Asymmetric Price Adjustment, Sticky Costs and Operating Leverage over the Business Cycle

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Abstract

‘Operating leverage’ describes the extent to which a firm’s operating costs are fixed in the short term. Operating leverage amplifies the earnings impact of a change in revenues; an effect which is further amplified by financial leverage and by non-proportionality in the tax system. Since the costs of adjusting capacity are likely to vary depending on the nature of the inputs, we expect to see sectoral differences in operating leverage around the business cycle and, indeed, differential adjustment costs underlie the distinction between cyclical and non-cyclical firms that is popular with financial market practitioners. We find using a large data set on quoted UK companies between 1966 and 2010 that there are significant differences among sectors in the way it which operating leverage adjusts.

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1 Introduction

‘Operating leverage’ describes the extent to which a firm’s operating costs are fixed in the short term. Operating leverage amplifies the earnings impact of a change in revenues; an effect which is further amplified by financial leverage and by non-proportionality in the tax system. Since the costs of adjusting capacity are likely to vary depending on the nature of the inputs, we expect to see sectoral differences in operating leverage around the business cycle and, indeed, differential adjustment costs underlie the distinction between cyclical and non-cyclical firms that is popular with financial market practitioners. In Novy-Marx
(2007), and as far back as Lev (1974) operating leverage has been central component of theories of the ‘value’ equity risk premium because, in the absence of operating leverage, growth options are riskier than assets in place.

If costs are sticky we expect to see a positive relationship between changes in revenues and operating profit margin \((\text{revenue} - \text{operating cost})/\text{revenue}\). Consistent with this, previous research has reported that profit margins are procyclical (Machin and van Reenen, 1993; Green and Porter (1984)). Differences between sectors in the response of operating margins to changes in revenue are directly observable, consistent with the operating leverage story. But beyond this, operating leverage has remained empirically elusive and it has been hard to derive measures of operating leverage and of cost structure from the observed behaviour of profit margins. Ultimately, all costs are variable, so that cost stickiness reflects the interplay between adjustment costs and expectations, which cannot be directly observed.

Consider a world in which firms face costs to adjusting of capacity, and where the reversal of capacity adjustments may also be costly. The supply of some raw materials may be rapidly adjustable, and the adjustment decision may be subsequently reversible without friction. However, highly specific industrial plant and equipment may be difficult to sell and slow to reacquire, trading in illiquid markets displaying a wide margin between disposal values and replacement cost. Employment law and labour contracts cause lags in the adjustment of labour on the downside, so that the labour-cost response may be observed significantly later than a fall in revenue. Skilled labour has some of the character of specific industrial plant – it may be costly to acquire or reacquire, needing both time and expenditure to equip it with organization-specific knowledge.

If a firm or an industry is experiencing secular growth or decline that is fully understood and anticipated by participants, then it may be possible to fully adjust capacity – as a result, firms undergoing a process of planned contraction may be able to maintain their operating margins. In practice, some firms may be slower to adapt to secular growth or decline and, even when a firm experiences a fall in revenue that is idiosyncratic and does not appear to be shared by competitors, management may hope to reverse the decline in the future. On the other hand, in the face of a cyclical – economy-wide or industry-level – change in demand, and if the adjustment of capacity is costly, it may be rational not to adjust. In this case the firm might rationally maintain and used capacity through the cycle. In practice, at an inflection point it may be unclear to individual firms whether an observed change in revenues is secular or cyclical, and how long the cycle will last.

One focus of the industrial economics literature has been to see whether firms respond to change in demand by adjusting price rather than quantity of output. It suggests the importance of distinguishing between demand and supply shocks. Price adjustments moderate aggregate demand shocks, quantity adjustments intensify, but price adjustments lead to higher profitability fluctuations. Therefore, both operating leverage and price adjustments provide alternative explanations for the positive relationship between unanticipated revenues growth and the profit margin. The confounding hypothesis of price adjustment is a challenge in drawing inferences about operating leverage from the behaviour of operating margin. To the extent that a fall in revenue reflects a price response with no change in output quantity, operating margin will fall unless the firm is able to achieve an equivalent adjustment to input price. In this case, falling operating margin will be an unreliable signal of operating leverage. With the exception of labour, where firms disclose both employment and wage, these components are unobservable.
These arguments suggest the following testable predictions:

1. Adjustment costs may be asymmetric, so that firms exhibit higher operating leverage – non-adjustment of capacity leading to relatively depressed margins – in cyclical downturns than in secular declines.

2. Since adjustment costs are likely to vary by nature of input we expect to see sectoral differences in operating leverage around the business cycle.

3. The effect of firm size on the observed degree of operating leverage. We cannot predict the direction of this relationship. Assuming size proxies financial strength, we may find that small firms experience greater cost of adjustment. Equally, large firms may be better able to bear the costs of non-adjustment of capacity.

In section 2 we consider an econometric model of how operating leverage is determined over the business cycle. In section 3 we provide some econometric results and finally in section 4 we provide some conclusions.

2 The econometric model

Using data for the larger UK firms on profits (π) and revenues (S) over the 1970s and 1980s, Machin and van Reenen (1993) estimated the panel data model

\[
\frac{\pi_{it}}{S_{it}} = \alpha_i + \mu \frac{\pi_{it-1}}{S_{it-1}} + \beta U_t + \varepsilon_{it} \quad i = 1, N, \quad t = 1, T. \tag{1}
\]

They regress profit margin (π/S) on the business cycle (the unemployment rate, U), allowing for firm-specific fixed effects and dynamics, and including several firm-level controls. They find important differences in the estimates for aggregate data and firm level data, as well as differences across industries. They find strong evidence that profit margins sharply decline in recessions, though the timing of the impact of aggregate shocks appears to differ across sectors. Their data covered only one major recession - the early 1980’s - and it will be interesting to see whether the inferences carry through over a longer time span. Second, their data did not allow profit margins to be decomposed into price and cost components, which is clearly an important part of the story; see also Bils (1987) and Bhaskar, Machin and Reid (1993).

Survey-based evidence from the UK suggests that quantity adjustments are preferred, but more so in recessions than in booms (Machin et al., 1993). Liquidity constrained firms are less likely to cut prices, consistent with theory in Gottfries (1991); therefore, the provision of additional liquidity is potentially more important in recessions that are driven by demand shocks. This evidence seems inconsistent with UK evidence of procyclical profit margins (Machin and van Reenen, 1993); however the theory is ambiguous. Profit margins are procyclical in Green and Porter (1984), but countercyclical in Rotemberg and Saloner (1986). Further, there is a difference between the reactions of small and large firms, which may reflect liquidity constraints, whereby small firms have limited access to capital markets, and therefore bear the brunt of monetary policy shocks (Gertler and Gilchrist, 1994).

Our starting point in this paper is a panel error correction model

\[
\Delta \ln c_{it} = \alpha_i + \beta_i \Delta \ln s_{it} - \gamma_i (\ln c_{i,t-1} - \delta_i \ln s_{i,t-1}) + \varepsilon_{it}, \quad i = 1, N, t = 1, T. \tag{2}
\]

\footnote{From Datastream.}
where $c_{it}$ and $s_{it}$ denote costs and sales, respectively, of firm $i$ in year $t$. The model includes firm-specific fixed effects $\alpha_i$, partial adjustment ($\gamma_i$) to a hypothesized long run equilibrium relationship between log-costs and log-sales, the effect of sales on costs in long-run equilibrium ($\delta_i$), and the short-run dynamic effect of sales on costs ($\beta_i$). In line with the recent literature on dynamic heterogenous slope panel data models, full heterogeneity across firms is allowed for all the above parameters; see, for example, Pesaran and Smith (1995) and Pesaran, Shin and Smith (2000). Hence, a random coefficients assumption is made, and inferences are sought on average slopes across the cross-section. Such inferences are obtained by mean group estimation (Pesaran and Smith, 1995), and if the long run effect is assumed homogeneous across the firms ($\delta_i = \delta$) stronger inferences are delivered by pooled mean group estimation (Pesaran, Shin and Smith, 2000). We conduct panel unit root tests (Im, Pesaran and Shin, 2003), and verify that both $\ln c_{it}$ and $\ln s_{it}$ are $I(1)$ variables.

Theory and prior evidence suggest the existence of a long run relationship, and perhaps also a homogenous long run effect. Furthermore, if $\delta_i = 1$, this means that $(\ln c_{it} - \delta_i \ln s_{it}) = \ln (1 - \pi_{it})$, where $\pi_{it}$ denotes the profit margin of firm $i$ in year $t$. Machin and van Reenen (1993) in their work find evidence that $\pi_{it}$ is stationary and cyclical, and explore its relationship with the business cycle which they measure by the unemployment rate. We verify that in our panel data, $\ln (1 - \pi_{it})$ is stationary. Of course, it is not necessary to assume homogeneity in $\delta_i$ and even if such homogeneity is found we do not need to assume that $\delta_i = 1$. We do not make such assumptions, but in using model (2) we consider empirically the possibility that a long run equilibrium does exist, implying that $\delta_i = \delta$ and that $\delta = 1$.

If an equilibrium relationship does exist, then the equilibrium value of $\ln (1 - \pi_{it})$ in the model (2) will be given by $-\alpha_i/\gamma_i$. In this case, the firm would expect partial adjustment of $\gamma_i (\ln c_{it} - \delta_i \ln s_{it})$ to this equilibrium, hence the short-run dynamic effect captured by $\beta_i$ gives us the effect of an unanticipated shock to sales. In an orderly economy, one would expect a firm to pass any shock to sales back to its costs, so that the margin stays unchanged. That is, $\beta_i = 1$ for all firms, at the very least on average, $E(\beta_i) = 1$. So the firm is able to match the increase/decrease in sales by a proportionate increase/decrease in costs.

However, the operating leverage hypothesis posits that such a pass-through is only incomplete, even on average, and hence $E(\beta_i) < 1$. The objectives of this paper lie in statistically testing the operating leverage hypothesis $H_0 : E(\beta_i) = 1$ against the left-tailed alternative $H_1 : E(\beta_i) < 1$, and to investigate potential reasons for such incomplete pass-through.

2.1 Short run dynamics

If indeed the above null hypothesis is rejected against the specific one-sided alternative, the question is why? It is possible that costs are sticky and cannot be adjusted seamlessly in the short run. In turn, such costs may relate to employment but could equally come from fixed capital. Further, it may equally be possible that the firm intends to make price adjustments (rather than quantity adjustments) and find that prices are sticky on the downside. This would then imply an asymmetric adjustment of costs to sales.

We investigate the above possibilities by modelling the short run effect $\beta_i$ as a function of employment ($n_{it}$), log of real fixed capital ($k_{it}$) and an indicator that sales have grown
over the previous year \( (I(\ln s_{it} > 0)) \):

\[
\beta_i = \beta_{0i} + \beta_{1i} I(\ln s_{it} > 0) + \beta_{2i} k_{it} + \beta_{3i} n_{it} + \beta_{4i} n_{i,t+1},
\]  

(3)

where \( \beta_{1i} \) now measures the short run effect of asymmetry and \( \beta_{2i} \) measures the effect of sticky capital costs, while \( \beta_{3i} \) and \( \beta_{4i} \) captures the possibility of sticky costs of adjusting labour. In line with some descriptive analysis that many firms can only adjust labour over the medium run, we allow an effect for one-year ahead labour costs as well. In the model combining (3) with (2), \( \beta_{0i} \) captures any remaining operating leverage effects after accounting for the above sources of operating leverage.

We test residual operating leverage as \( H_0 : E(\beta_{0i}) = 1 \) versus \( H_1 : E(\beta_{0i}) < 1 \). The asymmetry and sticky capital channels are tested as \( H_0 : E(\beta_{1i}) = 0 \) versus \( H_1 : E(\beta_{1i}) < 0 \), and \( H_0 : E(\beta_{2i}) = 0 \) versus \( H_1 : E(\beta_{2i}) < 0 \) respectively, while the sticky labour explanation is tested as \( H_0 : E(\beta_{3i}) = E(\beta_{4i}) = 0 \) against the alternative \( H_1 : \min \{E(\beta_{3i}),E(\beta_{4i})\} < 0 \).

The recent literature on large panels has highlighted the need to address issues of spatial (or cross section) strong dependence (Pesaran, 2004; Pesaran and Tosetti, 2011). The possibility of strong dependence comes from latent/unobservable factors with loadings that are heterogenous across all firms. In other words some factors affect all firms but with possibly different effects on each firm. So these factors generate strong cross section dependence among firms, and if omitted from the model, invalidate inferences from panel data models. Recently the common correlated effects method (Pesaran, 2006) has been used to proxy for the effect of latent factors. The method involves including cross sectional averages of the dependent and independent variables as additional regressors on the right hand side of the equation.

Short run dynamics in our model therefore take the form:

\[
SR = \beta_i \Delta \ln c_{it} + \psi_{1i} (\overline{\Delta \ln c_t}) + \psi_{2i} (\overline{\Delta \ln s_t}),
\]

\[
\beta_i = \beta_{0i} + \beta_{1i} I(\ln s_{it} > 0) + \beta_{2i} k_{it} + \beta_{3i} n_{it} + \beta_{4i} n_{i,t+1},
\]

(4)

\[
\overline{\Delta \ln c_t} = n^{-1} \sum_{i=1}^{n} \Delta \ln c_{it}, \quad \text{and} \quad \overline{\Delta \ln s_t} = n^{-1} \sum_{i=1}^{n} \Delta \ln s_{it}.
\]

The slopes on the cross section average growth rates of costs and sales, \( \overline{\Delta \ln c_t} \) and \( \overline{\Delta \ln s_t} \) respectively, are allowed to vary across firms. However, the slopes themselves usually do not have any economic interpretation and often they are not reported.

### 2.2 Long run equilibria and partial adjustments

However, as well as the addition of cross sectional averages to the short run dynamics, it is necessary to account for possible spatial strong dependence in the long run part of the model as well. Following the recent literature (see, for example, Holly, Pesaran and Yamagata, 2011; Bailey, Holly and Pesaran, 2013), we add to the model cross section averages of \( \ln c_{it-1} \) and \( \ln s_{it-1} \). To aid with interpretation of our model, we approximate these cross section averages by logarithms of average costs and sales, denoted \( \overline{\ln c_{t-1}} \) and \( \overline{\ln s_{t-1}} \) respectively.\(^2\) In addition, we include the lagged business cycle, \( y_{t-1} \), as

\(^2\)In other words, we take \( \ln \overline{c_{t-1}} = \ln (n^{-1} \sum_{i=1}^{n} c_{it-1}) \) as an approximation for \( n^{-1} \sum_{i=1}^{n} \ln c_{it-1} \). The justification goes as follows. First, some notation. Let \( s_{it} = c_{it}/(n \overline{c_t}) \) denote the (total costs) market
a hypothesized additional factor into the model. Therefore, our long run specification
takes the following general form:

\[
LR = \theta_0 y_{t-1} + \theta_1 \ln c_{i,t-1} + \theta_2 \ln s_{i,t-1} + \theta_3 \ln \tau_{t-1} + \theta_4 \ln \tilde{s}_{t-1}.
\] (5)

Since cross-section averages \( \ln \tau_{t-1} \) and \( \ln \tilde{s}_{t-1} \) are included, there are 4 \( I(1) \) variables
in the model that have cross sectional and time series variation, and there can be up
to 3 cointegrating relations between these variables. In this case, there are 3 potential
cointegrating relations as well. The first is the profit margin cointegration between log
costs and log sales which we have discussed earlier. The other two are market share relations for costs and sales, where costs and sales potentially maintain an equilibrium market share to total costs and total sales respectively. In addition, there is the potential partial adjustment of profit margin to the economic cycle. This substantially enriches
our specification of the long run equilibria and partial adjustment to these equilibria. So we use the latent factor structure (which is now the observed market share) to include three potential long run equilibrium relationships in our model.

First, our leading equilibrium relation is the profit margin relation discussed earlier:

\[
LR_{\text{margin}} = -\gamma_i (\ln c_{i,t-1} - \delta_i \ln s_{i,t-1}).
\] (6)

At the firm level, costs adjust to their long run equilibrium with sales, with \( \gamma_i \) as
the rate of partial adjustment to the departure from equilibrium in the previous year,
\( \ln c_{i,t-1} - \delta_i \ln s_{i,t-1} \). The long run coefficient \( \delta_i \) is potentially heterogenous across firms,
but expected to approximately have a unit value, \( \delta_i \approx 1 \). For firms within the same sector, it is possible that the long run coefficient is homogenous. Further, if \( \delta_i = 1 \) for all firms within the sector, the average profit margin is approximately given by \(-E(\alpha_i)/E(\gamma_i)\),
where the two parameters are allowed to be heterogenous across firms within the sector.
We call this equilibrium relationship the \textit{profit margin equilibrium}.

Second, we consider the potential market share equilibrium. Since there are only 4
long run coefficients connecting the costs, sales and average costs and sales terms in (5),
and each equilibrium relation requires identification of at least 2 parameters (the partial
adjustment and long run coefficient), we can identify only one of the two potential market
share equilibria. Hence, we impose the restriction that both these equilibria are the same:

\[
LR_{\text{share}} = -\gamma_i^* (\ln c_{i,t-1} - \delta_i^* \ln \tau_{t-1}) - \gamma_i^* (\ln s_{i,t-1} - \delta_i^* \ln \tilde{s}_{t-1})
= -\gamma_i^* [(\ln c_{i,t-1} + \ln s_{i,t-1}) - \delta_i^* (\ln \tau_{t-1} + \ln \tilde{s}_{t-1})].
\] (7)

We call this cointegrating relationship the \textit{market share equilibrium}.

The third equilibrium, the (business) cycle equilibrium, is the potential partial adjust-
ment of log costs and log sales (and therefore profit margin) to the economic cycle
share of firm \( i \) in year \( t \), and let \( s_i^* \) denote the equilibrium (or average) market share for firm \( i \), defined by
s_i^* = E(s_{it}). Then, \( \ln c_{it} = \ln (s_i^* \tau_{it}) = \ln n + \ln \tau_{it} + \ln [s_i^* + (s_{it} - s_i^*)] \approx n + \ln \tau_{it} + \ln s_i^* + (s_{it} - s_i^*) s_i^* \),
by first order Taylor approximation, which holds when \( s_{it} \) is close to its equilibrium value, that is \( s_{it} \approx s_i^* \)
is small. Now, \( E(s_{it}/s_i^*) = 1 \Rightarrow E \left[ \frac{s_{it} - s_i^*}{s_i^*} \right] = 0 \), and hence as \( n \to \infty, n^{-1} \sum_{i=1}^n (s_{it} - s_i^*) / s_i^* \to 0 \)
almost surely. Now, \( n^{-1} \sum_{i=1}^n \ln c_{it} \approx n + \ln \tau_{it} + n^{-1} \sum_{i=1}^n (s_{it} - s_i^*) / s_i^* \), which converges to \( \ln \tau_{it} \) as
\( n \to \infty \). Likewise, \( \ln \tilde{s}_{t-1} = \ln (n^{-1} \sum_{i=1}^n s_{it,t-1}) \) as an approximation for \( n^{-1} \sum_{i=1}^n \ln s_{i,t-1} \).
represented by $LR_{\text{cycle}} = -\gamma_i^{**} y_{t-1}$. Even though this equilibrium relation does not exploit cross section variation, it is important to allow for its potential importance in some sectors. Recent literature demonstrates the value of including hypothesized and a priori measured factors in large panel models in addition to including cross section averages; see, for example Bhattacharjee and Holly (2013) and Bailey, Holly and Pesaran (2013).

Next, we discuss identification and estimation of the long run equilibrium relationships and partial adjustment. Essentially, we show how the long run part of our model (5) identifies the cointegrating relations and partial adjustment parameters corresponding to the three equilibrium relationships: profit margin, market share and cycle. Identification of the cycle equilibrium is the simplest, because it involves a distinct variable $y_{t-1}$ and only one parameter has to be identified from its coefficient – the partial adjustment $-\gamma_i^{**}$. For the other two equilibria, we write the long run part in two distinct ways corresponding to the two different cointegrating relationships. Each of these relationships involve only two variables, and hence the partial adjustment term and long run slope has to be identified, and two other lagged $I(1)$ variables included with heterogenous slopes in the short run dynamic part of the model. The long run relations for the two equilibria are set up as follows:

$$LR = -(-\theta_{0i}) y_{t-1} - (-\theta_{1i}) \left[ \ln c_{i,t-1} - \left( -\frac{\theta_{2i}}{\theta_{1i}} \right) \ln s_{i,t-1} \right] + \theta_{3i} \ln \bar{c}_{t-1} + \theta_{4i} \ln \bar{s}_{t-1}$$  \hspace{1cm} (8)

$$LR = -(-\theta_{0i}) y_{t-1} - (-\theta_{2i}) \left[ \ln c_{i,t-1} + \ln s_{i,t-1} \right] - \frac{\theta_{4i}}{\theta_{2i}} \left( \ln \bar{c}_{t-1} + \ln \bar{s}_{t-1} \right) + (\theta_{3i} - \theta_{4i}) \ln c_{i,t-1} + (\theta_{3i} - \theta_{4i}) \ln \bar{c}_{t-1}$$  \hspace{1cm} (9)

Under the margin equilibrium, the model is estimated using the mean group estimator (Pesaran and Smith, 1995), setting the long run as (8) and including (4) in the short run dynamics. Assuming homogeneity in the long run coefficient $\delta_i = -\frac{\theta_{2i}}{\theta_{1i}} = \delta$, the model is also estimated by pooled mean group (Pesaran, Shin and Smith, 1999). We apply a Hausman test for the homogeneity assumption. Estimation under the market share equilibrium is similar, in this case using (9) as the long run specification; however, in this case, pooled mean group estimation is not used because equilibrium market shares for different firms is expected to vary across the firms.

3 Results

The above model was estimated, separately for 25 sectors, using panel data on UK listed firms from the Cambridge DTI Databank. This unique dataset covers annual accounting data on more than 5000 non-financial firms listed in the UK since 1948; for further discussion of the database, see, for example, Higson, Holly, Kattuman and Platis (2004) and Bhattacharjee, Higson, Holly and Kattuman (2009). There is substantial attrition in the included firms. So the data is an unbalanced panel, but including between 1000 and 1500 firms in each year, as firms enter and exit from the stock exchange listing. We use data for the period 1966 to 2010 which spans several business cycles. Sales, costs and fixed assets data are converted to real terms (deflating by the GDP deflator), and
employment is measured by number of employees. We use a Hodrik Prescott filter of quarterly output per capita averaged over the four quarters of every calendar year as a measure of the business cycle ($y_t$).³

Estimation is conducted using the Stata program *xtpmg* (Blackburne III and Frank, 2007) separately for firms in each of the 25 sectors. First, we estimate our full model using the pooled mean group (PMG) method and including firm fixed effects, short run dynamics (4) and the long run margin specification (8) as an unrestricted model. We also estimate restricted models omitting short run dynamics and long run equilibria, retaining in each case the components of our base model (2). This provides us with (pseudo) likelihood ratio tests for the joint significance of our short run and long run specifications. Detailed results are not reported, but in every sector we reject the null hypothesis that our specification of short run dynamics (long run equilibria) does not matter.⁴

Second, we estimate our full model also as a mean group (MG), in this case not making the assumption that there is a homogeneous long run profit margin coefficient for each firm within the sector. A Hausman test (Wu, 1973; Hausman, 1978) is conducted to verify the validity of the common long run effect assumption underlying the PMG estimates. In 23 of the 25 sectors (except Industrial Metals and General Retailers), the null hypothesis of validity of the PMG assumption cannot be rejected at the 5 percent level; these results are reported in Table 1 below.⁵

This we consider as tentative confirmation that a homogeneous costs-sales equilibrium relationship exists within most sectors. Despite this, efficiency gains from making the pooled mean group assumption is not always substantial. Because of considerable attrition in our data, the estimation can only be conducted over a limited sample of firms that have a substantial number of years of data, which in turn leads to larger standard errors for the PMG estimates. This data issue is considerably moderate for mean group estimation. Hence, our choice between PMG and MG estimates is based both on validity of the PMG assumption, as well as sample size considerations. Table 1 reports the chosen model for each of the 25 sectors, the minimum number of years of data for sampled firms within the sector, together with number of firms and number of firm-year observations in each case.

Third, we also estimate a model using the market share specification of the long run equilibrium (9) using mean group method only; this provides us with estimates of a partial adjustment to the market share equilibrium. The pooled mean group assumption of a common long run coefficient is expected to be invalid in this case, and hence PMG estimation is not conducted. Each of the above two steps also provides us estimates of partial adjustment to the third (business) cycle equilibrium.

³Machin and van Reenen (1993) used unemployment rate as a measure of the business cycle. This measure is based on the assumption of the unemployment rate is stationary, which is not true for the long time period that our study covers.

⁴For the "Healthcare Equipment & Services" sector, pooled mean group estimation omitting short run dynamics does not converge. This is likely due to an extremely flat nature of the pseudo log-likelihood surface. This we take as evidence of a rejection of the null hypothesis of no short run dynamics, beyond $\beta_i \Delta \ln s_{it}$ included our base model.

⁵In 3 other sectors (namely, "Beverages", "Leisure Goods" and "Technology Hardware & Equipment"), the null hypothesis of homogenous long run profit margin coefficient is rejected at the 10 percent level.
Fourth, we also estimate restricted models. First, we exclude the latent factor structure (common correlated effects and lagged business cycle); then second, we use only the base model (2). Estimates of the coefficient on sales growth from the short run dynamics for the full model, together with those from the above two restrictions, allows us to make some inferences about the operating leverage hypothesis.

Specifically, we examine:

(a) how large the operating leverage effect would appear to be if we considered partial adjustment only to the profit margin equilibrium and we ignored spatial strong dependence;

(b) how much is explained by the two other potential equilibria and corresponding latent factors; and finally

(c) how much of the model remaining is explained by sticky labour costs, sticky capital and asymmetric price adjustments.

Finally, we conduct the cross section dependence CD tests (Pesaran, 2004) on the residuals of our model to ensure that our specification of latent factors and equilibria has mitigated issues relating to strong dependence; these tests are not reported, but are available on request.

3.1 Long run equilibria

Table 1 reports estimates of the long run coefficient on the lagged logarithm of sales (profit margin equilibrium) together with partial adjustment to the three potential equilibrium relationships investigated here. There is substantial evidence of cointegration, supporting the existence of a long run profit margin equilibrium relationship between log costs and log sales. The partial adjustment to this equilibrium shows substantial variation across the sectors, and is statistically significant at the 5 percent level in 24 out of 25 sectors, and being significant at the 10 percent level in the one remaining sector Industrial Metals. Correspondingly, estimates of the long run effect of sales on costs is numerically close to $\delta_i = 1$ in most sectors (21 sectors out of 25). The exceptions are Technology Hardware & Equipment, Beverages, Industrial Metals and Gas, Water & Multi-utilities. In each of the above four sectors, even in the long run, costs do not fully adjust to a proportionate change in sales. Moreover, partial adjustment to this equilibrium is slow in two of the above sectors, Industrial Metals and Gas, Water & Multi-utilities (−0.35 and −0.26 respectively). Technology Hardware & Equipment is different, with strong partial adjustment (−0.88) to effectively a fixed costs equilibrium.
Furthermore, at the 5 percent level, there is evidence of a long run market share equilibrium in the majority of sectors (21 out of 25 sectors), and partial adjustment is significant at the 10 percent level in one other sector. The three remaining sectors are Construction & Materials, Support Services and Leisure Goods. Thus, the results suggest that competition in these three sectors is so severe that market shares of firms are continuously updated and do not fluctuate around firm specific equilibrium levels. This is in line with a priori notions about the industrial structure of UK listed firms.

Finally, there is considerably less evidence of a partial adjustment to the economic cycle equilibrium, which was the central focus of investigation in Machin and van Reenen (1993). Industrial Metals and Beverages show significant (at the 5 percent level) evidence of partial adjustment to the business cycle, together with Industrial Transportation and Food & Drug Retailers with weaker (significant at the 10 percent level) adjustment.

There are two ways to interpret this result. First, from an econometrics point of view, common correlated effects mop up most of the strong dependence in the data, and a measured factor such as the business cycle may consequently show considerably less importance. Second, from an industrial economics point of view, sectoral cycles in the UK are believed to be largely asynchronous so that an aggregate economic cycle may not appropriately capture cyclical patterns at the industry level. More disaggregated analysis, such as the one conducted here, is necessary, therefore, to understand behaviour.
3.2 Short run dynamics

Table 2 reports estimates of the short run dynamics. Our main object of inference in this paper is operating leverage, which relates to the question of how far below the theoretical unit value the coefficient on growth is, and how far this can be explained by asymmetric price adjustments, and sticky labour and capital costs. We revert to statistical tests to answer these questions in the following section. But, for the moment, we focus on the estimates themselves.

Visual inspection reveals that the estimated short run coefficient on sales growth, after accounting for explanatory variables, is less than unity in 16 of the 25 sectors. However, this coefficient is statistically significantly less than unity in only 5 sectors (namely Personal Goods, Industrial Engineering, Leisure Goods, Oil & Gas Producers and General Retailers). However, estimates of the base model, without latent factors and explanatory interaction variables, reveal a remarkably different story. The coefficient is less than unity in all but three sectors (except Beverages, General Retailers and Gas, Water & Multiutilities), and significantly lower than unity in 17 of the 25 sectors.

A partial explanation comes from the use of long run latent factors and partial adjustment to different equilibria. When these common correlated effects and the economic cycle are adjusted for, the coefficient is lower than unity for 22 of the 25 sectors, but the less than unit short run effect is statistically significant in 14 out of the 25 sectors. Thus, the combined effect of asymmetric price adjustments and sticky costs explains operating leverage fully in all but 5 of the above 14 sectors, that is for the following 9 sectors: Industrial Metals, Construction & Materials, General Industrials, Electronic & Electrical Equipment, Automobiles & Parts, Household Goods, Media, Software & Computer Services and Technology Hardware & Equipment. These constitute some of the most important sectors in the UK economy. In general, most of this explanation comes from sticky employment, but also in some sectors from fixed capital costs and asymmetric price adjustments. However, this inference is much more clearly apparent from statistical tests, to which we turn next.
3.3 Explanation of operating leverage

Table 3 presents several (left-tailed) tests of statistical hypotheses for operating leverage and its explanation. Based on estimates of our base model (2), there is evidence of the operating leverage channel (or margin shrink) as a result of an unexpected shock to sales, and statistically significantly at the 5 percent level, in a vast majority of sectors – 17 out of 25 sectors. However, this base model shows partial adjustment only to one cointegrating relationship, the log costs and log sales profit margin equilibrium. Given our evidence of potentially two other equilibria, to which costs and sales may adjust in many of the sectors, the above evidence is too simplistic. Presumably, firms would also anticipate partial adjustment to the market share and economic cycle equilibria, in sectors where these are appropriate.

Table 2: Estimates of short run dynamic coefficients on growth in sales and interactions

<table>
<thead>
<tr>
<th>Sector</th>
<th>Short-run, sales growth &amp; interactions</th>
<th>LR test Only</th>
<th>Growth (1971-1983)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oil &amp; Gas Refineries</td>
<td><img src="coefficients_table.png" alt="coefficients" /></td>
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<td>Chemicals</td>
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<td><img src="coefficients_table.png" alt="coefficients" /></td>
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<tr>
<td>Furniture &amp; Paper</td>
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<td><img src="coefficients_table.png" alt="coefficients" /></td>
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<tr>
<td>Industrial Metal</td>
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<tr>
<td>Construction &amp; Material</td>
<td><img src="coefficients_table.png" alt="coefficients" /></td>
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<tr>
<td>Forestry &amp; Farm</td>
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<tr>
<td>Oil &amp; Gas Exploration</td>
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<tr>
<td>Electronic &amp; Electrical Equipment</td>
<td><img src="coefficients_table.png" alt="coefficients" /></td>
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<tr>
<td>Industrial Engineering</td>
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<tr>
<td>Support Services</td>
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<td>Automobiles &amp; Parts</td>
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<td>Non-Metallics</td>
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<td>Pharmaceuticals &amp; Biotechnology</td>
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<td>Food &amp; Drug Products</td>
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<td>Health Care Equipment &amp; Services</td>
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<tr>
<td>Textiles &amp; Apparel</td>
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<td>Media</td>
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<tr>
<td>Dye, Paint &amp; Ink</td>
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<tr>
<td>Software &amp; Computer Services</td>
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<tr>
<td>Technology Hardware &amp; Equipment</td>
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</tbody>
</table>

**Notes:** (a)N observations per period. (b) Bold indicates significance at 5% (1%).
Hence, the unanticipated component in sales growth may be lower, and therefore also the operating leverage channel. This turns out to be the case in a vast majority of the above sectors (11 sectors out of the above 17), where margin shrink is significantly lower after accounting for the different equilibrium relationships: Oil & Gas Producers, Forestry & Paper, Industrial Metals, Construction & Materials, Industrial Engineering, Support Services, Automobiles & Parts, Leisure Goods, Healthcare Equipment & Services, Software & Computer Services and Technology Hardware & Equipment.

Nevertheless, the operating leverage effect is still statistically significant in 14 sectors. In all but 5 of the sectors (namely, Oil & Gas Producers, Industrial Engineering, Leisure Goods, Personal Goods and General Retailers), explanatory interaction variables fully explain operating leverage up to the point where it is no longer statistically significant. In the main, the explanation comes from sticky labour costs. Frictions in the labour market ensure that, faced with an unanticipated fall in sales, firms may not be able to fully adjust their employment. This implies that costs do not fall by as much as sales in the short run.

Our descriptive analyses suggest that part of employment is adjusted in the following year; we allow for such delayed adjustment in our estimated model. The sticky labour costs explanation is statistically significant at the 5 percent level in 4 sectors, namely, Oil & Gas Producers, Chemicals, Household Goods and Technology Hardware & Equipment.

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and significant at the 10 percent level in 5 other sectors (Industrial Metals, Construction & Materials, Aerospace & Defence, Industrial Engineering and Food & Drug Retailers. Added to the above 9 sectors, sticky fixed capital costs also provide an explanation at the 10 percent level, in 2 other sectors (General Industrials and Industrial Transportation); this makes a total of 11 sectors where sticky fixed costs provide an explanation for operating leverage effects.

There are 4 other sectors where asymmetric price adjustments provide an explanation; the effect is statistically significant at the 5 percent level in 2 sectors (Electronic & Electrical Equipment and Food Producers) and at the 10 percent level in 2 others (Forestry & Paper and Automobiles & Parts). The forces of competition, domestic and international restrict producers in these sectors from being able to adjust prices fully on the downside.

4 Conclusions

Our results suggest that the behaviour of operating leverage over the business cycle reflects sticky labour costs and some degree of asymmetric price adjustment. But we also find that there are a number of equibrating long run relationships to which operating profit also adjusts both to its relationship between costs and sales and to a market based average share.

References


