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An Empirical Analysis of Norwegian Firms

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Abstract:
This paper investigates the relationship between a firm's investment decision and its financial situation. We present a model of investment, where the cost of external finance is increasing in the debt ratio. The model is estimated using a panel of Norwegian manufacturing establishments for the period 1977-1990. The empirical analysis finds a positive relationship between a firm's debt ratio and its marginal return to capital. This indicates that firms with high debt ratios have higher costs of finance than other firms. Including convex adjustment costs in the model did not change this result, as the size of the adjustment costs was found to be very small.

Keywords: Investment, Financial markets, Panel data.

JEL classification: E22, G31, G32.

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1 Introduction

Will a market economy always supply funds for profitable investment projects? The answer to this question is important for policy makers seeking economic efficiency at the micro level, and for our understanding of the business cycle at the macro level. The purpose of this paper is to investigate the presence and the economic importance of credit market imperfections within a structural model of firm investment.

Modigliani and Miller (1958) presented conditions under which a firm's investment decision is independent of its financial situation. Newer theory has shown that there are several reasons to expect a wedge between the cost of outside and inside finance. First, there are transaction costs associated with debt and outside equity. Second, debt is costly if there are dead weight costs associated with bankruptcy. These costs can be both direct, for example in the form of fees to lawyers, or indirect in the form of lost reputation for the firm or the manager. Jensen and Meckling (1976) have pointed out that debt has an agency cost; limited liability will give the equity owners and the managers incentives to take on too risky projects because they will get the benefits of the projects without paying the costs. Finally, if there is a problem of asymmetric information between insiders and outsiders, the cost of outside finance might include a lemons premium, as suggested by Meyers and Majluf (1984).

A possible implication of financial constraints is that investment for constrained firms should be characterized with excess sensitivity to cash flow. However, a positive relationship between cash flow and investment has no clear interpretation. This is because cash flow not only measures liquidity, but also is a good proxy for the marginal product of capital, both in current and future periods.

To analyze our problem we need a structural model of investment, and a specification of how a financial constraint enters this model. We model the investment decision by assuming that there are convex adjustment costs associated with investment, and that firms have rational expectations. Future investment decisions can then give us information about current expectations, and the optimal investment path can be described in a dynamic, stochastic model. If capital is freely adjustable, the optimal capital stock can be described in a user price model — a special case of the model above.

We will not try to distinguish between the different theories of capital market imperfections [2], but simply model the interest rate on debt as increasing

[2] See Oliner and Rudebush (1992) for an empirical investigation of the source of the finance hierarchy.

in the debt to assets ratio. We then test the dependence of investment on financial factors by estimating over different sub samples where we expect different degrees of credit market imperfections. A priori we expect that credit constraints might vary over time, with firm size, with a firm's dividend and equity policy and with a firm's access to foreign capital. In this paper we will focus on differences over time and across different firm sizes.

The implications of credit constraints in our investment model are empirically testable. A credit constrained firm will act as if it faced a higher user price on capital than an unconstrained firm. An additional implication can be derived if adjustment costs are convex and of substantial economic importance. A credit constraint will then affect a firm's smoothing of investments over time, while adjusting to the optimal level of capital stock.

The empirical model is estimated using a panel of Norwegian manufacturing firms for the period 1977-1990. Over these years the financial sector went through large changes. A significant deregulation of the credit market took place in 1984, and in the late 1980s several large banks experienced financial distress. This raises two important questions: First, did the credit market deregulation lead to a structural change in the relationship between investment and finance? And second, how did the bank crisis affect the allocation of funds among firms competing for a limited pool of external finance?

This paper is organized as follows. The next section discusses some related papers. Section 3 presents a model of investment where the firm's cost of outside finance is increasing in its debt ratio. The econometric method is discussed in section 4. Section 5 describes the data and how the sample and the variables are constructed. In section 6 we present the results of our econometric analysis. The final section summarizes and concludes.

2 Other Studies of Investment and Finance

Two approaches appear in the literature of investment with adjustment costs: The Euler equation approach and the Tobin's q approach. The approaches differ by how the expected net present value of the marginal return to capital is measured. The Tobin's q approach uses the stock market valuation of the firm to measure future returns to capital, while the Euler equation approach equates these to the marginal cost of capital in the next period. Since share prices only were available for a small number of firms in our sample, and it is firms that are not publicly traded that are most likely to face capital market imperfections, this paper uses the Euler equation approach. Both approaches have been used to analyze the relationship between finance and investment. A brief overview of the literature with special emphasis on the Euler equation approach is given below.

2.1 The Tobin's q approach

This literature studies a regression of investment on cash flow, output, Tobin's q and other variables. A large coefficient for cash flow is taken as an indication of financial constraints. Separate parameters are estimated for various classes of firms where one expects different degrees of credit rationing.

Fazzari et al. (1988) use U.S. manufacturing data and estimate separate q models for firms that pay high and low dividends. They find that cash flow has the highest influence on investment for low dividend firms. This seems consistent with financial constraints, since low dividend firms are less likely to have internal funds available to finance investment projects.

Devereux and Schiantarelli (1990) use U.K. manufacturing data and classify firms by size, age and characteristics of their industry. In most cases cash flow is found to have the highest impact on investment when information problems are present.

In a similar fashion Hoshi et al. (1991) examine two groups of Japanese firms. They find that investment is least sensitive to cash flow for firms that are members of industrial groups with close relationships to banks.

Though the method seems intuitive and "excess sensitivity" of investment to cash flow has been documented in numerous papers, there are several problems with the q approach. A serious deficiency of the model is that cash flow is included in an ad hoc manner. Chirinko (1993) discusses how capital constraints may even be captured by q. In addition to this, the empirical results generally find that q does not explain investment well and that the estimated adjustment cost parameter is unreasonably large. An alternative explanation for the "excess sensitivity" result is that the firms that are thought to be constrained face larger uncertainty than more established firms, and therefore respond more strongly to information about the future embodied in current cash flow.

2.2 The Euler equation approach

This approach was pioneered by Zeldes (1989) who estimated Euler equations for consumers with different levels of wealth. A similar method is used in the investment literature which examines an Euler equation of investment, derived under the assumption of an exogenous constraint on the firm's level of debt. Unless the value of an unobserved multiplier is included, the Euler equation will be misspecified. The model without a constraint is then estimated for sub samples where different degrees of credit constraints are expected, and the existence of credit constraints is examined with a specification test. This method is unsatisfactory because there are several reasons a specification test can reject the model, and even if the model is rejected because of credit constraints the method does not say much about their economic importance. This line of analysis has been extended by modeling the multiplier on the credit constraint as a function of observables, but this is done in an ad hoc manner.

Hubbard and Kashyap (1992) estimate Euler equations for investment using aggregate data for U.S. agriculture for the period 1914-1987. A GMM estimator allows a test of the overidentifying restrictions of the model. The overidentifying restrictions are rejected unless a measure of net worth is included in the instrument set. Estimating the model over only the years in which net worth was increasing, helps the model pass the specification test. They also parameterize the multiplier for the credit constraint as a function of net worth. This term is found significant when included in the Euler equation.

Similarly, but using firm level panel data, Whited (1992) models the degree of credit rationing as a function of the debt to assets ratio and the interest coverage ratio. Separate Euler equations for firms grouped by these variables are estimated. Assuming that a firm can reduce the difference in information between insiders and outsiders by having its debt rated, she also splits the sample into firms with and without bond ratings. The results show that the proxies for credit rationing are significant. Using the test of overidentifying restrictions, the model is accepted for firms with low debt to assets ratios and interest coverage ratios and rejected for firms with high debt to assets ratios and interest coverage ratios. The difference between the firms with and without bond ratings is less apparent.

This approach is continued in Hubbard, Kashyap and Whited (1993) where the multiplier for the credit constraint is modeled as a function of cash flow and the change in the spread between the risky and the safe interest rates. The latter is meant to capture the tightness of borrowing constraints at the macro level. When only cash flow is included the overidentifying restrictions are rejected and the effect on the discount rate is found to be small, but significant. When both measures are included the overidentifying restrictions are no longer rejected and the effect on the discount rate is larger. The authors point out that one reason for this result can be that their regressions do not include time dummies.

A weakness of the models above is that the credit constraint is taken as exogenous in the modeling of optimal investment. A firm's investment or debt policy today will affect its probability of being constrained tomorrow. Bond and Meghir (1992) take this into account and include an interest rate premium on debt instead of an absolute constraint on the debt level. The model is estimated for a panel of U.K. manufacturing companies. Their empirical model does not use the Euler equation for debt and is therefore only specified correctly for firms that are not credit constrained. They find that measures of cash flow can explain investment and that this effect is strongest for firms that pay low dividends or firms that issue new equity.

Jaramillo, Sciantarelli and Weiss (1993) estimate Euler equations for a panel of Ecuadorian firms. Their model includes both an increased cost of borrowing and an exogenous ceiling for the debt to capital ratio, but assumes that the firm pays positive dividends. The results indicate that small and young firms are credit constrained, while large and old firms are not. The paper also finds that financial deregulation in Ecuador in the 1980s did not relax the constraint for small firms.

The Euler equation approach has successfully overcome most of the criticism of the models within the q approach. Little effort, however, has been spent specifying alternative adjustment cost technologies, and one should therefore be careful interpreting the results.

3 The Model

In this section we present the standard adjustment-cost model for investment. As in Bond and Meghir (1992) we model financial constraints by assuming that the firm's cost of funds is increasing in its debt to assets ratio. This interest rate premium is meant to capture three costs of external finance: from dead weight loss associated with bankruptcy, from the agency cost of debt and from a lemons premium. Our assumption is that all these costs, or the probabilities of incurring them, increase as a firm's level of debt increases relative to the value of its collateral.

The advantages of modeling financial constraints in the way described above are that we endogenize the firm's cost of external finance and that this cost has an easy interpretation. The disadvantage is that with our choice of functional forms, we exclude the possibility that firms are constrained in a non-smooth way. Our empirical model differs from that of Bond and Meghir

(1992) in that it is derived from the first order conditions for *both* investment and debt.

3.1 Theoretical Assumptions

We assume that the manager of the firm behaves in the interest of the current owners and maximizes the present value of their dividends , D_{t+j}

$$V_t = E_t \sum_{j=0}^{\infty} \beta_{t+j}(D_{t+j}) \tag{1}$$

Here $\beta_{t+j} = \Pi_{k=1}^{j}(\frac{1}{1+r_{t+k}})$ is the discount factor between period t and $t+j$. The dividends in period t are given by:

$$D_t = \Pi(K_t, L_t, I_t) + B_t - (1 + i\,(B_{t-1}, q_{t-1}K_{t-1}))B_{t-1} \tag{2}$$

where B_t is the net debt of the firm at time t, K_t the capital stock and i the interest rate. Profits are given by:

$$\Pi(K_t, L_t, I_t) = P_t(Y)\,[F(K_t, L_t) - G(K_t, I_t)] - w_t L_t - q_t I_t \tag{3}$$

where $Y(\cdot) = F(\cdot) - G(\cdot)$ is output net of adjustment costs, L_t variable factors and I_t investment with prices $P(Y)$, w_t and q_t respectively.

Two remarks about the model are necessary at this point. First, we assume that tax incentives and transaction costs make debt a cheaper form of finance than new equity, and do not include new share issues in our model. An alternative interpretation could be that the cost of new equity also is increasing in the debt ratio. Second, the fact that firms pay different interest rates is of course not an indication of imperfect credit markets. Stiglitz (1969) shows that the Modigliani-Miller theorem is also valid for the case with a given probability of bankruptcy. In this case the differences in the interest rates on debt reflect differences in the probability of bankruptcy. The interest rate premium on debt in our model is therefore meant to capture costs in addition to those reflecting a given probability of bankruptcy.

The firm maximizes V_t subject to:

$$K_t = (1 - \delta)K_{t-1} + I_t \tag{4}$$

$$D_t \geq 0 \tag{5}$$

(4) is the capital accumulation constraint. (5) restricts dividends to be positive and prevents a constrained firm from borrowing at the discount rate. Letting

λ_t denote the multiplier for the constraint in (5), the value function for the maximization problem is:

$$\max_{I,L,B} V_t(K_{t-1}, B_{t-1}) = (1+\lambda_t)\left[\Pi((1-\delta)K_{t-1}+I_t, L_t, I_t) + B_t - (1+i(\cdot))B_{t-1}\right] + E_t\left[\frac{1}{1+r_{t+1}} V_{t+1}((1-\delta)K_{t-1}+I_t, B_t)\right] \tag{6}$$

First order conditions for L,I and B together with envelope results are given in appendix A. Combining these we get the Euler equations for capital, (7), and debt, (8):

$$-\left(\frac{\partial \Pi}{\partial I}\right)_t = \left(\frac{\partial \Pi}{\partial K}\right)_t - (1-\delta)E_t\left[\frac{1}{1+r_{t+1}}\Lambda_{t+1}\left(\frac{\partial i}{\partial K_t}\right)B_t + \frac{1}{1+r_{t+1}}\Lambda_{t+1}\left(\frac{\partial \Pi}{\partial I}\right)_{t+1}\right] \tag{7}$$

$$\frac{1}{(1+i(B_t,K_t)+B_t\frac{\partial i(\cdot)}{\partial B_t})} = E_t\left[\frac{1}{1+r_{t+1}}\Lambda_{t+1}\right] \tag{8}$$

Here $\Lambda_{t+1} = \frac{1+\lambda_{t+1}}{1+\lambda_t}$ is the shadow value of funds in the next period relative to the present period.

Ignoring capital constraints we see that (7) equates the marginal cost of investing to the expected marginal revenue, where marginal revenues from period $t+1$ onwards are equated to marginal cost in period $t+1$. The equation can be solved forward to see that the marginal cost of investing should be equal to the expected discounted sum of marginal revenues. (8) gives the relationship between the firm's discount rate and the rate at which it borrows. We see that in the absence of financial constraints these rates must be equal if the maximization problem has an interior solution for debt.

Including a constraint on positive dividends we see that all revenues and costs are valued at the appropriate shadow value of funds. An interest rate premium on debt has two effects on a firm's Euler equations. First, investment implies increased collateral which may lower the cost of external finance in the future. This is the first term on the right hand side of (7). Second, from (8) we see that firms with high debt ratios behave as if they have a lower discount factor than firms with low debt ratios. Financially constrained firms value income today higher than income tomorrow.

3.2 Empirical Specification

In order to derive an empirical model we need to make further assumptions about expectations, demand, technology and the relationship between the debt ratio and the interest rate. We can remove the expectation operator in both the Euler equations by adding an expectation error. Under the assumption of rational expectations, this error is orthogonal to information available at time t. We assume a constant markup, $\mu = (1 - \frac{1}{\epsilon^D})^{-1}$, where ϵ^D is the price elasticity of demand. We also assume constant elasticity of scale, $\nu = \frac{\partial F}{\partial L}\frac{L}{F} + \frac{\partial F}{\partial K}\frac{K}{F}$. Adjustment costs that are convex in I_t and decreasing in K_t, are specified as in Summers (1981):

$$G(I_t, K_t) = \frac{b}{2}\left(\frac{I}{K}\right)_t^2 K_t \tag{9}$$

These assumptions give:

$$\left(\frac{\partial \Pi}{\partial I}\right)_t = -p_t \frac{1}{\mu} b \left(\frac{I}{K}\right)_t - q_t \tag{10}$$

$$\left(\frac{\partial \Pi}{\partial K}\right)_t = \frac{\nu}{\mu}\left(\frac{pY}{K}\right)_t - \left(\frac{wL}{K}\right)_t + \frac{1}{\mu} p_t b \left(\frac{I}{K}\right)_t^2 \tag{11}$$

The cost of outside finance is modeled as an interest rate premium, where the interest rate is linear in the debt to assets ratio:

$$i_t = i_t^0 + a\frac{B_{t-1}}{q_{t-1}K_{t-1}} \tag{12}$$

The Euler equation for debt is then:

$$\frac{1}{1 + i_{t+1}^0 + 2a(\frac{B}{qK})_t} = \frac{1}{1 + r_{t+1}}\Lambda_{t+1} + \epsilon_{t+1}^b \tag{13}$$

In appendix B we show how (10), (11) and (13) together with (7) and (8) after some simplifications gives :

$$\begin{aligned} \left(\frac{Y}{K}\right)_t = {} & \frac{\mu}{\nu}\left\{\pi_1 \left(\frac{L}{K}\right)_t\right\} \\ & + \frac{a\mu}{\nu}\left\{\pi_2 \left(\frac{B}{K}\right)_t - \pi_3 \left(\frac{B}{K}\right)_t^2\right\} \\ & + \frac{b}{\nu}\left\{\pi_4 \left(\frac{I}{K}\right)_t - \pi_5 \left(\frac{I}{K}\right)_t^2 - \pi_6 \left(\frac{I}{K}\right)_{t+1}\right\} \\ & + \frac{ab}{\nu}\left\{\pi_7 \left(\frac{B}{K}\right)_t \left(\frac{I}{K}\right)_{t+1}\right\} + f_i + d_t + e_{i,t+1} \end{aligned} \tag{14}$$

This is the estimated model. Here the π's are all positive parameters that are calculated from the depreciation rate, the interest rate and prices of output and capital. The "deep" parameters of the model are μ, ν, a and b.

For the model without adjustment costs and financial constraints ($a = 0$ and $b = 0$) our equation sets the return to capital equal to the user price which is captured by the time dummy, d_t. This allows the user price to vary across different time periods, as the interest rate and the inflation rate changes. When we include the cost of debt finance, but not adjustment costs, we see that firms with a high debt ratio act as if they face a higher user price. This is because these firms must cover higher financing expenses.

If convex adjustment costs are included, the marginal cost of investing will be increasing in the size of the investment. The higher the level of current investment, the higher is the required return to capital. Because large changes in the investment level are costly when adjustment costs are convex, current period's investment should be positively correlated with next period's investment. Next period's investment therefore enters with the opposite sign. The dynamic effects of financial constraints are easier to analyze if we solve the model with respect to current period's investment. We see that a constrained firm will invest less today than an unconstrained firm — given the same level of marginal product of capital today and expected investment tomorrow. The two final terms, f_i and $e_{i,t+1}$ are discussed in the next section.

4 Econometric Method

Since $e_{i,t+1}$ contains an expectation error it will not be orthogonal to information available after the investment decision was made. We use a GMM estimator where the right hand side variables are instrumented with predetermined variables. The theoretical model indicates that variables dated t and earlier are valid instruments, but this is due to our assumption that investment is productive immediately. If investment first is productive in the next period, or shocks to the production function are realized after the investment decision is made, variables dated $t-1$ and earlier are valid instruments. An additional reason for instrumenting is that productivity shocks may cause variable costs to be correlated with the error term, see Mundlak and Hoch (1965). The Sargan/Hansen test of overidentifying restrictions is used to choose the preferred instrument set.

The key identifying assumptions is that the error term, $e_{i,t+1}$ is uncorrelated with the instruments. This will not be the case if a substantial part of the error is due to macroeconomic shocks. We include time dummies to remove this correlation. The time dummies also measure the user price of capital. The firm effect, f_i, is included to capture variation in the user price across firms, and to capture omitted inputs as, for example, R&D capital. Since the traditional method of removing a fixed effect by subtracting firm means introduces a bias in short panels when instruments are not strictly exogenous, the variables are transformed to deviations from means of future values (orthogonal deviations). See Arrelano and Bond (1991) and Keane and Runkle (1992). Because most of the variation in debt ratios is across firms, we also report regressions with variables in levels and industry dummies. All regressions are performed using the program DPD for GAUSS, documented in Arrelano and Bond (1988).

5 Data

5.1 Data sources

Our data set is an unbalanced panel of Norwegian firms in the manufacturing sector (ISIC 31-38) for the period 1977-1990. The source for financial variables is the Statistics of Accounts[3], which gives income statement and balance sheet information for all firms in the manufacturing sector with more than 50 employees. A firm (enterprise) is defined as the "smallest legal unit comprising all economic activities engaged in by one and the same owner." Firms are classified into ISIC industry subgroups by their main activity.

These data are merged with the Manufacturing Statistics[4], which include information about ownership, production, costs, investment and capital stock at the plant/establishment level. The Manufacturing Statistics is a yearly survey of all firms in the manufacturing industry. When aggregating from the plant level to the firm level we included all plants with more than five employees.

5.2 Variables

Our measure of investment is an aggregate of gross investment in machinery, buildings and transport equipment, the latter of minor importance compared to the first two. We also tried to include purchases and sales of plants in our investment variable, but this did not change our conclusions below. For capital stock we used the fire insurance values of buildings and machinery, and the

[3]See NOS (1990) and earlier for documentation and a list of variables.
[4]See Halvorsen et al. (1991) for documentation and a list of variables.

book value of transport equipment. By using fire insurance values we avoided constructing a capital stock measure from the perpetual inventory formula, which needs several years of observations and may induce a time varying measurement error. Our sales variable is corrected for taxes and subsidies. Variable costs include inputs and wages. Constructing the net debt ratio we used book value of long term debt, net of fixed assets not included in our measure of capital stock. Further details are given in appendix C.

5.3 Data set construction

In selecting our final sample we deleted firms where more than 50% of the equity is owned by central or local government. Except for a small number of private firms and cooperatives, this left almost exclusively corporations in the sample. Trying to isolate measurement errors in the capital stock and firms for which the capital stock has a negligible role in production, we also deleted observations if the yield to capital was outside a range of $\pm$ 0.6 from the industry's yearly median. For similar reasons we deleted observations if long term debt and working capital was more than 50% larger than the capital stock. Finally, we kept only the observations where at least four consecutive years were observed. This is the lowest number of consecutive observations per firm needed to estimate the model with lagged values as instruments, fixed effect and adjustment costs. Together this construction reduced the number of observations by about 25%. Summary statistics for the sample and the variables are provided in appendix D.

6 Results

This section reports results for three alternative model specifications. Separate parameters are estimated for three different time periods[5] and for three sizes of firms[6]. The main objective of our empirical analysis is to estimate the parameter a and to study its variation across firm sizes and time periods. Estimating separate parameters for different subsamples also gives us a specification test for the modeling of demand and technology. Both OLS and GMM estimates are reported. We focus on the results where variables are transformed to orthogonal deviations, since the hypothesis of no fixed effect was strongly rejected for all models estimated by OLS. All tables are found in

[5] 1977-83, 1984-87 and 1988-90.

[6] small firms (50-100 employees), medium firms (100-500 employees) and large firms (500+ employees).

appendix D.

We start with the model without adjustment costs. Table 1 shows that there is a significant positive relationship between the marginal return to capital and the debt ratio. This result holds both when the model is estimated in levels and in deviations, and with and without instruments. Also notice the estimates of $\frac{\mu}{\nu}$. If we assume constant returns to scale this indicates a small but significant markup of prices over marginal costs of about 2-3%. This is slightly lower than what is found on a larger sample in Klette (1993).

In table 2 we estimate separate parameters for different size firms. For the estimates in deviations with lagged values of the right hand side variables as instruments, we see that the estimate of a is larger for small firms compared to medium and large size firms. This confirms the results from other studies in the literature — small firms are more likely to be credit constrained than larger firms.

Table 3 shows estimates for three different time periods — we see that the estimates of a from table 1 seem to be stable over the first two periods. This indicates that the credit market deregulation did not change the way funds were allocated among firms. For the last period (1988-90) we find a smaller and insignificant estimate. An explanation for this result can be that the most constrained firms left our panel in this period, due to bankruptcy or ownership changes. To test this explanation we estimated the model only for firms that existed in 1990. This also gave significant estimates of a in the first two periods, but not for 1988-90 (not reported). An alternative explanation is that this period has too few observations to obtain precise estimates after the fixed effect is removed.

Tables 4-6 give results for the model with adjustment costs. The estimate of a does not seem to be sensitive to the inclusion of adjustment costs. The estimate of the adjustment cost parameter, b, is generally found to be insignificant or very small. In most cases even a "large" investment gives an adjustment cost of less than 1% of the investment expenditure[7]. We also tried to estimate the model using next period's investment as the dependent variable, but in most cases this gave negative values for the estimated adjustment cost parameter. A similar result was found by Bond and Meghir (1992). One explanation for this result is that the adjustment cost technology is misspecified. Another explanation is that adjustment costs are very small or non convex. If the latter is the case, a model with investment as the dependent variable has no clear

[7]For an investment expenditure equal to 30% of the value of the capital stock, an adjustment cost parameter of 0.10 gives an adjustment cost of $\frac{0.1}{2}0.3I = 0.015I$, that is 1.5% of the value of the investment.

interpretation. We are therefore left with the user cost interpretation of the model.

So far we have only included long term assets and liabilities. Short term assets can be thought of both as a factor of production and as a source of finance. In the last specification we include working capital, short term assets net of short term debt, $\frac{A^S - B^S}{K}$. Fazzari and Petersen (1993) include the change in working capital in a q-model of investment and find that working capital is an input that competes with fixed investment for finance. Tables 7-9 report results for this model. In table 7 we see that working capital enters with a positive coefficient. This was to be expected if working capital is an input. The estimates of a are somewhat reduced, but note that for the model in deviations the Sargan test rejects the overidentifying restrictions of the model. This indicates that we have an endogeneity problem for working capital.

A high level of working capital may signal that a firms financial situation is good, and reduce its required return to capital. Working capital should therefore enter the user price model with a lower coefficient for constrained firms than for unconstrained firms. In table 8 we see that the estimated coefficients are lowest for small firms, though the difference is not significant. The results from the last specification are somewhat inconclusive, but indicate that a closer study of the role of working capital, including inventory behaviour, is an interesting topic for future research.

7 Conclusion

This paper has two conclusions. The main result of the paper is that there exists a positive relationship between a firm's debt ratio its marginal return to capital. The relationship is economically (and statistically) significant. A 10 percentage point increase in a firm's debt ratio increases the required return on capital by 1/2 to 1 percentage point. The effect seems to be strongest for small firms. It is also robust with respect to the deregulation of the credit market in the mid-1980s, but somewhat surprisingly it seems to disappear in the last years of our analysis.

The second result is that our estimates of adjustment costs are very small compared to what has been found in the studies discussed in section 2 of this paper. For most studies within the Euler equation approach, adjustment costs amount to 10-20% of the average investment expenditure, which is still very little compared to results for Tobin's q models. Further research within this area should extend the adjustment costs model, both using different functional forms and considering non-convex adjustment costs and irreversibility.

Numerous studies, including this, find that small and young firms are most prone to be financially constrained. This indicates that additional evidence of financing constraints can be found by studying the smallest firms in the Manufacturing Statistics. For these firms, however, balance sheet information of the type used in this paper is unavailable, and thus a different approach is needed.

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Appendix A: Envelope and first order conditions

$$\left(\frac{\partial \Pi}{\partial L}\right)_t = 0 \tag{15}$$

$$(1+\lambda_t)\left(\frac{\partial \Pi}{\partial K}\right)_t + (1+\lambda_t)\left(\frac{\partial \Pi}{\partial I}\right)_t + E_t\left[\frac{1}{1+r_{t+1}}\frac{\partial V_{t+1}}{\partial K_t}\right] = 0 \tag{16}$$

$$\frac{\partial V_t}{\partial K_{t-1}} = (1+\lambda_t)(1-\delta)\left(\frac{\partial \Pi}{\partial K}\right)_t - (1+\lambda_t)B_{t-1}\left(\frac{\partial i}{\partial K_{t-1}}\right) + (1-\delta)E_t\left[\frac{1}{1+r_{t+1}}\frac{\partial V_{t+1}}{\partial K_t}\right] \tag{17}$$

$$(1+\lambda_t) + E_t\left[\frac{1}{1+r_{t+1}}\frac{\partial V_{t+1}}{\partial B_t}\right] = 0 \tag{18}$$

$$\frac{\partial V_t}{\partial B_{t-1}} = -(1+\lambda_t)\left(1 + i_t + B_{t-1}\frac{\partial i}{\partial B_{t-1}}\right) \tag{19}$$

Combining (16) with (17) for period t and $t+1$ gives (7). Combining (18) with (19) for period $t+1$ gives (8).

Appendix B: The simplified Euler equation

To derive a model which is linear in the parameters we use a first order Taylor approximation of (13):

$$\frac{1}{1+i^0_{t+1}} - \frac{1}{(1+i^0_{t+1})^2}2a\left(\frac{B}{qK}\right)_t \approx \frac{1}{1+r_{t+1}}\Lambda_{t+1} + \epsilon^b_{t+1} \tag{20}$$

Inserting (10), (11) and (20) into (7), and multiplying trough by $\frac{\mu}{\nu q_t}$ we get [8]:

[8] We have assumed that ϵ^b_{t+1} is uncorrelated with variables in the Euler equation for capital. As discussed in Hubbard, Kashyap and Whited (1993) this assumption is valid under the null hypothesis of no capital market imperfections.

(21)

$$
\begin{aligned}
\left(\frac{pY}{qK}\right)_t &= \frac{\mu}{\nu}\left(\frac{wL}{qK}\right)_t \\
&+\frac{\mu a}{\nu}\frac{q_{t+1}}{q_t}\frac{2(1-\delta)}{(1+i^0_{t+1})^2}\left(\frac{B}{qK}\right)_t - \frac{\mu a}{\nu}\frac{(1-\delta)}{1+i^0_{t+1}}\left(\frac{B}{qK}\right)_t^2 \\
&+\frac{b}{\nu}\frac{p_t}{q_t}\left(\frac{I}{K}\right)_t - \frac{b}{\nu}\frac{p_t}{q_t}\left(\frac{I}{K}\right)_t^2 - \frac{b}{\nu}\frac{p_{t+1}}{q_t}\frac{(1-\delta)}{1+i^0_{t+1}}\left(\frac{I}{K}\right)_{t+1} \\
&+\frac{ab}{\nu}\frac{p_{t+1}}{q_t}\frac{2(1-\delta)}{(1+i^0_{t+1})^2}\left(\frac{B}{qK}\right)_t\left(\frac{I}{K}\right)_{t+1} \\
&+\frac{\mu}{\nu}(1-\frac{q_{t+1}}{q_t}\frac{(1-\delta)}{1+i^0_{t+1}}) + \frac{\mu a^2}{\nu}\frac{(1-\delta)}{(1+i^0_{t+1})^2}\left(\frac{B}{qK}\right)_t^3 + \epsilon_{t+1}
\end{aligned}
$$

Since a is small we ignore the second term in line 5. Also notice the first term in line 5 which is the user price of capital. For simplicity we write the equation:

(22)

$$
\begin{aligned}
\left(\frac{Y}{K}\right)_t &= \frac{\mu}{\nu}\left\{\pi_1\left(\frac{L}{K}\right)_t\right\} \\
&+\frac{a\mu}{\nu}\left\{\pi_2\left(\frac{B}{K}\right)_t - \pi_3\left(\frac{B}{K}\right)_t^2\right\} \\
&+\frac{b}{\nu}\left\{\pi_4\left(\frac{I}{K}\right)_t - \pi_5\left(\frac{I}{K}\right)_t^2 - \pi_6\left(\frac{I}{K}\right)_{t+1}\right\} \\
&+\frac{ab}{\nu}\left\{\pi_7\left(\frac{B}{K}\right)_t\left(\frac{I}{K}\right)_{t+1}\right\} + f_i + d_t + e_{i,t+1}
\end{aligned}
$$

Appendix C: Construction of variables

The source and construction of the variables used in the analysis is given below. Variable numbers in the Statistics of Accounts and the Manufacturing Statistics are referred to as $[\quad]_a$ and $[\quad]_m$ respectively.

Investment (I): Gross investment in machinery $[1141]_m$, transport equipment $[1151]_m$ and buildings $[1161]_m$.

Capital (K): Fire insurance value of machinery $[871]_m$, and buildings $[881]_m$ plus book value of transport equipment $[4340]_a$. In addition to the reported fire insurance value, two alternative measures of K_t were constructed using the capital accumulation constraint. For observations where K_t was not consistent with either of these measures it was replaced by an average of the two alternatives.

Output (Y) Gross production $[1041]_m$, plus subsidies $[291]_m$ minus taxes $[301]_m$.

Variable costs (L): Inputs $[1061]_m$ and wages $[381]_m$.

Long term debt (B): Book value of long term debt $[5200]_a$ minus fixed assets $[4200]_a$ plus book value of buildings, transport equipment and machinery $[4330]_a$ trough $[4410]_a$, plus 50% of conditional tax-free allocations $[5300]_a$. Negative values were replace by 0.

Short term debt (B^S): Book value of short term debt $[5000]_a$.

Current assets (A^S): Book value of current assets $[4000]_a$.

The following variables were used in constructing the π's in the model, but not in constructing the user price which was measured using time dummies.

Depreciation rates (δ): 0.06 for machinery and 0.02 for buildings. From Norwegian National Accounts.

Interest rate (i^0): Interest rate on bearer bonds, from Bank og Kredittstatistikk 15/93.

Price indexes (p q): Price indexes for gross output, buildings and machinery. From Norwegian National Accounts.

Appendix D: Tables

Table 1: **MODEL WITHOUT ADJUSTMENT COSTS**

$$\left(\frac{Y}{K}\right)_t = \frac{\mu}{\nu}\left\{\pi_1\left(\frac{L}{K}\right)_t\right\} + \frac{a\mu}{\nu}\left\{\pi_2\left(\frac{B}{K}\right)_t - \pi_3\left(\frac{B}{K}\right)_t^2\right\} + f_i + d_t + e_{i,t+1}$$

Method	OLS LEVELS		OLS DEVIATIONS		GMM LEVELS		GMM DEVIATIONS	
$\frac{\mu}{\nu}$	1.028	(0.002)[1]	1.024	(0.005)	1.030	(0.002)	1.024	(0.005)
$a\frac{\mu}{\nu}$	0.083	(0.008)	0.074	(0.010)	0.085	(0.009)	0.115	(0.016)
Sargan[2]					42.2	[46]	53.1	[46]
$W(d_t)$[3]	32.2	[11]	164.3	[12]	36.6	[11]	146.3	[12]
$W(f_{industry})$	95.1	[10]			99.8	[10]		
m_1[4]	22.8	[1282]	14.3	[1282]	22.7	[1282]	14.3	[1282]
m_2[5]	17.5	[1116]	8.3	[1116]	17.5	[1116]	8.2	[1116]
Instruments					t-1,t-2		t-1,t-2	
Observations	8691		8691		8691		8691	
Firms	1282		1282		1282		1282	

Notes:

[1]Robust standard errors in parentheses.

[2]Sargan is the Sargan/Hansen test of overidentifying restrictions which has a χ^2 distribution with [N] degrees of freedom.

[3]W() is a Wald test of joint significance which has a χ^2 distribution with [N] degrees of freedom.

[4]m_1 is a test of first order serial correlation and is normally distributed with mean 0 and variance 1.

[5]m_2 is a test of second order serial correlation and is normally distributed with mean 0 and variance 1.

Table 2: **MODEL WITH ADJUSTMENT COSTS**
PARAMETERS ESTIMATED BY FIRM SIZE

$$\left(\frac{Y}{K}\right)_t = \frac{\mu}{\nu}\left\{\pi_1\left(\frac{L}{K}\right)_t\right\} + \frac{a\mu}{\nu}\left\{\pi_2\left(\frac{B}{K}\right)_t - \pi_3\left(\frac{B}{K}\right)_t^2\right\} + f_i + d_t + e_{i,t+1}$$

Method	OLS LEVELS		OLS DEVIATIONS		GMM LEVELS		GMM DEVIATIONS	
$\frac{\mu}{\nu}d_{small}$	1.030	(0.002)	1.030	(0.004)	1.033	(0.002)	1.032	(0.004)
$\frac{\mu}{\nu}d_{medium}$	1.027	(0.003)	1.025	(0.005)	1.030	(0.002)	1.011	(0.004)
$\frac{\mu}{\nu}d_{large}$	1.022	(0.005)	0.998	(0.007)	1.010	(0.003)	0.994	(0.004)
$a\frac{\mu}{\nu}d_{small}$	0.071	(0.010)	0.068	(0.015)	0.066	(0.010)	0.150	(0.021)
$a\frac{\mu}{\nu}d_{medium}$	0.094	(0.011)	0.078	(0.014)	0.090	(0.011)	0.078	(0.021)
$a\frac{\mu}{\nu}d_{large}$	0.105	(0.023)	0.066	(0.025)	0.148	(0.018)	0.058	(0.038)
Sargan					142.3	[138]	141.0	[138]
W(d_t)	31.6	[11]	162.0	[12]	34.9	[11]	137.0	[12]
W($f_{industry}$)	96.4	[10]			98.9	[10]		
m_1	22.7	[1282]	14.2	[1282]	22.7	[1282]	14.4	[1282]
m_2	17.4	[1116]	8.1	[1116]	17.3	[1116]	8.3	[1116]
Instr.					t-1,t-2		t-1,t-2	
Obs.	8691		8691		8691		8691	
Firms	1282		1282		1282		1282	

Notes:

See table 1.

Table 3: **MODEL WITHOUT ADJUSTMENT COSTS**

PARAMETERS ESTIMATED BY TIME PERIODS

$$\left(\frac{Y}{K}\right)_t = \frac{\mu}{\nu}\left\{\pi_1\left(\frac{L}{K}\right)_t\right\} + \frac{a\mu}{\nu}\left\{\pi_2\left(\frac{B}{K}\right)_t - \pi_3\left(\frac{B}{K}\right)_t^2\right\} + f_i + d_t + e_{i,t+1}$$

Method	OLS LEVELS		OLS DEVIATIONS		GMM LEVELS		GMM DEVIATIONS	
$\frac{\mu}{\nu}d_{77-83}$	1.028	(0.003)	1.024	(0.006)	1.032	(0.002)	1.022	(0.005)
$\frac{\mu}{\nu}d_{84-87}$	1.029	(0.003)	1.024	(0.004)	1.031	(0.003)	1.016	(0.006)
$\frac{\mu}{\nu}d_{88-90}$	1.025	(0.005)	1.020	(0.005)	1.027	(0.004)	1.007	(0.009)
$a\frac{\mu}{\nu}d_{77-83}$	0.081	(0.011)	0.085	(0.013)	0.082	(0.012)	0.109	(0.017)
$a\frac{\mu}{\nu}d_{84-87}$	0.097	(0.013)	0.077	(0.013)	0.089	(0.016)	0.090	(0.027)
$a\frac{\mu}{\nu}d_{88-90}$	0.063	(0.018)	0.024	(0.016)	0.087	(0.021)	0.049	(0.054)
Sargan					41.4	[42]	41.6	[42]
W(d_t)	9.0	[11]	39.2	[12]	10.1	[11]	34.8	[12]
W($f_{industry}$)	95.3	[10]			99.8	[10]		
m_1	22.7	[1282]	14.3	[1282]	22.7	[1282]	14.0	[1282]
m_2	17.5	[1116]	8.3	[1116]	17.5	[1116]	8.3	[1116]
Instr.					t-1,t-2		t-1,t-2	
Obs.	8691		8691		8691		8691	
Firms	1282		1282		1282		1282	

Notes:

See table 1.

Table 4: **MODEL WITH ADJUSTMENT COSTS**

$$\left(\frac{Y}{K}\right)_t = \frac{\mu}{\nu}\left\{\pi_1\left(\frac{L}{K}\right)_t\right\} + \frac{a\mu}{\nu}\left\{\pi_2\left(\frac{B}{K}\right)_t - \pi_3\left(\frac{B}{K}\right)_t^2\right\}$$
$$+\frac{b}{\nu}\left\{\pi_4\left(\frac{I}{K}\right)_t - \pi_5\left(\frac{I}{K}\right)_t^2 - \pi_6\left(\frac{I}{K}\right)_{t+1}\right\} + \frac{ab}{\nu}\left\{\pi_7\left(\frac{B}{K}\right)_t\left(\frac{I}{K}\right)_{t+1}\right\} + f_i + d_t + e_{i,t+1}$$

Method	OLS LEVELS		OLS DEVIATIONS		GMM LEVELS		GMM DEVIATIONS	
$\frac{\mu}{\nu}$	1.023	(0.003)	1.020	(0.004)	1.024	(0.002)	1.022	(0.003)
$a\frac{\mu}{\nu}$	0.074	(0.010)	0.067	(0.012)	0.038	(0.017)	0.086	(0.019)
$b\frac{1}{\nu}$	-0.001	(0.025)	-0.032	(0.019)	0.169	(0.094)	0.043	(0.035)
$ab\frac{1}{\nu}$	0.168	(0.066)	0.152	(0.046)	0.572	(0.153)	0.188	(0.100)
Sargan					102.2	[88]	133.8	[88]
W(d_t)	33.3	[11]	157.7	[12]	36.5	[11]	136.9	[12]
W($f_{industry}$)	54.8	[10]			61.0	[10]		
m_1	21.4	[1282]	12.3	[1282]	20.4	[1282]	12.3	[1282]
m_2	16.6	[1116]	6.6	[1116]	15.3	[1116]	6.3	[1116]
Instruments					t-1,t-2		t-1,t-2	
Observations	8691		8691		8691		8691	
Firms	1282		1282		1282		1282	

Notes:

See table 1.

Table 5: **MODEL WITH ADJUSTMENT COSTS**

PARAMETERS ESTIMATED BY FIRM SIZE

$$\left(\frac{Y}{K}\right)_t = \frac{\mu}{\nu}\left\{\pi_1\left(\frac{L}{K}\right)_t\right\} + \frac{a\mu}{\nu}\left\{\pi_2\left(\frac{B}{K}\right)_t - \pi_3\left(\frac{B}{K}\right)_t^2\right\}$$
$$+\frac{b}{\nu}\left\{\pi_4\left(\frac{I}{K}\right)_t - \pi_5\left(\frac{I}{K}\right)_t^2 - \pi_6\left(\frac{I}{K}\right)_{t+1}\right\} + \frac{ab}{\nu}\left\{\pi_7\left(\frac{B}{K}\right)_t\left(\frac{I}{K}\right)_{t+1}\right\} + f_i + d_t + e_{i,t+1}$$

Method	OLS LEVELS		OLS DEVIATIONS		GMM LEVELS		GMM DEVIATIONS	
$\frac{\mu}{\nu}d_{small}$	1.026	(0.002)	1.021	(0.004)	1.028	(0.002)	1.027	(0.003)
$\frac{\mu}{\nu}d_{medium}$	1.025	(0.003)	1.026	(0.005)	1.028	(0.002)	1.022	(0.006)
$\frac{\mu}{\nu}d_{large}$	1.009	(0.003)	1.000	(0.005)	1.004	(0.002)	1.005	(0.004)
$a\frac{\mu}{\nu}d_{small}$	0.069	(0.010)	0.079	(0.016)	0.062	(0.014)	0.166	(0.024)
$a\frac{\mu}{\nu}d_{medium}$	0.069	(0.016)	0.051	(0.018)	0.079	(0.019)	0.046	(0.021)
$a\frac{\mu}{\nu}d_{large}$	0.071	(0.020)	0.039	(0.029)	0.066	(0.017)	0.067	(0.028)
$b\frac{1}{\nu}d_{small}$	-0.014	(0.027)	-0.050	(0.025)	0.080	(0.094)	0.022	(0.042)
$b\frac{1}{\nu}d_{medium}$	0.009	(0.046)	-0.009	(0.028)	0.115	(0.101)	0.073	(0.034)
$b\frac{1}{\nu}d_{large}$	0.078	(0.082)	0.003	(0.051)	0.264	(0.078)	-0.033	(0.045)
$ab\frac{1}{\nu}d_{small}$	0.093	(0.056)	0.098	(0.053)	0.237	(0.127)	-0.042	(0.096)
$ab\frac{1}{\nu}d_{medium}$	0.214	(0.157)	0.210	(0.087)	0.124	(0.200)	0.190	(0.102)
$ab\frac{1}{\nu}d_{large}$	0.766	(0.203)	0.303	(0.135)	1.228	(0.141)	0.084	(0.088)
Sargan					320.4	[264]	305.3	[264]
W(d_t)	34.6	[11]	154.9	[12]	38.4	[11]	145.2	[12]
W($f_{industry}$)	55.8	[10]			76.2	[10]		
m_1	21.3	[1282]	12.4	[1282]	20.8	[1282]	12.7	[1282]
m_2	16.1	[1116]	6.4	[1116]	16.0	[1116]	6.3	[1116]
Instr.					t-1,t-2		t-1,t-2	
Obs.	8691		8691		8691		8691	
Firms	1282		1282		1282		1282	

Notes:

See table 1.

Table 6: **MODEL WITH ADJUSTMENT COSTS**

PARAMETERS ESTIMATED BY TIME PERIODS

$$\left(\frac{Y}{K}\right)_t = \frac{\mu}{\nu}\left\{\pi_1\left(\frac{L}{K}\right)_t\right\} + \frac{a\mu}{\nu}\left\{\pi_2\left(\frac{B}{K}\right)_t - \pi_3\left(\frac{B}{K}\right)_t^2\right\}$$
$$+\frac{b}{\nu}\left\{\pi_4\left(\frac{I}{K}\right)_t - \pi_5\left(\frac{I}{K}\right)_t^2 - \pi_6\left(\frac{I}{K}\right)_{t+1}\right\} + \frac{ab}{\nu}\left\{\pi_7\left(\frac{B}{K}\right)_t\left(\frac{I}{K}\right)_{t+1}\right\} + f_i + d_t + e_{i,t+1}$$

Method	OLS LEVELS		OLS DEVIATIONS		GMM LEVELS		GMM DEVIATIONS	
$\frac{\mu}{\nu}d_{77-83}$	1.022	(0.004)	1.019	(0.004)	1.024	(0.003)	1.024	(0.004)
$\frac{\mu}{\nu}d_{84-87}$	1.026	(0.003)	1.021	(0.004)	1.023	(0.003)	1.021	(0.005)
$\frac{\mu}{\nu}d_{88-90}$	1.019	(0.005)	1.018	(0.004)	1.020	(0.005)	1.013	(0.006)
$a\frac{\mu}{\nu}d_{77-83}$	0.080	(0.012)	0.076	(0.013)	0.043	(0.019)	0.070	(0.022)
$a\frac{\mu}{\nu}d_{84-87}$	0.061	(0.014)	0.058	(0.014)	-0.011	(0.034)	0.074	(0.032)
$a\frac{\mu}{\nu}d_{88-90}$	0.050	(0.021)	0.023	(0.018)	0.008	(0.034)	0.055	(0.061)
$b\frac{1}{\nu}d_{77-83}$	-0.015	(0.039)	-0.038	(0.028)	0.175	(0.149)	0.042	(0.053)
$b\frac{1}{\nu}d_{84-87}$	0.038	(0.033)	-0.007	(0.026)	0.291	(0.222)	0.048	(0.074)
$b\frac{1}{\nu}d_{88-90}$	0.000	(0.040)	-0.048	(0.032)	0.099	(0.191)	0.014	(0.091)
$ab\frac{1}{\nu}d_{77-83}$	0.091	(0.092)	0.145	(0.068)	0.446	(0.187)	0.333	(0.140)
$ab\frac{1}{\nu}d_{84-87}$	0.343	(0.084)	0.194	(0.063)	1.050	(0.306)	0.099	(0.155)
$ab\frac{1}{\nu}d_{88-90}$	0.207	(0.079)	0.099	(0.061)	1.009	(0.275)	0.021	(0.180)
Sargan					92.4	[80]	92.2	[80]
W(d_t)	11.3	[11]	56.8	[12]	12.0	[11]	28.5	[12]
W($f_{industry}$)	54.0	[10]			55.7	[10]		
m_1	21.5	[1282]	12.4	[1282]	19.5	[1282]	13.2	[1282]
m_2	16.9	[1116]	6.6	[1116]	14.7	[1116]	6.2	[1116]
Instr.					t-1,t-2		t-1,t-2	
Obs.	8691		8691		8691		8691	
Firms	1282		1282		1282		1282	

Notes:

See table 1.

Table 7: **MODEL WITHOUT ADJUSTMENT COSTS**

$$\left(\frac{Y}{K}\right)_t = \frac{\mu}{\nu}\left\{\pi_1\left(\frac{L}{K}\right)_t\right\} + \frac{a\mu}{\nu}\left\{\pi_2\left(\frac{B}{K}\right)_t - \pi_3\left(\frac{B}{K}\right)_t^2\right\} + \alpha\left(\frac{A^S - B^S}{K}\right)_t + f_i + d_t + e_{i,t+1}$$

Method	OLS LEVELS		OLS DEVIATIONS		GMM LEVELS		GMM DEVIATIONS	
$\frac{\mu}{\nu}$	1.027	(0.002)	1.022	(0.004)	1.030	(0.001)	1.017	(0.004)
$a\frac{\mu}{\nu}$	0.049	(0.008)	0.020	(0.011)	0.071	(0.008)	0.062	(0.018)
α	0.091	(0.010)	0.116	(0.014)	0.045	(0.010)	0.155	(0.026)
Sargan					83.6	[69]	105.0	[69]
W(d_t)	45.5	[11]	189.3	[12]	38.4	[11]	155.7	[12]
W($f_{industry}$)	120.2	[10]			114.0	[10]		
m_1	22.6	[1282]	14.2	[1282]	22.7	[1282]	14.4	[1282]
m_2	17.4	[1116]	8.3	[1116]	17.4	[1116]	8.4	[1116]
Instruments					t-1,t-2		t-1,t-2	
Observations	8691		8691		8691		8691	
Firms	1282		1282		1282		1282	

Notes:

See table 1.

Table 8: **MODEL WITHOUT ADJUSTMENT COSTS**

PARAMETERS ESTIMATED BY FIRM SIZE

$$\left(\frac{Y}{K}\right)_t = \frac{\mu}{\nu}\left\{\pi_1\left(\frac{L}{K}\right)_t\right\} + \frac{a\mu}{\nu}\left\{\pi_2\left(\frac{B}{K}\right)_t - \pi_3\left(\frac{B}{K}\right)_t^2\right\} + \alpha\left(\frac{A^S - B^S}{K}\right)_t + f_i + d_t + e_{i,t+1}$$

Method	OLS LEVELS		OLS DEVIATIONS		GMM LEVELS		GMM DEVIATIONS	
$\frac{\mu}{\nu}d_{small}$	1.029	(0.002)	1.028	(0.004)	1.032	(0.002)	1.031	(0.004)
$\frac{\mu}{\nu}d_{medium}$	1.027	(0.003)	1.025	(0.005)	1.030	(0.002)	1.010	(0.003)
$\frac{\mu}{\nu}d_{large}$	1.022	(0.005)	0.999	(0.007)	1.013	(0.003)	1.000	(0.004)
$a\frac{\mu}{\nu}d_{small}$	0.050	(0.010)	0.025	(0.015)	0.059	(0.009)	0.100	(0.023)
$a\frac{\mu}{\nu}d_{medium}$	0.039	(0.012)	0.015	(0.015)	0.066	(0.011)	0.011	(0.022)
$a\frac{\mu}{\nu}d_{large}$	0.081	(0.025)	0.016	(0.030)	0.150	(0.018)	-0.051	(0.036)
αd_{small}	0.071	(0.012)	0.097	(0.019)	0.033	(0.012)	0.139	(0.031)
αd_{medium}	0.130	(0.017)	0.132	(0.020)	0.068	(0.015)	0.174	(0.034)
αd_{large}	0.037	(0.033)	0.099	(0.037)	-0.024	(0.022)	0.225	(0.026)
Sargan					230.8	[207]	223.8	[207]
W(d_t)	44.9	[11]	186.1	[12]	39.3	[11]	162.5	[12]
W($f_{industry}$)	119.7	[10]			113.5	[10]		
m_1	22.7	[1282]	14.0	[1282]	22.9	[1282]	14.5	[1282]
m_2	17.3	[1116]	8.1	[1116]	17.3	[1116]	8.5	[1116]
Instr.					t-1,t-2		t-1,t-2	
Obs.	8691		8691		8691		8691	
Firms	1282		1282		1282		1282	

Notes:

See table 1.

Table 9: **MODEL WITHOUT ADJUSTMENT COSTS**

PARAMETERS ESTIMATED BY TIME PERIOD

$$\left(\frac{Y}{K}\right)_t = \frac{\mu}{\nu}\left\{\pi_1\left(\frac{L}{K}\right)_t\right\} + \frac{a\mu}{\nu}\left\{\pi_2\left(\frac{B}{K}\right)_t - \pi_3\left(\frac{B}{K}\right)_t^2\right\} + \alpha\left(\frac{A^S - B^S}{K}\right)_t + f_i + d_t + e_{i,t+1}$$

Method	OLS LEVELS		OLS DEVIATIONS		GMM LEVELS		GMM DEVIATIONS	
$\frac{\mu}{\nu}d_{77-83}$	1.028	(0.002)	1.023	(0.005)	1.031	(0.002)	1.019	(0.005)
$\frac{\mu}{\nu}d_{84-87}$	1.027	(0.003)	1.022	(0.004)	1.030	(0.002)	1.014	(0.006)
$\frac{\mu}{\nu}d_{88-90}$	1.025	(0.004)	1.019	(0.004)	1.027	(0.004)	1.009	(0.009)
$a\frac{\mu}{\nu}d_{77-83}$	0.053	(0.011)	0.036	(0.013)	0.072	(0.012)	0.059	(0.021)
$a\frac{\mu}{\nu}d_{84-87}$	0.052	(0.013)	0.007	(0.014)	0.067	(0.015)	0.008	(0.034)
$a\frac{\mu}{\nu}d_{88-90}$	0.029	(0.018)	-0.029	(0.017)	0.075	(0.020)	0.007	(0.061)
αd_{77-83}	0.095	(0.014)	0.121	(0.018)	0.046	(0.014)	0.153	(0.031)
αd_{84-87}	0.092	(0.017)	0.127	(0.017)	0.050	(0.017)	0.208	(0.044)
αd_{88-90}	0.082	(0.020)	0.098	(0.020)	0.037	(0.021)	0.177	(0.077)
Sargan					82.7	[63]	87.4	[63]
W(d_t)	8.2	[11]	43.6	[12]	10.6	[11]	36.1	[12]
W($f_{industry}$)	121.1	[10]			114.0	[10]		
m_1	22.6	[1282]	14.1	[1282]	22.6	[1282]	13.9	[1282]
m_2	17.5	[1116]	8.4	[1116]	17.5	[1116]	8.5	[1116]
Instr.					t-1,t-2		t-1,t-2	
Obs.	8691		8691		8691		8691	
Firms	1282		1282		1282		1282	

Notes:

See table 1.

Table 10: **SUMMARY STATISTICS**

VARIABLE	SAMPLE	OBS.	MEAN	MED.	S.DEV.	A.CORR.	MIN	MAX
$\frac{I}{K}$	All	11255	0.057	0.032	0.091	0.320	-0.730	0.999
	1977 - 1983	6260	0.060	0.033	0.095	0.323	-0.730	0.999
	1984 - 1987	3165	0.058	0.034	0.091	0.315	-0.471	0.913
	1988 - 1990	1830	0.044	0.026	0.076	0.316	-0.585	0.740
	Small firms	5435	0.059	0.030	0.100	0.341	-0.532	0.999
	Medium firms	4761	0.055	0.033	0.084	0.266	-0.730	0.913
	Large firms	1059	0.052	0.034	0.070	0.441	-0.359	0.681
$\frac{B}{K}$	All	11255	0.212	0.167	0.184	0.790	0.000	1.466
	1977 - 1983	6260	0.220	0.173	0.188	0.813	0.000	1.420
	1984 - 1987	3165	0.203	0.159	0.181	0.779	0.000	1.466
	1988 - 1990	1830	0.203	0.161	0.174	0.735	0.000	1.211
	Small firms	5435	0.224	0.173	0.197	0.795	0.000	1.420
	Medium firms	4761	0.203	0.163	0.174	0.783	0.000	1.466
	Large firms	1059	0.192	0.158	0.150	0.767	0.000	1.364
$\frac{A^S-B^S}{K}$	All	11255	0.103	0.073	0.212	0.788	-1.490	1.491
	1977 - 1983	6260	0.089	0.066	0.206	0.787	-1.490	1.491
	1984 - 1987	3165	0.125	0.086	0.225	0.791	-0.956	1.422
	1988 - 1990	1830	0.111	0.079	0.204	0.782	-1.056	1.147
	Small firms	5435	0.098	0.068	0.219	0.793	-1.490	1.422
	Medium firms	4761	0.102	0.074	0.206	0.774	-1.266	1.491
	Large firms	1059	0.133	0.101	0.196	0.824	-1.056	1.377
$\frac{Y-L}{K}$	All	11255	0.097	0.077	0.109	0.543	-0.503	0.697
	1977 - 1983	6260	0.102	0.081	0.114	0.495	-0.474	0.697
	1984 - 1987	3165	0.096	0.077	0.107	0.617	-0.503	0.669
	1988 - 1990	1830	0.078	0.066	0.097	0.572	-0.462	0.657
	Small firms	5435	0.099	0.080	0.112	0.500	-0.463	0.681
	Medium firms	4761	0.097	0.076	0.110	0.578	-0.503	0.697
	Large firms	1059	0.087	0.071	0.093	0.623	-0.356	0.681

Table 10: **SUMMARY STATISTICS, continued**

VARIABLE	SAMPLE	OBS.	MEAN	MED.	S.DEV.	A.CORR.	MIN	MAX
$\frac{Y}{K}$	All	11255	1.441	1.064	1.429	0.776	0.063	41.35
	1977 - 1983	6260	1.466	1.107	1.501	0.744	0.063	41.35
	1984 - 1987	3165	1.464	1.071	1.372	0.847	0.110	16.43
	1988 - 1990	1830	1.319	0.931	1.258	0.766	0.141	23.43
	Small firms	5435	1.474	1.098	1.421	0.782	0.063	31.28
	Medium firms	4761	1.436	1.055	1.370	0.820	0.109	23.43
	Large firms	1059	1.299	0.935	1.699	0.646	0.139	41.35
$\frac{L}{K}$	All	11255	1.345	0.974	1.389	0.773	0.062	41.08
	1977 - 1983	6260	1.364	1.004	1.462	0.740	0.062	41.08
	1984 - 1987	3165	1.368	0.981	1.328	0.846	0.116	16.05
	1988 - 1990	1830	1.241	0.876	1.226	0.763	0.113	23.25
	Small firms	5435	1.375	0.999	1.380	0.781	0.062	30.67
	Medium firms	4761	1.340	0.972	1.329	0.819	0.106	23.25
	Large firms	1059	1.211	0.847	1.671	0.635	0.170	41.08

Table 11: **OBSERVATIONS BY YEAR**

YEAR	FREQUENCY		PERCENT		CUM. PERCENT	
	Trimmed	Complete	Trimmed	Complete	Trimmed	Complete
1977	800	1118	7.11	8.14	7.11	8.14
1978	855	1089	7.60	7.93	14.70	16.08
1979	910	1062	8.09	7.74	22.79	23.81
1980	945	1042	8.40	7.59	31.19	31.40
1981	950	1052	8.44	7.66	39.63	39.07
1982	929	1025	8.25	7.47	47.88	46.53
1983	871	964	7.74	7.02	55.62	53.55
1984	838	925	7.45	6.74	63.07	60.29
1985	791	902	7.03	6.57	70.09	66.86
1986	777	919	6.90	6.69	77.00	73.56
1987	759	924	6.74	6.73	83.74	80.29
1988	683	941	6.07	6.85	89.81	87.14
1989	613	886	5.45	6.45	95.26	93.60
1990	534	879	4.74	6.40	100.00	100.00
Total	11255	13728	100.00	100.00		

Table 12: **OBSERVATIONS BY INDUSTRY**

INDUSTRY (ISIC)	FREQUENCY		PERCENT		CUM. PERCENT	
	Trimmed	Complete	Trimmed	Complete	Trimmed	Complete
Food (31)	2234	2689	19.85	19.59	19.85	19.59
Textiles (32)	890	1079	7.91	7.86	27.76	27.45
Wood (33)	1231	1484	10.94	10.81	38.69	38.26
Paper (34)	1648	1955	14.64	14.24	53.34	52.50
Chemicals (35)	826	933	7.34	6.80	60.68	59.29
Mineral Products (36)	471	515	4.18	3.75	64.86	63.05
Basic Metals (37)	347	399	3.08	2.91	67.94	65.95
Metal Products (381)	875	1117	7.77	8.14	75.72	74.09
Machinery (382)	959	1320	8.52	9.62	84.24	83.70
Electrical Products (383)	529	682	4.70	4.97	88.94	88.67
Transp./Instr. (384/5)	1245	1555	11.06	11.33	100.00	100.00
Total	11255	13728	100.00	100.00		

Table 13: **OBSERVATIONS PER FIRM**

OBS.	FREQUENCY		PERCENT		CUM. PERCENT	
	Trimmed	Complete	Trimmed	Complete	Trimmed	Complete
1		350		2.55		2.55
2		518		3.77		6.32
3		582		4.24		10.56
4	600	624	5.33	4.55	5.33	15.11
5	635	620	5.64	4.52	10.97	19.62
6	786	864	6.98	6.29	17.96	25.92
7	798	847	7.09	6.17	25.05	32.09
8	776	904	6.89	6.59	31.94	38.67
9	792	810	7.04	5.90	38.98	44.57
10	880	950	7.82	6.92	46.80	51.49
11	869	924	7.72	6.73	54.52	58.22
12	768	804	6.82	5.86	61.34	64.08
13	767	871	6.81	6.34	68.16	70.43
14	3584	4060	31.84	29.57	100.00	100.00
Total	11255	13728	100.00	100.00		

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