<u>Working Paper No. 39/01</u>

Markup Cyclicality, Employment Adjustment, and Financial Constraints

by

Jan Erik Askildsen
Øivind Anti Nilsen

SNF Project No. 4590
Deregulering, internasjonalisering og konkurransepolitikk

The project is financed by the Research Council of Norway

FOUNDATION FOR RESEARCH IN ECONOMICS AND BUSINESS ADMINISTRATION
BERGEN, AUGUST 2001
ISSN 0803-4028

Markup Cyclicality, Employment Adjustment, and Financial Constraints

by[*]

Jan Erik Askildsen and **Øivind Anti Nilsen**

Department of Economics, University of Bergen
Fosswinckelsgt. 6, N-5007 Bergen, Norway

June 2001

Abstract

We investigate the existence of markups and their cyclical behaviour. Markup is not directly observed. Instead, it is given as a price-cost relation that is estimated from a dynamic model of the firm. The model incorporates potential costly employment adjustments and takes into consideration that firms may be financially constrained. When considering size of the future labour stock, financially constrained firms may behave as if they have a higher discount factor, which may affect the realised markup. The markups and their fluctuations are estimated for different sectors using firm and plant level data for Norwegian manufacturing industries. The results indicate a frequent presence of procyclical markups but also countercyclical markups are found. Financial constraints do not seem to be negligible and adjustments costs are small.

JEL codes: E32, D92
Keywords: Markups, business cycles, panel data, adjustment costs, financial constraints.

[*] We are grateful for comments and suggestions on an earlier draft from Stephen Bond, Eiliv S. Jansen and Erling Steigum jr. The usual disclaimer applies.

1. Introduction

Microeconomic foundations of modern macroeconomics give rise to the expectation that the price-cost margins of firms will vary over the business cycle. Empirical evidence, available largely from US industry sector studies but increasingly from other countries, supports the case. On the other hand, theoretical as well as empirical studies are inconclusive as to the magnitude and directions of the cyclical movements. The theoretical underpinnings for fluctuations in markups over the business cycle are often related to industrial organisation theory. The seminal papers by Green and Porter (1984) and Rotemberg and Saloner (1986), who argue respectively in favour of pro- and countercyclical markups, have triggered several studies with different assumptions about oligopoly price setting games. However, factor markets and investment behaviour should also be included when deriving estimates of markups, see e.g. Domowitz, Hubbard and Petersen (1986), Bils (1987) and Chevalier and Sharfstein (1996). Empirical studies have revealed both procyclical and countercyclical markups. In different contexts, Bils (1987), Chevalier and Scharfstein (1995, 1996), Borenstein and Shepard (1996) and Galeotti and Schiantarelli (1998) find evidence of countercyclical markups. Domowitz, Hubbard and Petersen (1986, 1987), Chirinko and Fazzari (1994) and Bottasso, Galeotti and Sembenelli (1997) tend to find more procyclical markup behaviour.

The contribution of this paper is new empirical evidence on the existence and magnitude of markups and their cyclical variations by using firm and plant level data. One advantage of this particular Norwegian micro data set is that balance sheet information is collected even for relatively small firms and plants. Most of the papers investigating markup fluctuations use sector level data.[1] Utilising micro-data for plants and firms means that we are using data at the level where decisions about production are taken. We believe that firm and plant level data will give more reliable markup estimates. Firstly, it allows us to correct for firm specific non-observabilities, such as productivity differences between firms, which is of importance since production technology and scale economies are relevant for the price setting behavior of firms. Aggregating up to industry level ignores these differences, and may thereby introduce biases into the estimation of the marginal costs and markups. Secondly, using plant and firm level data have the added advantage that the model is implemented at the level for which it is constructed and thereby eliminates the notion of a representative firm. This is of significance if the cost elements of importance for markup cyclicality are firm specific and not industry sector specific. Such heterogeneity is captured using firm or plant level data. However, the markups are measured for different manufacturing industry sectors separately, which enables us to detect possible sectoral differences.

In this paper we apply the research strategy of the "new empirical industrial organisation". The sector-wise estimates of markups are allowed to vary over the business cycles. There are several advantages from using an approach where markups are estimated instead of taken as observable. It is unnecessary to make assumptions concerning specific relationships between average and marginal costs, nor is it necessary to proxy for marginal costs. Furthermore, the econometric model is based on an Euler equation for labour, making it unnecessary to parameterise the gross production function or the cost function of the firm. Another advantage of our study is that the economic model is based on the optimisation problem of the firm, and not a reduced form as in many studies. The dynamic modelling framework takes current as well as future production and labour demand into account. This

[1] The only study we are aware of using micro level data for analyzing cyclical markup is Chirinko and Fazzari (1994).

way we determine within the model whether adjustment costs are present when estimating the cyclicality of markups.

With labour demand governed by intertemporal considerations, credit constraints or capital market imperfections will effect labour costs and thus labour demand. With costly adjustment of labour, firms will at any point in time have to consider the size of current as well as future labour stock. Financially constrained firms may be considered behaving as if they have a higher discount factor, i.e. they are more myopic than unconstrained firms, and financial constraints will affect production and employment decisions. When firms depend on adjusting factors of production between periods, such as labour, the derived markups may be affected by capital market imperfections. A major concern related to labour hoarding is the provision of collateral for short term finance of the wage bill. Financial constraints may prove more severe in connection with labour hoarding than for investments in real capital. The constraints will influence pricing behaviour via the shadow discount factor of the firms, which affects per period production and resource allocation between periods (see Hubbard (1998)).

The interaction between product market competition and the financial situation of the firms has been studied by Brander and Lewis (1986, 1988), Maksimovic (1988), Gottfries (1991), Stenbacka (1994), Showalter (1995) and Hendel (1996). According to the 'limited liability effect', financially distressed firms increase their output or reduce their output prices to generate cash. The 'strategic bankruptcy' models postulate that a rival might increase its output to increase the probability of driving a high-debt firm into insolvency. Phillips (1995), Chevalier (1995), Chevalier and Scharfstein (1995, 1996), Hendel (1997) and Chatelain (1999) are empirical analyses studying interactions between the output decisions of firms and their financial situation. Chevalier and Scharfstein (1995, 1996) are among the few studies that explicitly address the effects of liquidity constraints on markups. They show that the incentives for a firm to invest in market shares may give rise to cyclicality. They hypothesise and find evidence of countercyclical markups but note that it is hard in general to postulate in which direction financial constraints will affect markup fluctuations.

We use a panel data set of Norwegian manufacturing industries covering the period 1978-1991. Financial data are available at firm level, while data on production, production costs, employment and capital are given at plant level. We use sector variations in gross domestic product to represent business cycles. Gross domestic product may reflect demand shocks affecting the sales potentials of firms, and thereby the price setting behaviour of firms.

The next section describes the model The empirical specification is derived in Section 3, and data are presented in Section 4. In Section 5 we report the results, while Section 6 includes some concluding remarks.

2. The Dynamic Optimisation Problem[2]

The model represents a firm facing a dynamic optimisation problem. Short-term price and production decisions are made under the influence of labour adjustment costs and possibly restricted by financial constraints. We make the simplifying assumption that the stock of capital is predetermined. It reflects the fact that investment is generally sunk before prices are set. We note that several studies have addressed adjustment costs when investing in capital. The evidence for the existence of such adjustment costs in Norwegian firms is not clear. With a predetermined capital stock we avoid the problem of formalising the capital adjustment costs function, whose functional form is also unsettled.[3] Thus, we assume that investment in

[2] An appendix with more detailed derivation of the model is available from the authors upon request.
[3] See Nilsen and Schiantarelli (1998) for a discussion of capital adjustments costs for Norwegian firms.

fixed capital is a long-run decision, and changes in the capital stock do not affect the short-term pricing behaviour. On the other hand, we assume labour hoarding to be relevant due to costs of changing the employment levels between periods. Contemporary as well as expected demand changes will therefore affect employment and pricing decisions each period. Financing short term hoarding of labour is assumed more difficult than the long-term finance of real capital. The main reasons for this are that servitude is ruled out and labour can hardly be used as collateral. Furthermore, our model is able to capture general financial restrictions facing the firm, irrespective of why the firm is short of finance.

We model the behaviour of a firm whose objective at the end of period *t-1* is to maximise the present value, $V_{i,t-1}$, of dividends, $D_{i,s+t}$. The subscript *s* and *t* denote time, and *i* denotes the firm.[4] The firm operates in an imperfectly competitive market. However, no assumptions are made concerning specific kinds of output market imperfections. The firm may operate in a monopolistically competitive market where several firms produce different brands of the same product, or in an oligopoly. The model can be formally expressed as[5]

$$V_{i,t-1} = E_{i,t-1} \sum_{s=0}^{\infty} \beta_{t+s} D_{i,t+s} \tag{1}$$

where $E_{i,t-1}$ denotes the conditional expectations operator as of time *t-1*, and $\beta_{t+s} = \prod_{\tau=0}^{s} \frac{1}{1+r_{t+\tau}}$ is the discount factor between time *t* and *t*+s, with the discount rate r_t reflecting the investor's opportunity cost of investing in period *t*. Contemporary variables are

---

[4] This formulation is based on the assumption that owners and managers are risk neutral, and that managers act in the interests of the stockholders.
[5] This formulation is based on the standard capital market arbitrage condition:

$$r_t V_{i,t-1} = D_{i,t} + \left(E_{t-1}\left[V_{i,t}\right] - V_{i,t-1}\right)$$

assumed to be known to the firm with certainty whereas future variables are stochastic. In addition, we assume that the decision-makers have rational expectations.

Wages are settled prior to the production decisions. The financial constraints are at the outset represented by a dividend restriction, which prevents the firm from raising external funds by issuing shares to meet the owners' return claims. The non-negative dividend restriction can loosely be interpreted as a premium on external funding. Below we will extend the model to account for an explicit credit constraint.

The firm maximises (1) subject to the constraint

$$D_{i,t} \geq 0$$

Denote

$Y_{i,t} = F(K_{i,t}, L_{i,t}, Z_{i,t}) - G(L_{i,t}, L_{i,t-1})$ = real output net of adjustment costs

$F(.)$ = concave production function

$G(.)$ = adjustment cost function for labour

$L_{i,t}$ = employment level

$Z_{i,t}$ = variable factors

$\overline{K}_{i,t}$ = predetermined, fixed capital stock

$p_{i,t}$ = output price

$w_{i,t}$ = wage cost per employee

$c_{i,t}$ = cost per unit of other variable input factors

$B_{i,t}$ = actual debt

$\overline{B}_{i,t}$ = debt ceiling

i_t = nominal interest rate on debt

With dividend defined as in the curly bracket in (2), the firm's optimising behaviour is found as the solution the following dynamic programming problem:

$$V_{i,t-1}\left(L_{i,t-1}\right)=\max_{L_{i,t},Z_{i,t}}\left\{p_{i,t}\left(Y_{i,t}\right)\left[F\left(\overline{K}_{i,t},L_{i,t},Z_{i,t}\right)-G\left(L_{i,t},L_{i,t-1}\right)\right]-w_{i,t}L_{i,t}-c_{i.t}Z+B_{i,t}-\left(1+i_{t}\right)B_{i,t-1}\right\}$$
$$+E_{t}\left[\frac{1}{1+r_{t+1}}V_{i,t}\left(L_{i,t}\right)\right] \quad (2)$$

For the variable input factors, $Z_{i,t}$, the first order condition is given by

$$\frac{\partial Y_{i,t}}{\partial Z_{i,t}}=c_{i,t}\frac{\mu_{i,t}}{p_{i,t}} \quad (3)$$

where $\mu_{i,t}=\frac{1}{1-\frac{1}{\varepsilon_{i,t}^{D}}}$ is the markup and $\varepsilon_{i,t}^{D}=-\frac{\partial Y_{i,t}}{\partial p_{i,t}}\frac{p_{i,t}}{Y_{i,t}}$ is the price elasticity of demand facing firm *i* in period *t*. To see the generality of the formulation, and relating it to other studies of markup cyclicality, e.g. Domowitz, Hubbard and Petersen (1987), we rewrite (3) as

$$p_{i,t}\left(1-\frac{a_{i,t}}{\varepsilon_{t}^{D}}\left(1+\sum_{j\neq i}\frac{\partial Y_{j,t}}{\partial Y_{i,t}}\right)\right)\frac{\partial Y_{i,t}}{\partial Z_{i,t}}=c_{i,t} \quad (3')$$

where ε_{t}^{D} denotes the price elasticity for the industry in period *t*, $a_{i,t}$ is the i^{th} firm's market share, and $\frac{\partial Y_{j,t}}{\partial Y_{i,t}}$ is the conjectural variation. If there were only one firm, $a_{i,t}$ = 1, and $\frac{\partial Y_{j,t}}{\partial Y_{i,t}}=0$. Then we get the standard markup pricing expression given in equation (3).

Another extreme case is $a_{i,t} \to 0$, which yields a competitive market solution. A Cournot solution emerges when the conjectural variations are set equal to zero. Thus, our formulation can accommodate several different price games. Note that our measure of markup is related to the demand elasticity. In equilibrium the markup level and its fluctuations can be explained by cost changes as well as the product market behaviour of the firm. The estimated markup will indicate whether an imperfectly competitive market is present.

The first order condition for labour is:

$$\frac{p_{i,t}}{\mu_{i,t}}\frac{\partial Y_{i,t}}{\partial L_{i,t}} + E_t\left[\frac{1-\Lambda_{i,t+1}}{1+r_{t+1}}\frac{p_{i,t+1}}{\mu_{i,t+1}}\frac{\partial Y_{i,t+1}}{\partial L_{i,t}}\right] = w_{i,t} \qquad (4)$$

where $\Lambda_{i,t+1} = 1 - \frac{1+\lambda_{i,t+1}^D}{1+\lambda_{i,t}^D}$, and $\lambda_{i,t}^D$ is the Lagrange multiplier associated with the dividend constraint at time *t*. If no dividend constraint is binding at times *t* and *t+1*, then $\Lambda_{i,t+1} = 0$, and the firm is financially unconstrained. According to equation (4) the present value of a marginal unit of labour should equal the wage cost w_{it}. The first term at the left hand side, which equals $\frac{\partial Y_{i,t}}{\partial L_{i,t}} = \frac{\partial F_{i,t}}{\partial L_{i,t}} - \frac{\partial G_{i,t}}{\partial L_{i,t}}$, represents increased revenue net of labour adjustment costs. Employment adjustments affect the following period as well. The last term in the square brackets, $\frac{\partial Y_{i,t+1}}{\partial L_{i,t}}\left(= -\frac{\partial G_{i,t+1}}{\partial L_{i,t}}\right)$, represents the cost of postponing employment adjustment.[6] Using the laws of variance on the expectations expression $E_t[.]$ and the rational expectation property, the first order condition for labour may be written as

[6] If the firm has to take into account explicit credit limits, financially constrained firms, (for which $(1+\lambda_{i,t+1})/(1+\lambda_{i,t})>1$,) behave as if they face a higher discount rate. This is further addressed below.

$$\frac{p_{i,t}}{\mu_{i,t}}\frac{\partial Y_{i,t}}{\partial L_{i,t}}+\left(\frac{1-\Lambda_{i,t+1}}{1+r_{t+1}}+e_{i,t+1}^{I}\right)\cdot\left(\frac{p_{i,t+1}}{\mu_{i,t+1}}\frac{\partial Y_{i,t+1}}{\partial L_{i,t}}+e_{i,t+1}^{II}\right)+\mathrm{cov}\left(\frac{1-\Lambda_{i,t+1}}{1+r_{t+1}},\frac{p_{i,t+1}}{\mu_{i,t+1}}\frac{\partial Y_{i,t+1}}{\partial L_{i,t}}\right)=w_{i,t} \quad (5)$$

We have replaced the expectation operators with white noise expectation errors, $e_{i,t+1}^{I}$ and $e_{i,t+1}^{II}$ respectively, which are uncorrelated with any information at time *t*.

The standard adjustment cost function for labour, introduced by Holt et al. (1960), is quadratic in employment changes. Since the size of the labour stock in different plants may vary considerably, we normalise squared employment changes by firm employment level. The labour adjustment cost function is thus written as

$$G_{i,t}=\frac{s}{2}\frac{X_{i,t}^{2}}{L_{i,t}} \quad (6)$$

where $X_{i,t}=L_{i,t}-L_{i,t-1}$.[7] We use a modified version of (6) reading

$$G_{it}=\begin{cases}\frac{s}{2}\left(\left(\frac{X_{i,t}}{L_{i,t-1}}+a\right)^{2}\cdot\left(1-D_{it}^{+}\right)+\left(\frac{X_{i,t}}{L_{i,t-1}}-a\right)^{2}\cdot D_{it}^{+}\right)\cdot L_{i,t-1} & \text{if } \left(\left|X_{i,t}\right|-a\right)\geq 0\\ 0 & \text{otherwise}\end{cases} \quad (7)$$

where D_{it}^{+} is equal to one if X_{it} is positive and zero otherwise.[8] The parameter *a* is introduced to capture an assumption that small changes in employment may be associated with small or

[7] Including in X some voluntary quitting which does not induce costs, Nickell (1986), will not affect the results.
[8] The *s*-parameter may also be made dependent on the sign of the employment change. However, deriving asymmetric adjustment costs goes beyond the scope of this paper.

negligible costs. Thus, we may ignore costs from small adjustments of the labour stock. A justification for this is that it is hard from existing literature to establish the costs of small labour adjustments. With $a > 0$, relative changes in employment must exceed a to be considered as costly and thus economically interesting.[9] When concentrating on costs of larger employment adjustments only, we therefore introduce the parameter a as a bliss point. However, in the empirical analyses we will also use the more standard formulation of the adjustments cost function with $a = 0$.

Lastly we consider a possible borrowing constraint. It seems reasonable that a firm may lack short-term credit to finance labour costs, in particular during a slump.[10] Assume that there is a credit ceiling $\overline{B}_{i,t}$ for each firm, in each period. This exogenous type 1 credit rationing constraint implies that the firms will receive credit up to a limit, which the firms are unable to influence. Together with the dividend constraint, $D_{i,t} \geq 0$, this ceiling effectively cuts the firms off from external finance, either in the form of new equity and/or further debt. Thus, the dividend expression in (2) is in addition to the non-negative dividend constraint maximised, subject to the debt constraint

$$B_{i,t} \leq \overline{B}_{i,t}$$

The first order condition for debt is given by

$$1+\lambda_{i,t}^{D} = \lambda_{i,t}^{B} + (1+i_t)E_t\left[\frac{1+\lambda_{i,t+1}^{D}}{1+r_{t+1}}\right] \qquad (8)$$

[9] A full description of the model should include a dummy variable indicating whether labor adjustments are in the zero-cost interval [-a, a] or not. This is for simplicity ignored in the *G*(.)-function here but will be incorporated in the empirical specification.

[10] For empirical evidence for such a pattern, see for instance Sharpe (1994).

Here $\lambda_{i,t}^{B}$ is the shadow value of relaxing the debt ceiling. If $\lambda_{i,t}^{B}=0$, the first order condition for debt states that the value of issuing a marginal unit of new debt to finance dividend payment must equate the discounted value of repaying debt with interests. If the debt constraint binds, there is a wedge between the residual profit, or dividend, for the current period and the dividend expected to be paid next period. Defining $\tilde{\lambda}_{i,t}^{B}=\frac{\lambda_{i,t}^{B}}{1+\lambda_{i,t}^{D}}$, the first order condition for debt, (8), can be rewritten as

$$\left[\frac{1-\tilde{\lambda}_{i,t}^{B}}{1+i_t}\right]=E_t\left[\frac{1-\Lambda_{i,t+1}}{1+r_{t+1}}\right] \tag{9}$$

The dividend and borrowing constraints makes it more expensive to transfer resources between periods, thus having similar effects as an increase in marginal costs compared to an unconstrained regime, as shown in expression (9).

Now, to arrive at a final expression summarising the optimising behaviour of the firm, assume that the short term returns to scale in production, $Y_{i,t}=F\left(K_{i,t},L_{i,t},Z_{i,t}\right)-G\left(L_{i,t},L_{i,t-1}\right)$, is given by the constant parameter $\tilde{v}_{i,t}$. From Euler's theorem, and using the first order conditions (3), (5) and (9), together with the formulation of adjustment costs in (7), after some rearranging we obtain the following equation which serves as the basis for our empirical specification:

$$
\begin{aligned}
\frac{p_{i,t}Y_{i,t}}{q_{i,t}K_{i,t}} &= \frac{\mu_{i,t}}{\tilde{v}_{i,t}}\left(\frac{w_{i,t}L_{i,t}}{q_{i,t}K_{i,t}}+\frac{c_{i,t}Z_{i,t}}{q_{i,t}K_{i,t}}\right) \\
&+\frac{s}{\tilde{v}_{i,t}}\frac{p_{i,t}L_{i,t}}{q_{i,t}K_{i,t}}\left(1-\frac{X_{i,t}}{L_{i,t}}\right)\left(\left(\frac{X_{i,t}}{L_{i,t}}+a\right)\cdot\left(1-D_{it}^{+}\right)+\left(\frac{X_{i,t}}{L_{i,t}}-a\right)\cdot D_{it}^{+}\right) \\
&-\frac{\mu_{i,t}}{\mu_{i,t+1}}\frac{s}{\tilde{v}_{i,t}}\left(\frac{1}{1+i_t}\right)\frac{p_{i,t+1}L_{i,t+1}}{q_{i,t}K_{i,t}}\left(1-\frac{X_{i,t+1}}{L_{i,t+1}}\right)\cdot\left(\left(\frac{X_{i,t+1}}{L_{i,t+1}}+a\right)\cdot\left(1-D_{it+1}^{+}\right)+\left(\frac{X_{i,t+1}}{L_{i,t+1}}-a\right)\cdot D_{it+1}^{+}\right) \\
&+\frac{\mu_{i,t}}{\mu_{i,t+1}}\frac{s}{\tilde{v}_{i,t}}\left(\frac{1}{1+i_t}\right)\frac{p_{i,t+1}L_{i,t+1}}{q_{i,t}K_{i,t}}\left(1-\frac{X_{i,t+1}}{L_{i,t+1}}\right)\cdot\left(\left(\frac{X_{i,t+1}}{L_{i,t+1}}+a\right)\cdot\left(1-D_{it+1}^{+}\right)+\left(\frac{X_{i,t+1}}{L_{i,t+1}}-a\right)\cdot D_{it+1}^{+}\right)\cdot\tilde{\lambda}_{i,t}^{B} \\
&-\frac{\mu_{i,t}}{\tilde{v}_{i,t}}\frac{L_{i,t}}{q_{i,t}K_{i,t}}\operatorname{cov}(.)+\frac{\mu_{i,t}}{\tilde{v}_{i,t}}\frac{L_{i,t}}{q_{i,t}K_{i,t}}e_{i,t+1}
\end{aligned}
$$

(10)

It is reasonable to assume that financial constraints are more severe during a downturn, leading to higher marginal costs in such periods. Still, the effect from financial constraints and labour adjustment costs on markups cannot be stated unambiguously. Price setting and the aggressiveness of firms in their pricing behaviour may also vary over the business cycle. The concept of super-game perfectness explains how firms through tacit collusion will be able to charge a market price higher than the price given from a competitive equilibrium. A tacit collusion exists because of the threat of punishment from the competitors in later periods if a firm undercuts the collusion price in a given period. Such co-operation may break down in downturns, Green and Porter (1984), or in booming periods, Rotemberg and Saloner (1986). We have not modelled explicitly such price games, since we have no reasons to believe them to be systematic over several industry sectors. However, if tacit or open co-operation is withheld over the business cycle, then with our modelling set-up, countercyclical costs will give rise to a procyclical markup. We note also that if demand is iso-elastic and marginal costs are constant, a constant markup will result.

Since prices and marginal costs cannot be directly observed, we follow the strategy of using the above representation for estimating the markup. The markup will be parameterised to take into consideration its variation over the business cycle, controlling for the possible appearance of adjustment costs and financial constraints.

3. Empirical Specification

Several assumptions have to be made in order to estimate the model in equation (10). Firstly, there may be cyclical fluctuations in markups due to cyclical variation in demand and marginal costs, which may affect prices and price strategies. Secondly, we have to find a representation of the unobservable credit constraint multiplier, which according to (10) affects the optimising behaviour.

We represent the cyclicality of the markup by parameterising $\mu_{i,t}$ as

$$\mu_{i,t} = \mu^0 + \mu^1 \Psi_t \tag{11}$$

According to (11), the markup term consists of a constant term, μ^0, and a variable term, μ^1. The variation is related to changes in gross domestic products Ψ_t, as measured relative to the four surrounding years. The Ψ_t variable is expressed as

$$\Psi_t = \ln(GDP_t) - \frac{1}{4}\left(\ln(GDP_{t-2}) + \ln(GDP_{t-1}) + \ln(GDP_{t+1}) + \ln(GDP_{t+2})\right) \tag{12}$$

The variable Ψ_t picks up the degree to which demand each year is higher or lower than the general trend. We will use a Taylor approximation of first order for the term $\frac{\mu_{i,t}}{\mu_{i,t+1}}$ in (10).

We have tried several ways to represent a firm's potential financial constraint. Interest payments as a share of cash flow seem to represent the data at best (see also Whited (1992), and Hubbard, Kashyap, and Whited (1995) for related discussion and alternative formulations). Thus, it is those firms which pay the highest interest rates in relation to its per period cash flow, which are most likely to be rationed. This interest payment ratio may be interpreted as serving as a signal of the firm's bankruptcy risk. When paying a high interest rate, as measured by interest payments to cash flow, a firm is assumed to be less capable of serving additional debt. Alternatively, such a firm will have to pay a high premium if it is to obtain further debt finance. Thus, we parameterise the debt multiplier $\tilde{\lambda}_{i,t}^{B}$ as

$$\tilde{\lambda}_{i,t}^{B} = \alpha \frac{IE_{i,t}}{CF_{i,t}} \tag{13}$$

where $IE_{i,t}$ is the interest expenditure and $CF_{i,t}$ is cash flow in period t. Both variables are measured at firm level, i.e. they are an aggregate over all plants within a firm. Even though we use plant level data when estimating markup, we assume that it is the financial position of the parent firm that is most relevant for considering a plant's financial situation. It is at the firm level that the formal accounting information to be used by external sources is reported. Furthermore, a plant belonging to a larger firm must be assumed to be able some way or other to participate in the common value of all the merged plants.

The final model to be estimated is given by (10), with the expressions (11)-(13) substituted for $\mu_{i,t}$ and $\tilde{\lambda}_{i,t}^{B}$. When estimating the model in (10), we will include a firm specific fixed effect. The fixed firm effect can be interpreted as accounting for firm specific characteristics that are constant over the sample period. We have also included time dummies to represent the effect of macro shocks. The estimation is carried through separately for each sector, since we want to allow for sectoral differences in the parameters.

We assume that the decision-makers have rational expectations, i.e. the errors they make in forecasting are uncorrelated with the information available when the forecasts are made. This rational expectations hypothesis suggests orthogonality conditions that can be used in a generalised method of moments (GMM) as outlined in Hansen (1982). Variables dated *t* and earlier which are correlated with the variables in the regression, are valid instruments given that the error term, $e_{i,t+1}$, is serially uncorrelated. The firm-fixed effects are removed by estimating the model in first-differences and, therefore, a first-order serial correlation is introduced. We apply the *m2* test to control for the absence of higher order serial correlation. Further testing for the validity of the instruments is done by the *Sargan/Hansen* test.[11] In our estimation, we have used the following variables in levels as instruments, $\frac{w_i L_i + c_i Z_i}{q_i K_i}, \frac{X_i}{q_i K_i}, L_i, \frac{IE_i}{CF_i}, \frac{IE_i}{CF_i} \cdot L_i$, all at dates *t-1* and earlier.

The GMM-estimates of the model expressed in equation (10) give unrestricted estimates of the deep parameters of interest; μ^0, μ^1, $\tilde{v}$, *s*, and α. To find these latter parameters from the GMM-estimates we use a minimum distance estimation method.[12]. We restrict the *s* parameter in the adjustment function to be non-negative by assuming $s = \exp(\eta)$ and allowing η to be computed without restrictions. We have also restricted the α parameter

[11] See Arellano and Bond (1991) for a complete discussion of both the *m2*-test and the overidentification test.
[12] The proof of the consistency and asymptotic normality of the minimum distance estimator can be found in appendix 3A, Hsiao (1986).

in (13) to be within a reasonable interval by assuming $\alpha = \kappa \frac{\exp(\xi)}{1+\exp(\xi)}$, where ξ can take any value and κ is the upper limit of α.

4. Data.

The empirical analysis is carried through at the plant level. Variables representing financial constraints are constructed from the balance sheet of the firm to which the plant belongs.[13]

The empirical work is based on a large set of unbalanced data of Norwegian plants and firms within manufacturing industry for the period 1978-1991. The data are collected by Statistics Norway. Income statement and balance sheet information are provided from Statistics of Accounts for all firms with more than 50 employees during the period 1978-1990. There may still be firms of smaller size in the sample. The reason is that information is collected once the firm is registered. In 1991 no new small firms (less than 100 employees) were added to the sample due to new sampling routines used by Statistics Norway. For all firms included in Statistics Norway's Statistics of Accounts, plant level information about production, production costs, investment and capital stock is available from the Manufacturing Statistics. All data are annual. The micro level data are matched with information about the gross domestic product at sector level. The industry sector values are collected from National Accounts.

We investigate plants where the changes in the number of employees are of reasonable magnitude. Observations with employment level 3 times larger than or less than 1/3 of the employment previous year, are therefore excluded. Furthermore, to make the

[13] See the Data Appendix for details on variable definitions and construction.

sample as homogeneous as possible, we include only plants with more than 5 and fewer than 500 employees, whereas firm size is limited to 1500 employees. Lastly we exclude observations where the calculated annual man-hours worked per employee are outside the interval [400,2500].

As discussed in Section 2, we assume that small changes in employment may be associated with small or negligible costs. We therefore use two different formulations of the adjustments costs, with a = 0 and a = 0.05. With the latter formulation, the employment adjustment costs are zero when $\left(\frac{|X_{it}|}{L_{it}} - a\right) < 0.05$.

The descriptive statistics are reported in Table 1. We see that the sales/capital ratio, pY/qK, as well as the costs/capital ratio, (wL+cZ)/qK, vary among the industries. Comparing the differences between the sales/capital ratio and the costs/capital ratio, we find that these differences are approximately 0.1, which indicates the presence of a markup and possibly some degree of market power. Size differences between and within industries are noticeable. As measured by average number of employees per firm it varies from 78 to 183. The average firm size is over 100 employees in most industries, which in a Norwegian context implies that we are dealing with relatively large plants. This may have implications for our latter findings about adjustment costs and financial constraints. Although not reported in Table 1, it should be noted that the minimum plant size is 5 and the largest is 491. Details about labour adjustments are reported in the same table. The frequencies of labour stock increases seem to be somewhat higher than the frequencies of reductions in the labour stock. At the same time we find the average labour adjustment to be just below zero. We see that the frequencies of labour adjustments in the interval $a\ (=\Delta L/L) \in$ (-0.05,0.05) are around 40-45 percent.

5. Results

The estimation results are reported in Tables 2-5, for different formulations of adjustment costs and the financial constraint multiplier.

The null hypothesis is no market power, implying a base markup $\mu^0 \approx 1$. The cyclical part of the markup, μ^1, may be positive or negative, indicating pro- and countercyclical markup fluctuations respectively. To interpret its size and magnitude, assume that we find $\mu^1 = 0.5$. This implies that a relative change in the (detrended) GDP of 6 percent increases the markup by 0.03, for instance from 1.00 to 1.03. With the restriction on labour adjustment costs, we will get an adjustment cost parameter $s \geq 0$, and similarly for the parameter associated with the financial constraint, $\alpha \geq 0$. We assume constant unit elasticity of scale. This assumption is supported by the findings in Klette (1999) that increasing returns to scale are not a widespread phenomenon in Norwegian manufacturing industries.

We report only the restricted estimates revealed by the minimum distance procedure. The unrestricted parameter estimates of the Euler equation used for calculating the deep parameters are at the outset (Table 2) based on first step estimates of GMM, denoted GMM1, which makes use of a consistent but suboptimal weighting matrix. In Tables 3-5 we report second step estimates of the deep parameters, GMM2, with an optimal weighting matrix.

In Table 2 we use what may be termed the standard adjustment cost function, i.e. a = 0. The financial constraint multiplier α is restricted to be non-negative but with no upper bound. The results are based on unrestricted GMM1 results. We find that the invariant markup term, μ^0, deviates significantly from unity in two out of eight industries. An estimate of $\mu^0 \geq 1$ is consistent with the descriptive statistics in Table 1, and also with other international studies using an Euler-equation approach on panel data (see for instance Whited

(1992) and Hubbard et al. (1995)). For industries with a fixed markup term statistically insignificant from one, we should not rule out that some degree of market power is relevant even though it does not follow directly from the results in Table 2. For instance, some fluctuations in the markup may indicate periods where market power is effective, but the potential to reap these benefits are not present continuously, due to price setting procedures ('price wars') as well as cost fluctuations. It is also worth noting that a richer set of instruments, and the utilisation of more orthogonality conditions in GMM, might produce sharper estimates. However, we are restricted in this sense since the relatively small number of firms in each of the sectors limits our set of instruments. We note therefore that Klette (1999) finds small but statistically significant market power (μ^0 greater than one) when using larger panel data sets of Norwegian manufacturing industry.

The cyclical markup term is statistically different from zero in three out of the eight sectors. For Textiles (321-4) and Mineral Products (361-9) there is evidence of countercyclical markups, while for Wood Products and Furniture (331-2) there is a significant procyclical markup. For the other sectors there are non-significant procyclical fluctuations in markups. The generally (weak) tendency of procyclical markups corresponds to the findings of Domowitz, Hubbard and Petersen (1986, 1987), Chirinko and Fazzari (1994) and Bottasso, Galeotti and Sembenelli (1997). However, the difference in the signs of the cyclical markup-terms among sectors gives support to what is stressed in the "new industrial organisation literature", namely that, when investigating industry behavior, the preferred unit of study should be industries defined as narrow and homogeneous as possible This includes the analysis of price setting and markups.

According to (10), adjustment costs for labour will affect the marginal costs and the pricing behaviour of firms. The employment adjustment costs parameter, *s*, is statistically different from zero only for Food (311). Thus, it seems like labour adjustment costs do not play an important role for the industry sectors in question. It should be noted that the insignificant adjustment costs parameter may only be used to reject the symmetric and convex adjustment costs structure, not to exclude the existence of labour adjustment costs in general. We have also tried specifications with different formulations, including asymmetric adjustment costs, without this giving sharper results, and we will see below that the introduction of a zero cost interval will not dramatically change the result that labour adjustment costs may play a negligible role. We note that several other studies tend to find relatively small adjustment costs for labour, see Hamermesh and Pfann (1996). The insignificance of the labour adjustment costs coefficient here may be explained by particular Norwegian institutional arrangements during the period of investigation, when it was actually relatively easy for firms to lay off workers temporarily. During short-term unemployment spells, the workers could claim unemployment compensation that was not far below their ordinary wage rates. These rules have now been somewhat changed, which may affect labour adjustment costs were these to be estimated on more recent data.

The frequent insignificance of a binding capital constraint may be related to the negligible adjustment costs, although our formulation would be able to represent other reasons for capital shortage. The coefficient is significant for Food (311) only. Moreover, for this sector the labour adjustment cost parameter is significant. We have experimented with several different formulations of the capital constraint but no other formulation commonly used in the literature gives better or sharper estimates of the shadow price of capital, or on the adjusted discount factor of the firms. Some of the reported values are too high, indicating that its interval of variation should be restricted. To see this, note that with the given parameterising of $\tilde{\lambda}_{i,t}^{B}$, α measures the change in discount factor when the interest payments increase relative to the cash flow, holding the investment opportunities constant. The average discount factor in the sample is 0.95. Thus, an estimate of the interest-cash flow ratio coefficient of 5.0, together with an increase in the interest-cash flow ratio from 0.11 to 0.12 (a 9 percent increase) will decrease the discount factor with 0.04. Even this reduction is rather large, and estimates of a > 5 will give quite dramatic changes in discount factors compared to the estimates reported in e.g. Hubbard and Kashyap (1992) and Hubbard et al. (1995). Such estimates should thus indicate that the capital market restrictions would seriously influence the intertemporal behaviour of a firm.

Our estimated results are only valid as long as the overidentification test does not reject the chosen set of instruments, and when there is no serial correlation in the error terms. In Table 2, the Sargan test rejects the set of instruments for Wood Products and Furniture (331-332) and Paper Products (341). In the same table, both the overidentifaction test and the *m2*-test reject the set of instruments for Metals (371-372). This is also the case when lagging the instruments *t-3* but for sake of brevity these latter results are not reported.

In Table 3 we report the same set of results for the deep parameters based on GMM2 unrestricted estimates. Note, however, that the second step of the two-step GMM procedure appears to overstate the efficiency gains, see Arrelano and Bond (1991). With this in mind, we point out that neither the *m2* test nor the Sargan test reject our set of instruments for any of the analysed industries. If we concentrate on the parameters of interest, the overall picture is that several fixed and cyclical markup terms are now statistically significant. There is no change of sign compared to results in Table 2 but we now find a statistically significant procyclical markup in all sectors except for Textiles (321-4) and Mineral Products (361-9). Moreover, according to Table 2 markup fluctuations were countercyclical for these two sectors. Contrary to the results reported in Table 2, we find that the labour adjustment cost parameter *s* is zero for five out of the eight analysed industries and still significant only for Food (311). This is not necessarily an unreasonable result, and we note that the capital constraints, as measured by α, are still significant only when labour adjustment costs are present (sector 311).

To check the robustness of these estimates, we report in Table 4 the results when assuming that small adjustments of employment do not carry any costs. As described by the summary statistics, a large fraction of labour adjustments takes place in the interval *a* $(=\Delta L/L) \in$ (-0.05,0.05), which might indicate zero or very small adjustment costs for an interval around zero. Thus, we set a = 0.05 in the adjustment costs function (the *G(.)*-function). The results in Table 4 should be compared to the estimates reported in Table 3, as they are all based on GMM2 results. There is little change in results other than for two sectors, Chemicals (351-6) and Metals (371-2). These two sectors show insignificant procyclical markup fluctuations. Magnitude and significance of labour adjustment costs and shadow price of capital remain the same.

Lastly, in Table 5 we restrict the capital market coefficient, α, to be less than 5. With an interest expenditure to cash flow ratio equal to 0.2, which is in the 90% percentile of the interest cash-flow ratio, and α=5.0, then $\tilde{\lambda}_{i,t}^{B}$ = 1.0, and thus a discount factor equal 0. Lower levels of α produces higher discount factors. We see that markup levels and its cyclicality remain basically unaltered over industries compared to the results reported in Table 4. For labour adjustment costs there is one change. The coefficient *s* is now significant also for Textiles (321-4), and even the capital market coefficient α becomes significant for this sector.

6. Concluding remarks

We have used a structural approach to estimate markup and its fluctuations over the business cycle for a panel of Norwegian manufacturing firms. An advantage of this method, which draws on the research strategy of the 'new empirical industrial organisation' is that it economises on information. We avoid collecting data to represent variables that are in reality unobservable, and can thus study several firms and industries simultaneously.

The general findings are that some market power seems to prevail, and that markups in Norwegian manufacturing as measured from a sample of medium sized firms seem to vary procyclically for most manufacturing industry sectors. However, there are also sectors with countercyclical markup behaviour. Labour adjustments costs seem not be of large importance but, when they are significant, there is also a tendency for some capital market imperfection to prevail.

Some caveats and suggestions for extensions are in place. Firstly, care should be taken when in general interpreting the importance of financial constraints for the variations in markups. It is well established that capital market imperfections may lead to financial constraints. However, in the presence of financial constraints, the output prices and the markups of the liquidity constrained firms may go in either direction. The insignificance of the financial variable coefficient may be a result of competing effects working simultaneously. To reveal the simultaneous event of financial constraints, employment adjustment costs, and markup fluctuations might therefore require even more homogeneous and narrowly defined sectors than studied here. Another test of the importance of financial constraints, which might give some insight, would be to split the sample into *a priori* financial constrained and non-constrained firms. However, with the limited number of observations in some of the sectors, it would be difficult to get separate estimates for the two sub-samples, and there would be too few observations to get reliable GMM-estimates. Therefore, we did not choose this research path. It may be the case that the insignificance of the debt constraints is due to sample selection biases. The sample used consists of plants with at least six consecutive observations belonging to firms with more than 50 employees. These firms are in fact relatively large within the Norwegian manufacturing industry and their access to credit should therefore be better than for smaller firms.[14] The relatively easy access to credit may also explain why labour adjustment costs are of negligible significance for forward looking firms over a business cycle. Therefore, it might be the case that financial constraints are less likely for firms in our sample, and there is no strong evidence from other Norwegian studies that financial constraints strongly affect firms' behaviour.

In total, it seems that factor markets and financial constraints will affect markup behaviour only to a limited degree. Further studies on markup cyclicality should therefore focus more on price setting behaviour and price games. Such studies would require much narrower industry groups for defining a relevant product market.

[14] Data from the Manufacturing Statistics reveal that approximately 85 percent of all firms have less than 50 employees.

References

Arellano, M., and S. and Bond, 1991, "Some Tests of Specification for Panel Data: Monte Carlo Evidence and an Application to Employment Equations", *Review of Economic Studies 58*, 277-97.

Bils, M., 1987, "The Cyclical Behavior of Marginal Cost and Price", *American Economic Review 77*, 838-55.

Borenstein, S. and A. Shepard, 1996, "Dynamic Pricing in Retail Gasoline Markets", *Rand Journal of Economics 27*, 429-51.

Bottasso, A., M. Galeotti and A. Sembenelli, 1997, "The Impact of Financing Constraints on Markups: Theory and Evidence From Italian Firm Level Data", Fondazione Eni Enrico Mattei Note di Lavoro: 73/97.

Brander, J.A. and T.R. Lewis, 1986, "Oligopoly and Financial Structure: The Limited Liability Effect", *American Economic Review 76*, 956-70.

Brander, J.A. and T.R Lewis, 1988, "Bankruptcy Costs and the Theory of Oligopoly", *Canadian Journal of Economics 21*, 221-43.

Chatelain, J.B.,1999, "Taux de marge et structure financiere", *Annales d'Economie et de Statistique 53*, 127-47.

Chevalier, J.A., 1995, "Capital Structure and Product-Market Competition: Empirical Evidence from the Supermarket Industry", *American Economic Review 85*, 415-35.

Chevalier, J.A., and D.S. Scharfstein, 1995, "Liquidity Constraints and Cyclical Behavior of Markups", *American Economic Review, Paper and Proceedings 85*, 390-6.

Chevalier J.A., and D.S. Scharfstein, 1996, "Capital Market Imperfections and Countercyclical Markups: Theory and Evidence", *American Economic Review 86*, 703-25.

Chirinko, R.S., and S.M. Fazzari, 1994, "Economic Fluctuations, Market Power, and Returns to Scale: Evidence from Firm-Level Data", *Journal of Applied Econometrics 9*, 47-69.

Domowitz, I., R.G. Hubbard, and B.C. Petersen, 1986, "Business Cycles and the Relationship between Concentration and Price-Cost Margins", *Rand Journal of Economics 17*, 1-17.

Domowitz, I., R.G. Hubbard, and B.C. Petersen, 1987, "Oligopoly Supergames: Some Empirical Evidence on Prices and Margins", *Journal of Industrial Economics 36*, 9-28.

Galeotti M., and F. Schiantarelli, 1998, "The Cyclicality of Markups in a Model with Adjustment Costs: Econometric for U.S. Industry", *Oxford Bulletin of Economics and Statistics 60*, 121-42.

Gottfries, N., 1991, “Customer Markets, Credit Market Imperfections and Real Price Rigidity”, *Economica 58*, 317-23.

Green E., and R. Porter, 1984, “Noncooperative Collusion under Imperfect Price Information”, *Econometrica 52*, 87-100.

Hamermesh, D.S., and G.A. Pfann, 1996, “Adjustment Costs in Factor Demand”, *Journal of Economic Literature 34*, 1264-92.

Hansen, L.P., 1982, “Large Sample Properties of Generalized Method of Moments Estimators”, *Econometrica 50*, 1029-54.

Hendel, I., 1996, “Competition under Financial Distress”, *Journal of Industrial Economics 44*, 309-24.

Hendel, I., 1997, “Aggressive Pricing as a Source of Funding”, *Economics Letters 57*, 275-81.

Holt, C., F. Modigliani, J. Muth and H. Simon, 1960, “*Planning Production Inventories, and Work Force”*, Prentice Hall.

Hsiao C., 1986, “Analysis of panel data”, *Econometric Society Monographs no. 11*, Cambridge; New York and Sydney: Cambridge

Hubbard, R.G., 1998, “Capital-Market Imperfections and Investment”, *Journal of Economic Literature 36*, 193-225.

Hubbard, R.G. and A.K Kashyap, 1992, “Internal Net Worth and the Investment Process: An Application to U.S. Agriculture”, *Journal of Political Economy 100*, 506-34.

Hubbard, R.G., A.K Kashyap, and T.M. Whited, 1995, “International Finance and Firm Investment”, *Journal of Money, Credit, and Banking 27*, 683-701.

Klette, T.J., 1999, “Market Power, Scale Economies and Productivity: Estimates from a Panel of Establishment Data”, *Journal of Industrial Economics 47*, 451-76.

Maksimovic, V. 1988, “Capital Structure in Repeated Oligopolies”, *Rand Journal of Economics 19*, 389-407.

Nickell, S., 1986, “Dynamic Models of Labour Demand”, ch. 9 in *Handbook of Labor Economics I*, ed. by O. Ashenhelter and R. Layard, Elsevier Science Publishers.

Nilsen, Ø.A. and F. Schiantarelli, 1998, “Zeroes and Lumps: Investment Patterns of Norwegian Firms”, Working Paper No. 337, Department of Economics, Boston College.

Phillips, 1995, “Increased Debt and Industry Product Markets: An Empirical Analysis”, *Journal of Financial Economics 37*, 189-238.

Rotemberg J.J., and G. Saloner, 1986, “A Super Game Theoretic Model of Price Wars during Booms”, *American Economic Review 77*, 390-407.

Sharpe, S.A., 1994, “Financial Market Imperfections, Firm Leverage, and the Cyclicality of Employment”, *American Economic Review 84*, 1060-74.

Showalter, D.M., 1995, “Oligopoly and Financial Structure: Comment”, *American Economic Review 85*, 647-53.

Stenbacka, R. 1994, “Financial Structure and Tacit Collusion with Repeated Oligopoly Competition”, *Journal of Economic Behavior and Organization 25*, 281-92.

Whited, T.M., 1992, “Debt, Liquidity Constraints, and Corporate Investment: Evidence from Panel Data”, *Journal of Finance 47*, 1425-60.

DATA APPENDIX

1. Criteria for Sample Selection

Firms in which the central or local governments own more than 50 percent of the equity have been excluded from the sample, as well as observations that are reported as "copied from previous year". This actually means missing data. We also excluded observations from auxiliary (non-production) plants as well as plants where part-time employees count for more than 25 percent of the work force. Since the capital stock is used as the denominator in most of the variables used in the regression analysis, we make an attempt to isolate plants whose capital stock has a negligible role in production. Observations where the calculated replacement value of equipment and buildings together was less than NOK 200,000 (1980 prices) are deleted.[15] To avoid measurement errors of production, observations with non-positive production levels are also deleted. The remaining data set was trimmed to remove outlayers. Observations with ratios outside of five times the interquartile range above or below the sector specific median were excluded.[16]

Our analysis is conducted on plants belonging to the manufacturing industry sectors (ISIC code in parentheses): Food (311), Textiles and Clothing (321-324), Wood Products (331-332), Paper and Paper Products (341), Chemicals (351-356), Mineral Products (361-369), Metals (371-372), Metal Products and Machinery (381-382). Some of the plants changed sector during the sample period. We group these plants into the sector where they had their highest frequency of observations.

Finally, we included only series with at least six consecutive observations. Due to leading and lagging when constructing the explanatory variables, we loose two cross-sections. This leaves us with series of at least four consecutive observations.

2. Variable Definition and Construction

Codes in square brackets refer to variable number in the Manufacturing Statistics.

Replacement value of capital stock (q_tK_t): The replacement value of capital is calculated separately for equipment and buildings using the perpetual inventory formula

$$q_t^j K_t^j = q_t^j K_{t-1}^j \cdot \left(1 - d^j\right) \cdot PI_t^j + I_t^j$$

where superscript *j* indicates the different types of capital. Depreciation rates, d^j, are taken from the Norwegian National Accounts (0.06 and 0.02 for equipment and buildings, respectively). Also the price indices for investment, PI_t^j, are taken from the Norwegian National Accounts. When calculating the replacement value of capital, we use as a benchmark the oldest reported fire insurance value ([871] and [881] for equipment and buildings, respectively) larger than or equal to NOK 200,000, measured in 1980 prices. From these initial values we calculate the replacement value backwards and forwards, using the investment figures.[17] Finally we added together the two categories of capital. Real investment

---

[15] Approximately £ 20,000.

[16] We used ratios for output and variable costs.

[17] If the replacement value of capital became negative, it was set equal to zero. When calculating the capital

at time t in capital of type j equals purchases minus sales of fixed capital. Investments in equipment include machinery, office furniture, fittings and fixtures, and other transport equipment, excluding cars and trucks ([501]+[521]+[531]-[641]-[661]-[671]). The measure of buildings includes buildings used for production, offices and inventory storage ([561]-[601]).

Output (p_tY_t): Gross production [1041], plus subsidies [291], and minus taxes [301].

Variable costs: ($w_tL_t + c_tZ_t$): Wage expenses [291] and inputs [1061].

Employees (L_t): Number of employees [131]. The change in the labor stock is defined as $X_{it} = L_{it} - L_{it-1}$. We have assumed that small relative employment changes, $\left(\frac{|X_{it}|}{L_{it}} - a\right) < 0.05$, are zero.

Interest Expenditure (IR/CF): Profit before year-end adjustments $[310]_{\text{Accounts}}$ normalised with the cash-flow defined as the sum of Operating Profit $[2400]_{\text{Accounts}}$, Depreciation $[2290]_{\text{Accounts}}$, and Wage Expences $[2120+2140]_{\text{Accounts}}$.

Real interest rates (i_t): We have used interest rates for loans with three months duration (NIBOR) minus the Consumer Price Index.

Price indices (p_t): Price indices for industry sectors gross output collected from National Accounts.

Gross Domestic Product (GDP_t): The industry sector values are collected from National Accounts. The GDP_t values are annual. For sectors where the National Accounts give information at a less aggregated level than our sector specification, we have used the more detailed information.

---

stock forward it may happen that the replacement value becomes negative because of large sales of capital goods. When calculating it backwards the replacement value becomes negative if the net purchase of fixed capital is larger than the replacement value in year *t+1*.

Table 1. Summary statistics

Sectors	Food (311)	Textiles and Clothing (321-324)	Wood Products (331-332)	Paper (341)	Chemicals (351-356)	Mineral Products (361-369)	Metals (371-372)	Metal Products and Machinery (381-382)
pY/qK	2.216	1.412	1.440	0.917	1.329	1.119	1.113	1.527
(wL+cZ)/qK	2.107	1.330	1.309	0.840	1.162	0.996	0.987	1.426
Int. exp/ cash flow	0.105	0.097	0.123	0.106	0.113	0.109	0.144	0.088
L_{it}	71	91	82	128	91	102	175	104
$\Delta L_{it}/L_{it}$	-0.019	-0.048	-0.016	-0.027	-0.036	0.028	-0.008	-0.028
Freq.								
$\Delta L_{it}/L_{it} < -0.05$	0.307	0.394	0.288	0.296	0.329	0.322	0.287	0.327
$-0.05 <= \Delta L_{it}/L_{it} <= 0.05$	0.441	0.415	0.441	0.488	0.435	0.445	0.447	0.423
$0.05 < \Delta L_{it}/L_{it}$	0.252	0.191	0.271	0.215	0.236	0.233	0.267	0.250
$\Delta L_{it}/L_{it} = 0$	0.179	0.091	0.125	0.104	0.103	0.121	0.047	0.091
Nbr. of firms	305	71	128	65	106	64	30	186
Nbr. of observations	2118	530	1073	537	876	544	300	1490

Sector	Food (311)	Textiles and Clothing (321-324)	Wood Products (331-332)	Paper (341)	Chemicals (351-356)	Mineral Products (361-369)	Metals (371-372)	etal Products and Machinery (381-382)
μ^0	0.980	1.084*	1.045	1.078*	1.009	1.064	1.078	1.002
	(0.040)	(0.030)	(0.063)	(0.028)	(0.085)	(0.071)	(0.055)	(0.047)
μ^1	0.034	-2.730*	0.330*	0.227	0.156	-0.847*	0.055	0.219
	(0.065)	(0.068)	(0.164)	(0.196)	(0.104)	(0.314)	(0.133)	(0.143)
s	34.498	1.093	38.474	2.613	0.000	4.565	7.151	2.044
	(20.393)	(2.423)	(20.663)	(6.948)	(24.988)	(41.056)	(23.851)	(2.991)
α	7.063	41.036	11.409	13.057	3.227	0.000	28.719	7.840
	(3.876)	(70.369)	(7.062)	(26.413)	(1.7 E+9)	(108.450)	(71.776)	(47.986)
m2 -test	-1.90	0.12	-0.62	-0.78	-1.73	1.63	-1.90	-0.70
p-value	0.06	0.91	0.53	0.44	0.08	0.10	0.06	0.49
Sargan	35.28	37.13	169.67	79.51	46.31	43.24	73.46	61.05
p-value	0.82	0.76	0.00	0.00	0.38	0.50	0.00	0.05
Instruments used:	*t*-2	*t-2*	*t-1, t*-2	*t*-2	*t*-2	*t*-2	*t*-2	*t*-2
Nbr. of firms	305	71	128	65	106	64	30	186

* Indicates significance at the 5 % level.

1) Dependent variable is pY. All variables are normalised with qK
2) For variable definitions, see Data Appendix.
3) All standard errors in parentheses are robust to heteroskedasticity.
4) m2 is a test of second order serial correlation.
5) Sargan/Hansen is the Sargan/Hansen test of overidentification restrictions.

Sector	Food (311)	Textiles and Clothing (321-324)	Wood Products (331-332)	Paper (341)	Chemicals (351-356)	Mineral Products (361-369)	Metals (371-372)	etal Products and Machinery (381-382)
μ^0	1.005	1.078*	1.140*	1.033*	1.021	1.149*	0.993	1.042*
	(0.016)	(0.006)	(0.004)	(0.008)	(0.038)	(0.025)	(0.033)	(0.018)
μ^1	0.077*	-0.257*	0.269*	0.478*	0.116*	-0.883*	0.226*	0.193*
	(0.031)	(0.015)	(0.017)	(0.024)	(0.040)	(0.102)	(0.093)	(0.054)
s	15.791*	0.232	0.000	0.000	0.000	0.000	0.000	0.447
	(7.957)	(0.816)	(0.847)	(1.344)	(7.246)	(6.500)	(16.987)	(1.667)
α	12.931*	123.257	1.889	0.426	0.263	28.015	0.203	18.175
	(5.819)	(427.943)	(1.7 E+8)	(2.5 E+10)	(1.4 E+10)	(7.1 E+11)	(6.3 E+12)	(119.637)
m2-test	-1.95	0.26	-0.64	-0.65	-1.26	1.66	-1.90	-0.78
p-value	0.05	0.80	0.52	0.52	0.21	0.10	0.06	0.44
Sargan	38.52	43.60	99.50	45.86	45.33	43.17	14.47	55.19
p-value	0.71	0.49	0.33	0.40	0.42	0.51	1.00	0.12
Instruments used:	*t*-2	*t-2*	*t-1*, *t*-2	*t*-2	*t*-2	*t*-2	*t*-2	*t*-2
Nbr. of firms	305	71	128	65	106	64	30	186

Notes: See Table 2.

Sector	Food (311)	Textiles and Clothing (321-324)	Wood Products (331-332)	Paper (341)	Chemicals (351-356)	Mineral Products (361-369)	Metals (371-372)	etal Products and Machinery (381-382)
μ^0	1.005	1.078*	1.093*	1.008	1.037	1.177*	1.071*	1.036*
	(0.017)	(0.005)	(0.022)	(0.014)	(0.034)	(0.027)	(0.031)	(0.018)
μ^1	0.076*	-0.271*	0.319*	0.412*	0.006	-0.575*	0.012	0.174*
	(0.032)	(0.015)	(0.050)	(0.048)	(0.042)	(0.084)	(0.099)	(0.055)
s	23.610*	1.384	0.000	0.000	0.807	0.000	0.000	0.000
	(11.238)	(0.878)	(9.903)	(4.237)	(8.188)	(9.494)	(23.847)	(1.928)
α	11.055*	24.385	5.553	1.543	0.000	0.594	1.401	1.036
	(4.483)	(15.263)	(6.5 E+11)	(1.8 E+9)	(143.968)	(3.5 E+12)	(1.1 E+7)	(1.6 E+10)
m2 -test	-1.99	0.02	-0.66	-0.20	-1.20	1.74	-2.02	-0.79
p-value	0.05	0.81	0.51	0.84	0.23	0.08	0.04	0.43
Sargan	35.68	45.96	97.82	39.47	44.53	40.94	13.96	56.55
p-value	0.81	0.39	0.37	0.67	0.45	0.60	1.00	0.10
Instruments used	*t* -2	*t-2*	*t-1*, *t* -2	*t* -2	*t* -2	*t* -2	*t* -2	*t* -2
Nbr. of firms	305	71	128	65	106	64	30	186

Notes: See Table 2.

Sectors	**Food (311)**	**Textiles and Clothing (321-324)**	**Wood Products (331-332)**	**Paper (341)**	**Chemicals (351-356)**	**Mineral Products (361-369)**	**Metals (371-372)**	**etal Products and Machinery (381-382)**
μ^0	0.998	1.064*	1.093*	1.008	1.037	1.777*	1.071*	1.036*
	(0.017)	(0.005)	(0.022)	(0.014)	(0.034)	(0.027)	(0.031)	(0.018)
μ^1	0.084*	-0.269	0.319*	0.412	0.058	-0.575*	0.012	0.174*
	(0.032)	(0.015)	(0.050)	(0.048)	(0.042)	(0.084)	(0.099)	(0.055)
s	26.286(*)	3.306*	0.000	0.000	0.807	0.000	0.000	0.000
	(11.238)	(0.877)	(9.903)	(4.237)	(8.188)	(9.494)	(23.847)	(1.928)
α	5.000(*)	5.000*	0.966	2.872	0.000	3.659	4.437	2.826
	(2.782)	(1.946)	(4.9 E+11)	(9.7 E+8)	(143.968)	(1.1 E+7)	(8.6 E+9)	(4.0 E+7)
m2-test	-1.99	0.02	-0.66	-0.20	-1.20	1.74	-2.02	-0.79
p-value	0.05	0.81	0.51	0.84	0.23	0.08	0.04	0.43
Sargan	35.68	45.96	97.82	39.47	44.53	40.94	13.96	56.55
p-value	0.81	0.39	0.37	0.67	0.45	0.60	1.00	0.10
Instruments used	*t*-2	*t-2*	*t-1*, *t*-2	*t*-2	*t*-2	*t*-2	*t*-2	*t*-2
Nbr. of firms	305	71	128	65	106	64	30	186

Notes: The results in this table is based on the same set of unrestricted estimates as in the previous table.
See also notes in Table 2.