firms may choose the timing of their investment by balancing any loss from delay against the value of extra information that arrives over time. This may explain how uncertainty might raise the hurdle rate and delay investment projects.[2] Note that the empirical relevance of the argument stems from the existence of *both* irreversibility, and some feature of the firm's environment which makes delay valuable.

## 2.2 Expansion and compound options

The option to delay cannot always be presumed to exist, e.g. in industries characterized by first mover advantages (FMA). Under some circumstances, investment may be speeded up if other influences are favorable. For example in high-technology industries characterized by patent races, uncertainty may increase the value of the option obtained through early investment. Thus,

[2]One criticism of this argument is that although the hurdle rate may be raised, so too may the probability of hitting the hurdle with ambiguous implications for investment. Simulation results in Sarkar (2000) for a single firm partial equilibrium model suggest that a positive effect of uncertainty is possible at low levels of uncertainty. It is not clear however whether this can be generalised to the industry case. A further potential criticism of the real options argument is that with perfectly elastic demand (and constant returns to scale), irreversibility is irrelevant since the marginal rate of return on capital is, in these circumstances, invariant to the quantity of capital installed (Caballero 1991). This model effectively neutralises irreversibility through the focus on individual firm price uncertainty with no linkages from investment in one period to the investment decision in the next. However, at the industry level, new entry can erode excess profit and, in conjunction with irreversibility, create an asymmetry in price that biases investment downward by lowering the expected realised price. Thus, "...industry-wide uncertainty will affect irreversible investment by a competitive firm with constant returns to scale much as it would a non-competitive firm or a firm with decreasing returns to scale" (Pindyck 1993, p.274). Evidence in favour of real option effects may be found in Moel and Tufano (2002).

the literature on real options does not unambiguously predict the sign of the uncertainty-investment relationship. Today, several different kinds of options are routinely identified, leading to contradictory effects on investment (Copeland and Antikarov 2001). First, obtaining an option may in itself be a key part of each investment process, creating "compound options" where obtaining an option on an option is a key element in decision making. An example would be where follow-on products can more easily be launched on the back of a first success. Similarly, expansion options confer the ability to respond to higher than expected demand and are important in cases where lead times or adjustment cost would otherwise imply cost penalties. A variety of models have addressed the question of strategic decision-making in a real option framework and in particular whether the existence of FMA not only destroys the option to defer but actually speeds up investment due to the operation of expansion and compound options (Bar-Ilen and Strange 1996; Mason and Weeds 2001; Boyer *et al* 2004; Smit and Trigeorgis 2004).

The most likely industries where durable FMA exist are those with high product R&D intensity and where switching costs are also high - as they may be when firms advertise intensively. High technology and heavily branded goods will also tend to have high quasi-rents and this will give enhance the value of expansion options.

## 2.3 Testing the importance of the two channels

As noted above different industrial characteristics predict which real option influence is likely to operate in each case. We first identify which industries are affected (positively or negatively) by uncertainty and then, in a second stage, test whether the industrial characteristics can discriminate accurately as to which, if either, influence is present. The industry characteristics are of course only proxies for theoretical variables that feature in the two real option models. The theoretical variables, the predicted impact of uncertainty, and the industrial characteristics used to proxy the theoretical variables are detailed in Table I. We postpone to Section 4 the measurement of the proxy variables.

**[Insert Table I about here]**

# 3 Estimates of the impact of uncertainty on investment

Our modeling strategy requires a reasonably large cross-section of industries and, given the likely presence of lags of the dependent variable, a long time series. Official data series are not sufficiently disaggregated, at least for a sufficient length of time, for current purposes, but a useful alternative are the data on investment authorizations for over forty industries and eighty quarters, publicly available from the Industrial Trends Survey of the Confederation of British Industries (CBI). This is a quarterly survey based upon the replies from an average of over 1000 enterprises. The results are reported at an industrial level. It proved possible to obtain the necessary data for the analysis of 37 industries. Further details of our use of the Survey can be found in the Appendix, Section A1.

The dependent variable is constructed from Question 3b of the Survey which asks respondents: "Do you expect to authorise more or less capital expenditure in the next twelve months than you authorised in the past twelve months on: plant and machinery?" (The possible choices here are 'More', 'Same' or 'Less'). The resulting investment authorisations data record the percentage of firms in each industry responding in the three categories. These data differ of course from conventional gross investment data but may in fact offer some advantages (for example, gestation lags can be dispensed with). In practice however, these two variables are linked by a well determined realization function (Driver and Moreton 1992; European Commission, 1997. See also Lamont 2000). Although the fact that our data are qualitative represents a potential disadvantage, a well established and useful practical result for qualitative data is that the balance (the percentage responding more minus the percentage responding less) is closely correlated with rates of change (Smith and McAleer 1995; Driver and Urga 2004; Butzen *et al* 2003). Accordingly, we denote the investment authorisation balance as $Auth$, to represent investment growth. Summary statistics for this and all the variables described below and used in our investment equation can be found in Table A2 in the Appendix.

Our specification for investment authorisations for each industry $i$ at time $t$ ($Auth_{i,t}$) in equation (1) below follows the standard accelerator-type specification (Blanchard and Fisher 1989; Berndt 1990 equation 6.14). The accelerator form is chosen over the more common $q-$form in the light of the many findings of "fragile or implausible results" with Euler-equation specifications (Mairesse *et al* 1999, p.6). The basic equation is modified in four main ways as discussed below. First, it includes forward looking expectations derived from the Survey as recommended in Chirinko (1993). Second, additional regressors in the form of uncertainty and a measure of financial constraints are included as is now standard in the literature (Chatelain 2003). Third, the estimating equation has the form of an equilibrium correction model, a feature of many investment equations (Butzen et al 2003). Finally, to control for unobserved common factors such as the change in the tax regime imposed in the UK in 1984,.the equation is augmented by the unweighted arithmetic cross sectional mean $\left(\bar{x}_t = \sum_{i=1}^{N} x_{it}/N\right)$ of all the industries in the sample for each right hand side variable. This was recently advocated by Pesaran (2006). The estimating equation is therefore:

$$\begin{aligned} Auth_{it} = {} & b_{i,0} + b_{i,1}Auth_{i,t-1} + b_{i,2}Auth_{i,t-2} + b_{i,3}y_{i,t} + b_{i,4}y_{i,t-1} + b_{i,5}y^{e}_{i,t} + \\ & b_{i,6}opt_{it} + b_{i,7}unc_t + b_{i,8}unc_{i,t-1} + b_{i,9}unc_{i,t-2} + b_{i,10}fi_{i,t-1} + \\ & + b_{i,11}cu_{i,t-1} + b_{i,12}dcu_{i,t} + \textit{cross-sectional means} + e_{i,t} \end{aligned} \tag{1}$$

where $i = 1, ..., 37$ and $t = 1978:1-1990:2$. This equation was estimated by OLS for each of the 37 industries using the common specification above but with the lag structure of the focal uncertainty variables tested down one at a time.

In line with the standard specification, our specifcation includes both lags on the dependent variable, ($Auth$), and on the past output growth term ($y$). The survey data also allow us to construct an expected future growth variable ($y^e$) which represents short period expectations and thus complements the usual accelator term. Details concerning the precise construction of both $y$ and $y^e$ can be found in the Appendix, Section A1. A further forward looking variable, *opt*, reflecting survey-based business confidence is also included. Previous work has shown that this variable captures demand, interest rates and exchange rate influences (Junankar 1989).

The equation also contains a vector of additional terms reflecting both uncertainty, *unc*, and the possibility that firms may be experiencing financial constraints on investment, $fi$ (Chatelain 2003). Our uncertainty variable *unc* is derived from the cross-sectional dispersion of beliefs across firms in an industry about prospects for that industry. Assuming a high degree of homogeneity in demand conditions within the industry, the cross-section dispersion of beliefs about the same sector may be regarded as a measure of uncertainty. The precise measure used is the concentration of responses to the survey question on industry optimism[3] . We compute this measure as the entropy (negative concentration) of the three replies (more/same/less). Writing $S_j$ for the share of reply $j$ ( $j = 1, 2, 3$) we define: $unc_{it} = \Sigma_{j=1}^{3} \left[-S_{jit} \log S_{jit}\right]$.

[3] Uncertainty in real option models is generally captured by the volatility of some key variable. However, it is not always simple to measure volatility. GARCH models can be used to estimate conditional volatilities but convergence is often a problem and in our case we wished to retain as full a sample of industries as possible. Furthermore it can be argued that it is the future path of conditional volatility that is important (Leahy and Whited, 1996) so that our measure, which is based on forward expectations, is particularly appropriate in this regard. Guiso and Parigi (1999) have used Italian data with similar belief dispersion.

The constructed measure is not highly correlated with the level of optimism: the mean absolute value of the correlation coefficient over our sample of industries is 0.13. An even spread in the replies (each share $S_j$ equal to one third) corresponds to maximum entropy and maximum uncertainty[4]. The entropy variable has been used successfully in other contexts involving surveys with three possible replies to measure the extent of disagreement among respondents (Fuchs, Krueger and Poterba 1998). Using lack of consensus as a measure of uncertainty receives empirical support in a number of studies (Zarnowitz and Lambros 1987, Bomberger 1999).

Our estimating equation also allows for the potential role of financing constraints $fi$ by using the responses to question 16(c) of the Industrial Trends Survey which allows for both internal and external constraints as one of the reasons for limiting investment authorisations. After experimentation, our preferred measure sums the proportions of respondents who report either a "shortage of internal finance" or an "inability to raise external finance."

The estimating equation includes an equilibrium correction term in the form of a lagged capacity utilization variable directly recorded in the Survey ($cu$). Such utlization terms often appear in investment equations to capture (integral control) cumulative deviation from target levels - in this case the capital-output ratio. Given this specification, it is also standard to include the first difference of the $cu$ ($dcu$) as the dynamic counterpart to the levels term. Further details of the construction of these variables is given in the

[4]The *unc* variable may be measured with error. However, using the standard Hausman test procedure, we rejected the hypothesis that OLS estimates were statistically different from IV counterparts.

A further possible criticism of this uncertainty measure is that respondents may mistakenly reply to the survey question by projecting forecasts for their own firm on to the industry as a whole so that the spread of replies on industry optimism becomes an indicator of objective diversity. However the question posed in the survey is quite explicit on this point. Furthermore, we find that the entropy of optimism (relating to the industry) is significantly less than the entropy of output (relating to the firm) in all but four of the industries. We take this as evidence that firms are not just looking at their own fortunes in answering the optimism question.

Appendix.

The final vector of variables in the model consists of the controls for unobserved common factors, i.e, the cross section averages discussed above.

A summary of results from estimating (1) are reported in Table II. The *unc* coefficients are shown in standardised form to assist cross-industry comparisons[5]. Alongside the coefficients (which are shown in separate columns depending on the lag structure identified) we show the level of significance of the tested-down models using a minimum (one-sided) significance level of 10% that allows us to partition the industry set into negative, positive and null uncertainty effects[6]. In the two cases where more than one uncertainty term is retained, an $F-test$ on the joint significance of the coefficients is reported in column 10. The overall equation diagnostics are summarised in the final three columns and indicate that all equations are well determined. The $F-statistic$ (column 14) which tests the hypothesis that all the coefficients (except the constant) are zero is significant for all the industries at the 1% level or better.

The results do not support a simple pattern of a negative relationship of investment to uncertainty as suggested by much of the current literature, e.g. that cited in Carruth *et al* (2001). Instead we find a range of coefficients, from positive to negative, though a substantial number of the values are insignificant. The purpose of the next stage of analysis in the following section is to examine the predictability of this pattern.

**[Insert TABLE II about here]**

[5] These standardised coefficients are obtained by multiplying the raw coefficient by the standard deviation of *unc* in each industry and then normalising by the standard deviation of the dependent variable.

[6] The full set of results with all variables is available on request. From these it is apparent that for nearly all industries, at least one of the cross-sectional averages of the dependent variable and its lags is significant at the 5% level. Additionally, in the majority of cases, at least one extra average is also significant. For completeness we tested for the joint significance of all the cross-sectional averages and found them to be significant or borderline significant in about a third of cases.

# 4 Option values and the pattern of uncertainty effects on investment

To what extent can real options theory explain the pattern of coefficients contained in Table II? The table indicates 11 industries with significant *unc* effects at 10% or better, of which 7 are significantly negative. These are for ferrous metals, building materials, metal goods, constructional steel-work, electrical industrial goods, electrical consumer goods, and clothing and fur. Four are significant and positive (agricultural machinery, electronic consumer goods, aerospace, and wool textiles).

Our methodology requires us to construct an econometric model of the pattern of results described above. As discussed earlier, if the real options effect is important then the magnitude and sign of the uncertainty effect depends on the balance of the value of the deferment and expansion options as summarized in Table I above. To be able to test for the former, we need to measure the irreversibility associated with investment in any particular industry. For the latter, we require an indicator of the opportunities that will follow on from first-stage investments or indicators of the value of expansion options.

The measure of irreversibility ($irr$) is based upon a ranking of the ratio between second hand plant and equipment sales to the acquisition of such assets, averaged over an economic cycle. Where second-hand markets are thin, this ratio will be close to zero. Further details of all variables used in this analysis can be found in the Appendix, Section A3 and Table A4.

The option to wait will be more valuable when the random process determining investment decisions is highly persistent. Although mean reverting behaviour does not destroy option value it will reduce it (Sarkar 2003). Accordingly we also develop a measure of the persistence of the process, which in our case is calculated from the optimism variable ($opt$) used in the investment equations and discussed above. It is based on the normalised variance ratio (Cochrane 1988; Proietti 1996).

$$V_k = (1/k)(Var(opt_t - opt_{t-k})/Var(opt_t - opt_{t-1})) \tag{2}$$

where $k$ is the chosen lag length (20 quarters in our case)[7]. We call this variable $persis\_opt$. However, the theory of real options suggests that $irr$ and the measure of persistence should be seen as interactive. Accordingly, we constructed a new variable, based upon the joint distribution of the two variables, which combines $irr$ with our measure of persistence into an augmented measure of irreversibility, $irraug$. This used the quartiles of the distribution of the two variables, attaching the highest score to industries which were in the highest quartile on both measures ($= 6$). Those in the lowest quartile on both variables had a zero score.

Turning now to the measurement of opportunities for expansion, we base our indicator on both the R&D and advertising intensity of the industry. An industry which has a low intensity of either characteristics is assigned a score of zero; a score of one is assigned to industries exhibiting a high intensity for just one characteristic; industries which are both R&D and advertising intensive are assigned a score of two. This indicator variable is denoted $rdad$.[8] As well as representing expansion options, a high score on $rdad$ indicates possible preemption where competing technologies and brands are engaged in winner-takes-all competition. The option to wait would not exist in such circumstances[9].

In order to consider whether real options can predict the pattern of the

[7] Given that fixed investment assets are long-dated, we believe that a five year horizon is reasonable. We tested for sensitivity to this horizon by using a lag length of three years, but it made negligible differences to the results.

[8] The R&D and advertising variables are drawn from a study of EU industry by Davies and Lyons (1996, Table A2.1), who divided industries into high and low R&D and advertising intensities on the basis of the ratios of their expenditure on these variables to sales.

[9] We also constructed a profitability index as a rate of profit ($nprtea$) on total capital installed, adjusted for depreciation (See Appendix, Section A3). However, as this was not significant in any of the equations reported below we do not discuss it further.

uncertainty-investment relationships, we require measures of this pattern as the dependent variable. While a variety of such measures are possible, we consider first the simplest case, where the pattern of coefficient significance in Table II is assigned with $-1, 0, 1$ outcomes depending upon statistical significance and the predicted sign of the effect (-1 indicating a statistically significant and negative coefficient at the 10% level). The result is the variable $OPROB1$. Alternative dependent variables are then considered as a robustness check.

Table III reports some experiments with these variables. The first four results report experiments using $OPROB1$ with an ordered probit estimator. By itself, the measure of irreversibility, $irr$, has no explanatory power (column 1). When the value of waiting – measured by $persis\_opt$ - is added however, as suggested by our discussion above, both variables are correctly signed and significant at the 10% level (column 2). Moreover, the augmented measure of irreversibility $irraug$ - is significant at the 5% level (column 3), and when $rdad$ is included this is also correctly signed and significant (column 4).

The importance of $irraug$ appears robust to a number of alternative dependent variables and specifications. In column 5, we use a modified version of $OPROB1$ where the pattern of coefficient significance is assigned values $-2$,$-1$,0,+1,+2, where, for example $-1$ is negative significance at 10% and $-2$ is negative significance at 5%. The overall level of significance is now below 5% (0.023). This variable is labelled $OPROB2$.

The previous analysis has used conventional levels of statistical significance of the ordered probit regression to derive the dependent variable. An alternative is to use the estimated magnitudes of the uncertainty impact. Accordingly, column 6 shows results when we use the strength of the uncertainty effect as a dependent variable ($OSUM$). This variable takes on values $-2$, $-1$, 0, 1, or 2. Industries with insignificant uncertainty impacts take on a zero value. The other 11 industries were assigned values according to sign and whether the sum of the standardized coefficients is greater than the average of these sums across the same 11 industries. Using this approach, Column 6 of Table III reports results which show that both *irraug* and *rdad* are significant at the 5% level[10].

**[TABLE III about here]**

# 5 Conclusions

We have estimated a set of investment authorisation equations that are well determined and with acceptable diagnostics using OLS augmented by cross-sectional averages to control for unobserved common effects. Our main interest is in the sign, significance and magnitude of the uncertainty coefficients. In a second stage estimation we used this information to construct a set of limited dependent variables that indicate the importance and sign of the uncertainty effects by industry. These limited dependent variables are then regressed on a specially constructed set of industrial characteristics using the ordered probit model.

Our overall conclusion is that the industries showing positive or negative effects from uncertainty to investment are not random draws; in particular two strong conclusions are evident from the second stage regressions. First, in keeping with the predictions from real (deferment) options, irreversibility is a predictor of a negative effect from uncertainty, but only when combined with a measure of the value of waiting. Secondly, there is evidence that indicators of first mover advantages - such as that provided by R&D and advertising intensity - offset the irreversibility effect and contribute to explaining a positive effect of uncertainty on investment in some industries.

[10]These results could be replicated when all 37 industries were assigned an uncertainty impact (rather than just the 11 significant instances) using the sum of the point estimates of the coefficients in an unrestricted model i.e. when all uncertainty coefficients were retained.

These results are robust to using different categorisations of the importance of the uncertainty effects.

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*TABLE I*

***PREDICTIONS AS TO WHICH INDUSTRY CHARACTERISTICS WILL OBTAIN FOR EACH CHANNEL OF INFLUENCE FROM UNCERTAINTY TO INVESTMENT***

| Model | Likely sign of uncertainty on investment | Necessary Condition for the sign | Theoretical Variables | Possible proxy variables |
|---|---|---|---|---|
| REAL OPTION (deferment) | <0 | Irreversible investments with the option to postpone and where information is obtained by waiting | High sunk costs;<br>No FMA;<br>High value of waiting | Index of sunk costs;<br>Inverse index of R&D and/or advertising intensity;<br>Persistence in the uncertainty variable |
| REAL OPTION (expansion or compound) | >0 | Option obtained by investment (compound option); alternatively excess capacity minimises stock-out penalties | FMA and/or<br>High cost of non-supply; | Index of R&D and/or advertising intensity<br>Profitability. |

## TABLE II Results from First Stage Estimation of the Impact of Uncertainty by Industry

| CBI Table[1] | Industry | Standardised Coefficients on Uncertainty Variables[2] | | | | | | | | | | | Overall Equation | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) | (10) | (11) | (12) | (13) | (14) |
| | | coefficient on unc | p-value | sig[3] | coefficient on unc(-1) | p-value | sig[3] | coefficient on unc(-2) | p-value | sig[3] | F-test on unc coeffic-ients[4] | sig[3] | no of obs. | $R^2$ | F-statistic[5] |
| 24 | ferrous metals | **-0.2065** | 0.039 | ** | - | - | | - | - | | - | | 78 | 0.73 | 0.000 |
| 25 | non-ferrous metals | - | - | | - | - | | - | - | | - | | 78 | 0.59 | 0.000 |
| 26 | building materials | - | - | | - | - | | **-0.1364** | 0.095 | * | - | | 78 | 0.79 | 0.000 |
| 27 | glass and ceramics | - | - | | - | - | | - | - | | - | | 78 | 0.84 | 0.000 |
| 28 | industrial chemicals | - | - | | - | - | | - | - | | - | | 78 | 0.61 | 0.000 |
| 30 | pharmaceuticals and consumer chemicals | - | - | | - | - | | - | - | | - | | 78 | 0.52 | 0.000 |
| 32 | foundries; and forging, pressing, stamping | - | - | | - | - | | - | - | | - | | 78 | 0.76 | 0.000 |
| 33 | metal goods nes | - | - | | **-0.1829** | 0.034 | ** | **-0.1495** | 0.095 | * | 0.0127 | ** | 78 | 0.83 | 0.000 |
| 35 | constructional steelwork | - | - | | **-0.2858** | 0.002 | *** | - | - | | - | | 78 | 0.73 | 0.000 |
| 37 | agricultural machinery | - | - | | - | - | | **0.2483** | 0.012 | ** | - | | 78 | 0.62 | 0.000 |
| 38 | metal working machine tools | - | - | | - | - | | - | - | | - | | 78 | 0.67 | 0.000 |
| 39 | engineers small tools | - | - | | - | - | | - | - | | - | | 78 | 0.72 | 0.000 |
| 40 | industrial machinery | - | - | | - | - | | - | - | | - | | 78 | 0.62 | 0.000 |
| 41 | contractors' plant | - | - | | - | - | | - | - | | - | | 78 | 0.73 | 0.000 |
| 42 | industrial engines, pumps, compressors | - | - | | - | - | | - | - | | - | | 78 | 0.67 | 0.000 |
| 43 | heating, ventilating and refrigerating equipment | - | - | | - | - | | - | - | | - | | 78 | 0.62 | 0.000 |
| 44 | other mechanical engineering | - | - | | - | - | | - | - | | - | | 78 | 0.78 | 0.000 |
| 46 | electrical industrial goods | - | - | | **-0.2253** | 0.058 | * | - | - | | - | | 78 | 0.63 | 0.000 |
| 47 | elctronic industrial goods | - | - | | - | - | | - | - | | - | | 78 | 0.51 | 0.000 |
| 48 | electrical consumer goods | **-0.1904** | 0.036 | ** | - | - | | - | - | | - | | 67 | 0.75 | 0.000 |
| 49 | electronic consumer goods | - | - | | **0.2074** | 0.096 | * | **0.2548** | 0.035 | ** | 0.0155 | ** | 66 | 0.60 | 0.002 |
| 50 | motor vehicles | - | - | | - | - | | - | - | | - | | 78 | 0.73 | 0.000 |
| 52 | aerospace and other vehicles | - | - | | - | - | | **0.1937** | 0.050 | * | - | | 78 | 0.56 | 0.000 |
| 53 | instrument engineering | - | - | | - | - | | - | - | | - | | 78 | 0.57 | 0.000 |
| 56 | wool textiles | - | - | | - | - | | **0.1714** | 0.093 | * | - | | 78 | 0.69 | 0.000 |
| 57 | spinning and weaving | - | - | | - | - | | - | - | | - | | 78 | 0.67 | 0.000 |
| 58 | hosiery and knitwear | - | - | | - | - | | - | - | | - | | 78 | 0.50 | 0.001 |
| 59 | textile consumer goods | - | - | | - | - | | - | - | | - | | 78 | 0.46 | 0.002 |
| 61 | footwear | - | - | | - | - | | - | - | | - | | 78 | 0.67 | 0.000 |
| 62 | leather and leather goods | - | - | | - | - | | - | - | | - | | 69 | 0.76 | 0.000 |
| 63 | clothing and fur | - | - | | **-0.2486** | 0.024 | ** | - | - | | - | | 78 | 0.69 | 0.000 |
| 64 | timber and wooden products other than furniture | - | - | | - | - | | - | - | | - | | 78 | 0.75 | 0.000 |
| 65 | furniture, upholstery, bedding | - | - | | - | - | | - | - | | - | | 78 | 0.75 | 0.000 |
| 66 | pulp,paper, and board | - | - | | - | - | | - | - | | - | | 78 | 0.62 | 0.000 |
| 67 | paper and board products | - | - | | - | - | | - | - | | - | | 78 | 0.61 | 0.000 |
| 68 | printing and publishing | - | - | | - | - | | - | - | | - | | 78 | 0.54 | 0.000 |
| 70 | plastics products | - | - | | - | - | | - | - | | - | | 78 | 0.70 | 0.000 |

Notes:
1 Table number in CBI Industrial Trends Survey
2 The standardised coefficients multiply the raw coefficient of the relevant independent variable by its standard deviation and then divide this by the standard deviation of the dependent variable
3 * =significant at 10%; ** = significant at 5%; *** = significant at 1%
4. F-test of joint signficance of sum of uncertainty coefficients where appropriate

**TABLE III Results from Second Stage Analysis**

Estimation by Ordered Probit
Robust standard errors

| **Dependent Variable** | | OPROB1 (1) | | OPROB1 (2) | | OPROB1 (3) | | OPROB1 (4) | | OPROB2 (5) | | OSUM (6) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Explanatory Variable** | **Variable Descriptor** | | sig | | sig | | sig | | sig | | sig | | sig |
| **Irreversibility** | *irr* | **-0.012** | | **-0.026** | * | | | | | | | | |
| | | (0.700) | | (0.086) | | | | | | | | | |
| **Value of waiting** | *persis_opt* | | | **-11.233** | * | | | | | | | | |
| | | | | (0.088) | | | | | | | | | |
| | *irraug* | | | | | **-0.253** | ** | **-0.308** | ** | **-0.317** | ** | **-0.303** | ** |
| | | | | | | (0.033) | | (0.037) | | (0.024) | | (0.027) | |
| **Opportunities for expansion** | *rdad* | | | | | | | **0.543** | * | **0.620** | * | **0.681** | ** |
| | | | | | | | | (0.099) | | (0.067) | | (0.029) | |
| no. of observations | | 37 | | 37 | | 37 | | 37 | | 37 | | 37 | |
| Prob>Chi$^2$ | | 0.483 | | 0.042 | | 0.033 | ** | 0.069 | * | 0.023 | ** | 0.028 | ** |
| Pseudo $R^2$ | | 0.01 | | 0.08 | | 0.05 | | 0.11 | | 0.11 | | 0.11 | |

p-values in parentheses
* = sig at 10%; ** = sig at 5%; *** = sig at 1%

## DATA AND RESULTS APPENDIX

### A1. Data from the CBI Industrial Trends Survey

In this paper, we draw upon the Industrial Trends Survey of manufacturing industry carried out by the main employers' organisation, the Confederation of British Industry (CBI). It has been published on a regular basis since 1958 and has been widely used by economists. The survey sample is chosen to be representative and is not confined to CBI members. Questionnaires are targeted at chief executives, managing directors and finance directors. The survey is not confined to CBI members. A core of up to 1100 companies comprise the main panel with up to 300 other new or floating participants. A 50% response rate is typical. (Junankar 1995). The sample is based at the enterprise level except for some of the largest plants where replies are collected for that unit. Our data set is restricted to the period 1978 Q1 to 1999 Q1, since the question on authorisation of investment was added in 1978. The responses in the survey are weighted by net output with the weights being regularly updated and are reported at various aggregate levels. We use the data that are reported for over 40 manufacturing industries, of which we were able to use 37 in our analysis.

The various variables used in the analysis are constructed from the CBI Industrial Trends Survey Questions as follows.

*Auth*
Authorisation is interpreted by the vast majority of respondents as board approval. The authorisation data also includes leased assets (CBI 1988, p.29). It is calculated from the balance of replies (% responding more minus % responding less) from Question 3b of the Survey which asks:

Do you expect to authorise more or less capital expenditure in the next twelve months than you authorised in the past twelve months on: plant and machinery? (Possible choices: 'More', 'Same' or 'Less')

*opt, unc*
These variables are based upon Question 1 of the survey which asks :

"Are you more, or less, optimistic than you were four months ago about the general business situation in your industry?" (Possible choices: 'More', 'Same' or 'Less')

*opt* is the balance (% responding more minus % responding less) ; for details of *unc* see text.

$y$, $y^e$
These variables are derived from Question 8 which asks:

“Excluding seasonal variations, what has been the trend over the PAST FOUR MONTHS, and what are the expected trends for the NEXT FOUR MONTHS, with regard to: Volume of output?” (Possible choices: ‘Up’, ‘Same’ or ‘Down’)

The balance of Question 8 approximates to a rate of change in output. Using the generic symbol Y to refer both to *y*, $y^e$ , this rate of change is : $\Delta \log Y_t$ , whereas we require $\Delta \log \Delta Y_t$ as the dynamic output term on the assumption that the log of authorisation is cointegrated with the log of differenced output. It is easy to derive the latter as a Taylor approximation yields:

$$\Delta \log \Delta Y_t = [\Delta \log Y_t + \Delta\Delta \log Y_t]$$

Substituting *y*, $y^e$ for the LHS of the above equation gives the required definitions as the sum of the relevant survey balance plus the first difference of that balance.

*cu*

This variable is the logit transformation of the % responding ‘No’ to Question 4 which asks

Is your present level of output below capacity (i.e., are you working below a satisfactory full rate of operation)? (Possible choice: ‘Yes’, or ‘No’).

*dcu*

This is the first difference of the variable *cu*.

*fi*

This is the sum of the percentages of respondents reporting either a shortage of internal finance or an inability to raise external finance to *Question 16(c)* of the Survey, which invites respondents to consider which factors, including uncertainty about demand, are “expected to limit capital expenditure authorisations over the next twelve months”. Available replies are:

- inadequate net return on proposed investment;
- a shortage of internal finance;
- an inability to raise external finance;
- the cost of finance;
- uncertainty about demand;
- shortage of labour including managerial and technical staff;
- other.

# TABLE A2 Summary Statistics for Variables in First Stage Estimation

| | Variable | Auth | | | | | y | | | | | $y^e$ | | | | | opt | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CBI Table** | **Industry** | obs | mean | sd | min | max | obs | mean | sd | min | max | obs | mean | sd | min | max | obs | mean | sd | min | max |
| 24 | ferrous metals | 86 | -10.7 | 49.4 | -92 | 76 | 85 | -0.9 | 75.9 | -160 | 220 | 85 | -0.9 | 66.3 | -171 | 187 | 86 | -23.3 | 44.4 | -95 | 78 |
| 25 | non-ferrous metals | 86 | -1.6 | 34.0 | -72 | 55 | 85 | -3.5 | 63.7 | -160 | 140 | 85 | 4.3 | 42.4 | -136 | 90 | 86 | -13.4 | 30.5 | -87 | 42 |
| 26 | building materials | 86 | 1.3 | 28.0 | -69 | 55 | 85 | -3.5 | 49.3 | -112 | 97 | 85 | 3.4 | 47.7 | -103 | 107 | 86 | -7.5 | 35.8 | -88 | 57 |
| 27 | glass and ceramics | 86 | 4.5 | 31.8 | -60 | 84 | 85 | 0.3 | 40.2 | -83 | 103 | 85 | 2.8 | 37.1 | -100 | 80 | 86 | -7.4 | 30.3 | -74 | 49 |
| 28 | industrial chemicals | 86 | 3.0 | 30.3 | -63 | 84 | 85 | 2.9 | 47.3 | -128 | 108 | 85 | 5.1 | 41.7 | -106 | 92 | 86 | -6.2 | 33.3 | -89 | 53 |
| 30 | pharmaceuticals and consumer chemicals | 86 | 5.4 | 23.9 | -51 | 59 | 85 | 13.9 | 40.3 | -109 | 101 | 85 | 20.5 | 37.4 | -72 | 164 | 86 | -0.2 | 20.1 | -52 | 37 |
| 32 | foundries; and forging, pressing, stamping | 86 | 1.6 | 30.2 | -71 | 67 | 85 | -3.7 | 42.5 | -105 | 128 | 85 | 2.7 | 36.4 | -101 | 83 | 86 | -7.7 | 29.0 | -78 | 45 |
| 33 | metal goods nes | 86 | 1.0 | 27.5 | -71 | 53 | 85 | -3.6 | 39.6 | -101 | 74 | 85 | 3.9 | 33.2 | -75 | 78 | 86 | -8.7 | 27.8 | -78 | 42 |
| 35 | constructional steelwork | 86 | -8.4 | 23.5 | -56 | 46 | 85 | 3.5 | 41.7 | -103 | 105 | 85 | 7.3 | 36.7 | -78 | 118 | 86 | -2.0 | 29.6 | -83 | 51 |
| 37 | agricultural machinery | 86 | -6.8 | 42.5 | -94 | 84 | 85 | -8.2 | 64.5 | -141 | 158 | 85 | -4.5 | 58.7 | -186 | 114 | 86 | -14.8 | 35.7 | -100 | 59 |
| 38 | metal working machine tools | 86 | -5.2 | 27.9 | -65 | 74 | 85 | -2.1 | 46.3 | -108 | 110 | 85 | 6.1 | 37.8 | -84 | 104 | 86 | -6.6 | 31.6 | -75 | 60 |
| 39 | engineers small tools | 86 | 0.5 | 29.0 | -64 | 55 | 85 | 4.8 | 47.8 | -123 | 112 | 85 | 11.1 | 37.9 | -82 | 95 | 86 | -2.4 | 36.2 | -78 | 80 |
| 40 | industrial machinery | 86 | -1.7 | 29.3 | -69 | 58 | 85 | -6.4 | 53.0 | -121 | 172 | 85 | 5.1 | 47.2 | -141 | 114 | 86 | -7.5 | 29.4 | -90 | 62 |
| 41 | contractors' plant | 86 | -3.8 | 31.9 | -78 | 69 | 85 | 8.1 | 47.6 | -100 | 152 | 85 | 16.2 | 39.7 | -81 | 127 | 86 | 0.2 | 30.2 | -62 | 68 |
| 42 | industrial engines, pumps, compressors | 86 | 2.2 | 28.2 | -70 | 72 | 85 | 1.9 | 41.9 | -113 | 137 | 85 | 9.8 | 32.8 | -74 | 87 | 86 | -5.4 | 30.6 | -88 | 49 |
| 43 | heating, ventilating and refrigerating | 86 | 13.8 | 23.7 | -70 | 62 | 85 | 0.2 | 43.6 | -125 | 82 | 85 | 11.0 | 45.2 | -127 | 122 | 86 | 1.3 | 28.1 | -78 | 48 |
| 44 | other mechanical engineering | 86 | -2.4 | 25.7 | -65 | 47 | 85 | -1.4 | 39.1 | -98 | 105 | 85 | 5.5 | 33.5 | -84 | 105 | 86 | -3.4 | 26.5 | -68 | 51 |
| 46 | electrical industrial goods | 86 | 6.8 | 31.5 | -66 | 65 | 85 | 4.5 | 51.4 | -107 | 130 | 85 | 11.3 | 58.4 | -152 | 173 | 86 | 0.4 | 33.2 | -76 | 69 |
| 47 | elctronic industrial goods | 86 | 7.3 | 31.7 | -70 | 79 | 85 | -0.5 | 51.3 | -136 | 133 | 85 | 9.9 | 51.0 | -143 | 133 | 86 | -5.4 | 28.3 | -71 | 54 |
| 48 | electrical consumer goods | 78 | 6.4 | 44.3 | -88 | 88 | 75 | -4.8 | 96.2 | -230 | 219 | 75 | -0.5 | 76.6 | -177 | 175 | 78 | -17.8 | 39.7 | -91 | 89 |
| 49 | electronic consumer goods | 82 | 8.7 | 36.4 | -78 | 100 | 77 | 3.8 | 73.0 | -208 | 203 | 77 | 17.5 | 55.0 | -124 | 156 | 82 | -3.6 | 31.9 | -69 | 69 |
| 50 | motor vehicles | 86 | 0.9 | 32.9 | -64 | 73 | 85 | -1.7 | 56.4 | -121 | 158 | 85 | 9.7 | 48.2 | -143 | 114 | 86 | -9.3 | 33.4 | -99 | 58 |
| 52 | aerospace and other vehicles | 86 | 2.2 | 51.2 | -86 | 94 | 85 | 6.5 | 76.6 | -228 | 186 | 85 | 6.0 | 81.7 | -258 | 193 | 86 | -4.5 | 34.0 | -83 | 87 |
| 53 | instrument engineering | 86 | 9.4 | 27.2 | -58 | 67 | 85 | 6.6 | 56.1 | -134 | 130 | 85 | 15.8 | 48.2 | -98 | 140 | 86 | 0.0 | 29.2 | -66 | 56 |
| 56 | wool textiles | 86 | -23.1 | 27.1 | -77 | 49 | 85 | -12.5 | 44.6 | -121 | 79 | 85 | -9.5 | 48.4 | -123 | 106 | 86 | -13.4 | 33.8 | -93 | 75 |
| 57 | spinning and weaving | 86 | -5.7 | 30.7 | -81 | 62 | 85 | -5.7 | 55.7 | -163 | 135 | 85 | 1.4 | 39.2 | -135 | 85 | 86 | -6.1 | 36.5 | -90 | 75 |
| 58 | hosiery and knitwear | 86 | -2.0 | 22.0 | -55 | 42 | 85 | 1.8 | 42.8 | -115 | 116 | 85 | 7.9 | 38.0 | -113 | 97 | 86 | -7.5 | 28.0 | -69 | 44 |
| 59 | textile consumer goods | 86 | -8.1 | 34.3 | -72 | 67 | 85 | 4.8 | 58.7 | -145 | 139 | 85 | 6.5 | 58.9 | -174 | 173 | 86 | -10.3 | 39.8 | -91 | 67 |
| 61 | footwear | 86 | -3.3 | 29.2 | -67 | 63 | 85 | -7.2 | 44.9 | -108 | 96 | 85 | 0.8 | 42.0 | -131 | 107 | 86 | -11.6 | 29.0 | -90 | 55 |
| 62 | leather and leather goods | 80 | -8.8 | 39.9 | -83 | 80 | 77 | -9.2 | 57.8 | -158 | 108 | 77 | 5.4 | 49.6 | -129 | 100 | 80 | -2.1 | 33.7 | -88 | 74 |
| 63 | clothing and fur | 86 | -7.9 | 23.8 | -60 | 36 | 85 | 0.4 | 34.0 | -72 | 82 | 85 | 9.9 | 34.9 | -92 | 127 | 86 | -7.2 | 28.8 | -75 | 41 |
| 64 | timber and wooden products other than | 86 | -7.7 | 28.7 | -84 | 49 | 85 | -1.2 | 46.8 | -108 | 115 | 85 | 5.4 | 39.9 | -89 | 130 | 86 | -2.0 | 34.5 | -81 | 81 |
| 65 | furniture, upholstery, bedding | 86 | -0.2 | 28.9 | -63 | 67 | 85 | 3.4 | 44.6 | -96 | 153 | 85 | 9.1 | 40.6 | -107 | 122 | 86 | -4.0 | 31.5 | -89 | 62 |
| 66 | pulp,paper, and board | 86 | -6.9 | 33.8 | -84 | 72 | 85 | 2.7 | 58.7 | -129 | 131 | 85 | 3.6 | 36.5 | -90 | 82 | 86 | -6.7 | 37.4 | -89 | 79 |
| 67 | paper and board products | 86 | -0.4 | 31.3 | -77 | 50 | 85 | -1.3 | 51.9 | -129 | 136 | 85 | 9.8 | 44.8 | -90 | 108 | 86 | -8.0 | 33.0 | -89 | 73 |
| 68 | printing and publishing | 86 | -6.8 | 22.7 | -56 | 51 | 85 | 2.6 | 31.1 | -81 | 73 | 85 | 5.7 | 36.5 | -121 | 79 | 86 | 0.2 | 27.1 | -66 | 50 |
| 70 | plastics products | 86 | 10.4 | 27.1 | -59 | 64 | 85 | 6.6 | 43.7 | -107 | 125 | 85 | 13.2 | 42.4 | -80 | 137 | 86 | -2.1 | 31.4 | -90 | 65 |

## TABLE A2 continued

| | Variable | unc | | | | | fi | | | | | dcu | | | | | cu | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CBI Table** | **Industry** | obs | mean | sd | min | max | obs | mean | sd | min | max | obs | mean | sd | min | max | obs | mean | sd | min | max |
| 24 | ferrous metals | 86 | 0.30 | 0.08 | 0.08 | 0.465 | 79 | 39.5 | 27.0 | 2 | 80 | 85 | 0.00 | 0.43 | -0.99 | 1.176 | 85 | 1.40 | 0.80 | -0.70 | 2.75 |
| 25 | non-ferrous metals | 86 | 0.34 | 0.09 | 0.12 | 0.472 | 79 | 37.9 | 17.0 | 0 | 69 | 85 | 0.00 | 0.47 | -1.60 | 1.806 | 85 | 1.27 | 0.81 | -2.20 | 3.01 |
| 26 | building materials | 86 | 0.33 | 0.07 | 0.17 | 0.476 | 79 | 24.5 | 13.1 | 3 | 67 | 85 | 0.00 | 0.25 | -0.75 | 0.813 | 85 | 1.42 | 0.47 | -0.05 | 2.63 |
| 27 | glass and ceramics | 86 | 0.37 | 0.06 | 0.22 | 0.469 | 79 | 24.1 | 14.4 | 2 | 56 | 85 | 0.00 | 0.28 | -0.95 | 1.380 | 85 | 1.48 | 0.53 | -0.95 | 2.76 |
| 28 | industrial chemicals | 86 | 0.34 | 0.07 | 0.15 | 0.477 | 79 | 28.9 | 17.4 | 3 | 67 | 85 | 0.00 | 0.24 | -0.78 | 0.835 | 85 | 1.61 | 0.42 | 0.00 | 2.45 |
| 30 | pharmaceuticals and consumer chemicals | 86 | 0.31 | 0.07 | 0.11 | 0.449 | 79 | 22.4 | 16.0 | 0 | 58 | 85 | 0.00 | 0.15 | -0.58 | 0.567 | 85 | 1.71 | 0.29 | 0.69 | 2.34 |
| 32 | foundries; and forging, pressing, stamping | 86 | 0.38 | 0.05 | 0.24 | 0.477 | 79 | 22.3 | 14.7 | 3 | 78 | 85 | 0.00 | 0.19 | -0.57 | 0.535 | 85 | 1.46 | 0.39 | 0.26 | 2.08 |
| 33 | metal goods nes | 86 | 0.39 | 0.05 | 0.24 | 0.476 | 79 | 21.2 | 6.9 | 7 | 41 | 85 | 0.00 | 0.16 | -0.35 | 0.406 | 85 | 1.47 | 0.34 | 0.44 | 2.10 |
| 35 | constructional steelwork | 86 | 0.38 | 0.07 | 0.20 | 0.474 | 79 | 17.6 | 9.5 | 0 | 49 | 85 | 0.00 | 0.16 | -0.43 | 0.447 | 85 | 1.65 | 0.29 | 0.87 | 2.20 |
| 37 | agricultural machinery | 86 | 0.30 | 0.09 | 0.01 | 0.460 | 79 | 32.2 | 30.2 | 0 | 123 | 85 | -0.01 | 0.63 | -2.44 | 2.447 | 85 | 1.36 | 1.04 | -3.04 | 4.29 |
| 38 | metal working machine tools | 86 | 0.37 | 0.06 | 0.19 | 0.477 | 79 | 21.8 | 12.7 | 0 | 72 | 85 | 0.00 | 0.30 | -1.04 | 1.197 | 85 | 1.49 | 0.54 | -1.04 | 3.00 |
| 39 | engineers small tools | 86 | 0.37 | 0.05 | 0.22 | 0.471 | 79 | 29.3 | 15.3 | 6 | 72 | 85 | -0.01 | 0.35 | -1.78 | 1.833 | 85 | 1.53 | 0.61 | -2.38 | 3.06 |
| 40 | industrial machinery | 86 | 0.35 | 0.07 | 0.15 | 0.473 | 79 | 22.1 | 17.1 | 2 | 92 | 85 | 0.00 | 0.21 | -0.63 | 0.584 | 85 | 1.54 | 0.38 | 0.30 | 2.33 |
| 41 | contractors' plant | 86 | 0.38 | 0.07 | 0.19 | 0.475 | 79 | 13.5 | 9.6 | 0 | 41 | 85 | -0.01 | 0.24 | -0.56 | 0.497 | 85 | 1.48 | 0.42 | 0.36 | 2.23 |
| 42 | industrial engines, pumps, compressors | 86 | 0.38 | 0.06 | 0.15 | 0.474 | 79 | 18.8 | 11.2 | 3 | 67 | 85 | -0.01 | 0.23 | -0.80 | 0.426 | 85 | 1.46 | 0.46 | -0.32 | 2.11 |
| 43 | heating, ventilating and refrigerating | 86 | 0.37 | 0.06 | 0.21 | 0.477 | 79 | 15.5 | 10.6 | 0 | 42 | 85 | 0.00 | 0.23 | -0.66 | 0.730 | 85 | 1.55 | 0.41 | 0.04 | 2.36 |
| 44 | other mechanical engineering | 86 | 0.38 | 0.05 | 0.28 | 0.456 | 79 | 17.7 | 7.1 | 5 | 36 | 85 | 0.00 | 0.14 | -0.54 | 0.512 | 85 | 1.50 | 0.34 | 0.06 | 2.00 |
| 46 | electrical industrial goods | 86 | 0.33 | 0.06 | 0.21 | 0.471 | 79 | 21.0 | 16.6 | 3 | 63 | 85 | 0.00 | 0.28 | -0.68 | 0.681 | 85 | 1.49 | 0.50 | 0.09 | 2.41 |
| 47 | elctronic industrial goods | 86 | 0.32 | 0.08 | 0.14 | 0.472 | 79 | 29.0 | 22.4 | 2 | 80 | 85 | 0.00 | 0.28 | -0.89 | 0.735 | 85 | 1.52 | 0.54 | -0.29 | 2.62 |
| 48 | electrical consumer goods | 78 | 0.26 | 0.11 | 0.01 | 0.470 | 79 | 21.6 | 20.7 | 0 | 83 | 75 | 0.01 | 0.73 | -1.75 | 2.134 | 75 | 1.28 | 1.21 | -2.35 | 3.67 |
| 49 | electronic consumer goods | 82 | 0.32 | 0.11 | 0.01 | 0.461 | 79 | 23.8 | 22.2 | 0 | 89 | 77 | -0.02 | 0.34 | -0.93 | 0.785 | 77 | 1.56 | 0.55 | -0.29 | 2.61 |
| 50 | motor vehicles | 86 | 0.32 | 0.07 | 0.03 | 0.473 | 79 | 30.7 | 13.7 | 1 | 69 | 85 | 0.00 | 0.26 | -0.81 | 0.802 | 85 | 1.38 | 0.50 | -0.51 | 2.35 |
| 52 | aerospace and other vehicles | 86 | 0.27 | 0.11 | 0.05 | 0.470 | 79 | 35.7 | 31.0 | 0 | 157 | 85 | -0.01 | 0.43 | -1.49 | 1.176 | 85 | 1.45 | 0.79 | -1.49 | 3.09 |
| 53 | instrument engineering | 86 | 0.36 | 0.06 | 0.16 | 0.473 | 79 | 22.4 | 16.4 | 3 | 75 | 85 | 0.00 | 0.23 | -0.61 | 0.501 | 85 | 1.57 | 0.38 | 0.43 | 2.31 |
| 56 | wool textiles | 86 | 0.37 | 0.07 | 0.12 | 0.472 | 79 | 18.3 | 12.4 | 0 | 56 | 85 | -0.01 | 0.19 | -0.65 | 0.558 | 85 | 1.56 | 0.38 | 0.46 | 2.23 |
| 57 | spinning and weaving | 86 | 0.35 | 0.07 | 0.12 | 0.476 | 79 | 19.8 | 12.3 | 2 | 67 | 85 | 0.00 | 0.21 | -0.52 | 0.837 | 85 | 1.54 | 0.41 | 0.33 | 2.58 |
| 58 | hosiery and knitwear | 86 | 0.37 | 0.06 | 0.22 | 0.455 | 79 | 15.9 | 11.7 | 0 | 59 | 85 | -0.01 | 0.15 | -0.79 | 0.314 | 85 | 1.72 | 0.27 | 0.17 | 2.13 |
| 59 | textile consumer goods | 86 | 0.34 | 0.08 | 0.09 | 0.468 | 79 | 23.5 | 17.9 | 0 | 75 | 85 | 0.00 | 0.32 | -0.82 | 0.926 | 85 | 1.56 | 0.53 | -0.12 | 2.75 |
| 61 | footwear | 86 | 0.33 | 0.08 | 0.14 | 0.476 | 79 | 19.1 | 13.9 | 0 | 61 | 85 | 0.00 | 0.20 | -0.68 | 0.762 | 85 | 1.66 | 0.34 | 0.28 | 2.48 |
| 62 | leather and leather goods | 80 | 0.37 | 0.07 | 0.17 | 0.476 | 79 | 16.7 | 13.4 | 0 | 51 | 77 | -0.03 | 0.57 | -2.37 | 2.310 | 77 | 1.49 | 0.97 | -2.97 | 4.02 |
| 63 | clothing and fur | 86 | 0.40 | 0.05 | 0.26 | 0.477 | 79 | 22.6 | 11.0 | 0 | 55 | 85 | 0.00 | 0.14 | -0.61 | 0.444 | 85 | 1.70 | 0.25 | 0.34 | 2.17 |
| 64 | timber and wooden products other than | 86 | 0.37 | 0.07 | 0.22 | 0.476 | 79 | 18.5 | 11.0 | 0 | 51 | 85 | 0.00 | 0.41 | -1.60 | 1.924 | 85 | 1.47 | 0.71 | -2.20 | 3.25 |
| 65 | furniture, upholstery, bedding | 86 | 0.37 | 0.07 | 0.15 | 0.471 | 79 | 18.8 | 11.0 | 0 | 55 | 85 | 0.00 | 0.37 | -2.08 | 2.158 | 85 | 1.58 | 0.61 | -2.68 | 3.71 |
| 66 | pulp,paper, and board | 86 | 0.34 | 0.07 | 0.12 | 0.464 | 79 | 33.0 | 18.6 | 2 | 81 | 85 | 0.00 | 0.27 | -0.78 | 0.964 | 85 | 1.53 | 0.51 | -0.48 | 2.63 |
| 67 | paper and board products | 86 | 0.36 | 0.06 | 0.16 | 0.475 | 79 | 26.6 | 12.6 | 4 | 60 | 85 | 0.00 | 0.24 | -0.78 | 0.628 | 85 | 1.50 | 0.44 | -0.48 | 2.44 |
| 68 | printing and publishing | 86 | 0.38 | 0.05 | 0.23 | 0.476 | 79 | 22.2 | 8.6 | 5 | 55 | 85 | 0.00 | 0.12 | -0.28 | 0.398 | 85 | 1.56 | 0.26 | 0.68 | 2.01 |
| 70 | plastics products | 86 | 0.38 | 0.06 | 0.15 | 0.475 | 79 | 24.8 | 15.0 | 6 | 97 | 85 | 0.00 | 0.17 | -0.55 | 0.541 | 85 | 1.59 | 0.32 | 0.54 | 2.36 |

## A3. Other Data

Other data used in the paper are as indicated in the Table

**Table A3**

**Additional Data used for Second Stage Analysis**

| Variable | Definition and Source |
|---|---|
| *irr* | This irreversibility measure was constructed from *UK Census of Production* data for disposals and acquisitions of plant and machinery (for the period 1979-1989) at the 3-digit level of the 1980 Standard Industrial Classification. The ratio of disposals to acquisitions may be expected to provide a measure of the marketability of second-hand assets. The data for each industry were time averaged over the economic cycle 1979-1989. These 3-digit data were then matched with the CBI industries used for the estimation in this paper. With no strong reason for supposing cardinality, *irr* was constructed as a reverse ranking of the ratio. |
| *irraug* | This used the quartiles of both the *irr* and the *persist_opt* distributions (0,1,2,3), summing them, thereby attaching the highest score to industries which were in the highest quartile on both measures (=6). Those in the lowest quartile on both variables had a zero score. |
| *rdad* | Indicator variable based upon advertising and R&D intensities; 0=low R&D and low adversting;1=high on one source but not the other; 2 if high on both. (derived from: Table A2.1 Davies and Lyons 1996) |
| *nprtea* | The data used is based on a concordance between the CBI sectors and the 1980 Standard Industrial Classification (1980 SIC) and uses capital stock data kindly supplied by Mary O'Mahony of the National Institute of Economic and Social Research (see Oulton and O'Mahony, 1994). These however were on the basis of the 1968 Standard Industrial Classification (SIC). A correspondence with CBI tables was made using a published reconciliation between the SIC and that for 1980. Profits were calculated from gross value added in each industry less employee compensation and less estimated depreciation in each industry. |
| *OPROB1* | Indicator variable for uncertainty significance and sign (-1=negative,+1=positive, 0=null at 10% level). |
| *OPROB2* | Indicator variable for uncertainty significance and sign (-2=negative 5% ; -1=negative 10% ,+2=positive 5%; +1=positive 10%, 0=null accepted at 10% level). |
| *OSUM* | Indicator variable taking on values -2, -1, -1, 0, 1, 2 according to the relative magnitude of the standardized coefficients on the uncertainty variable *unc* (summed where more than one coefficient is significant) as reported in Table II. All industries with an insignificant coefficient were assigned a zero value. The other 11 industries with significant *unc* coefficients were given a value of 2 where the sum of the coefficients was greater than an average (across the same set of industries) of the absolute value of the summed *unc* coefficients. A sign was then attached according to whether the uncertainty effect is positive or negative |

**TABLE A4 Summary Statistics for Variables Used in Second Stage Analysis**

| CBI TABLE | INDUSTRY | Explanatory variables irr | persist_opt | irraug | rdad | npratea | Dependent variables OPROB1 | OPROB2 | OSUM |
|---|---|---|---|---|---|---|---|---|---|
| 24 | ferrous metals | 36 | 0.10 | 3 | 0 | -0.03 | -1 | -2 | -1 |
| 25 | non-ferrous metals | 28 | 0.07 | 3 | 0 | 0.19 | 0 | 0 | 0 |
| 26 | building materials | 30 | 0.13 | 5 | 0 | 0.30 | -1 | -1 | -1 |
| 27 | glass and ceramics | 31 | 0.19 | 6 | 0 | 0.16 | 0 | 0 | 0 |
| 28 | industrial chemicals | 37 | 0.13 | 5 | 1 | 0.10 | 0 | 0 | 0 |
| 30 | pharmaceuticals and consumer chemicals | 33 | 0.09 | 3 | 2 | 0.40 | 0 | 0 | 0 |
| 32 | foundries; and forging, pressing, stamping | 19 | 0.16 | 5 | 0 | 0.18 | 0 | 0 | 0 |
| 33 | metal goods nes | 18 | 0.14 | 3 | 0 | 0.26 | -1 | -2 | -2 |
| 35 | constructional steelwork | 9 | 0.19 | 3 | 0 | 0.61 | -1 | -2 | -2 |
| 37 | agricultural machinery | 29 | 0.08 | 3 | 2 | 0.27 | 1 | 2 | 2 |
| 38 | metal working machine tools | 2 | 0.10 | 1 | 1 | 0.19 | 0 | 0 | 0 |
| 39 | engineers small tools | 3 | 0.18 | 3 | 1 | 0.16 | 0 | 0 | 0 |
| 40 | industrial machinery | 15 | 0.09 | 1 | 0 | 0.32 | 0 | 0 | 0 |
| 41 | contractors' plant | 4 | 0.11 | 1 | 0 | 0.31 | 0 | 0 | 0 |
| 42 | industrial engines, pumps, compressors | 21 | 0.12 | 4 | 1 | 0.35 | 0 | 0 | 0 |
| 43 | heating, ventilating and refrigerating equipment | 22 | 0.10 | 3 | 1 | 0.43 | 0 | 0 | 0 |
| 44 | other mechanical engineering | 20 | 0.17 | 5 | 1 | 0.20 | 0 | 0 | 0 |
| 46 | electrical industrial goods | 25 | 0.08 | 2 | 1 | 0.20 | -1 | -1 | -1 |
| 47 | elctronic industrial goods | 24 | 0.11 | 3 | 1 | 0.31 | 0 | 0 | 0 |
| 48 | electrical consumer goods | 32 | 0.18 | 6 | 2 | 0.16 | -1 | -2 | -1 |
| 49 | electronic consumer goods | 17 | 0.08 | 1 | 2 | 0.69 | 1 | 2 | 2 |
| 50 | motor vehicles | 35 | 0.13 | 5 | 2 | 0.18 | 0 | 0 | 0 |
| 52 | aerospace and other vehicles | 27 | 0.08 | 2 | 1 | 0.20 | 1 | 1 | 1 |
| 53 | instrument engineering | 16 | 0.12 | 3 | 1 | 0.28 | 0 | 0 | 0 |
| 56 | wool textiles | 7 | 0.19 | 3 | 0 | 0.07 | 1 | 1 | 1 |
| 57 | spinning and weaving | 5 | 0.19 | 3 | 0 | 0.03 | 0 | 0 | 0 |
| 58 | hosiery and knitwear | 1 | 0.15 | 3 | 0 | 0.08 | 0 | 0 | 0 |
| 59 | textile consumer goods | 23 | 0.10 | 3 | 0 | 0.35 | 0 | 0 | 0 |
| 61 | footwear | 14 | 0.15 | 3 | 0 | 0.56 | 0 | 0 | 0 |
| 62 | leather and leather goods | 12 | 0.07 | 1 | 0 | 0.25 | 0 | 0 | 0 |
| 63 | clothing and fur | 10 | 0.21 | 4 | 0 | 0.58 | -1 | -2 | -2 |
| 64 | timber and wooden products other than furniture | 11 | 0.12 | 3 | 0 | 0.35 | 0 | 0 | 0 |
| 65 | furniture, upholstery, bedding | 13 | 0.11 | 2 | 0 | 0.42 | 0 | 0 | 0 |
| 66 | pulp,paper, and board | 34 | 0.10 | 4 | 0 | 0.06 | 0 | 0 | 0 |
| 67 | paper and board products | 6 | 0.11 | 1 | 0 | 0.14 | 0 | 0 | 0 |
| 68 | printing and publishing | 8 | 0.10 | 1 | 0 | 0.39 | 0 | 0 | 0 |
| 70 | plastics products | 26 | 0.13 | 4 | 0 | 0.30 | 0 | 0 | 0 |
| | mean | 19.00 | 0.13 | 3.08 | 0.54 | 0.27 | -0.08 | -0.16 | -0.11 |
| | standard deviation | 10.68 | 0.04 | 1.40 | 0.72 | 0.16 | 0.54 | 0.92 | 0.83 |
| | minmum | 1.00 | 0.07 | 1.00 | 0.00 | -0.03 | -1.00 | -2.00 | -2.00 |
| | maximum | 37.00 | 0.21 | 6.00 | 2.00 | 0.69 | 1.00 | 2.00 | 2.00 |