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Is Price Equal to Marginal Costs?

An Integrated Study of Price-Cost Margins and Scale Economies among Norwegian Manufacturing Establishments 1975-90

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Abstract

This paper presents an integrated study of price-cost margins and scale economies. The model is estimated on the basis of a comprehensive data set for individual establishments covering almost the whole Norwegian manufacturing sector over the period 1975-90. For most manufacturing industries prices significantly exceed marginal costs. However, the price cost margins are fairly small (1.06-1.16) compared to other findings by Hall (1988) and others. There is a tendency for larger firms to obtain a higher markup. None of the samples reveals significant scale economies, while 7 out of 20 samples exhibit moderate decreasing returns.

Keywords: Market power, scale economies, panel data

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1 Introduction

Theories about the nature and consequences of imperfect competition and scale economies have a central role throughout the field of economics. Furthermore, these issues have acquired renewed political influence. According to the E.C. Commission, two thirds of the estimated welfare gains from furthering the integration of the European community from 1993 onwards, will come through the elimination of market power and the exploitation of scale economies[1]. But the appropriate methodology to study scale economies and markups remains an unsettled topic in econometrics, despite its long history[2]. As a consequence, the empirical significance of these phenomena continues to be a controversial issue.

In his pioneering work, Hall (1988, 1990) has recently provided evidence of substantial market power and scale economies in US manufacturing. Hall's results were based on a new approach to the estimation of price-cost margins and scale economies. Notice that Hall estimated price cost margins and scale economies *separately*, and somewhat inconsistently. That is to say, in his studies of price cost margins, Hall kept constant return to scale as a maintained hypothesis. This seems *a priori* unsatisfactory, as the estimate of scale economies will tend to be tightly linked to the estimate of the ratio between price and marginal costs. Considering the large order of magnitude of Hall's estimate of scale economies, keeping constant returns as a maintained hypothesis in his study of price cost margins questions the consistency of the

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[1] Cf. Emerson et al. (1988).

[2] See Bresnahan (1989) for a survey of the econometric literature on the estimation of market power.

estimates[3]. This paper extends Hall's empirical analysis by *simultaneously* studying price-cost margins and scale economies.

Hall used macro and industry level data in his studies of price-cost margins and scale economies[4]. But micro level data are essential for a simultaneous study of price-cost margins and scale economies, since scale economies at the industry level are affected by externalities, entry and exit, which have little to do with the scale economies relevant for the firms' price setting decisions. The use of plant or firm level panel data has some other benefits. First, the model can be implemented at the level for which it is constructed, thereby eliminating some problems of aggregation and the need to resort to the notion of the representative firm. In the present study, I allow for permanent productivity differences between firms (by "fixed effects"). Such differences are known to be present in most data sets on firms, and their presence questions the validity of results from aggregate data that are based on the notion of a representative firm. Second, the use of panel data permits a less restrictive parameterization of technological change. Hall assumes that technological change can be represented by a time trend and a white noise term over the entire period 1953-1984. Given economists' perception of productivity growth before and after the oil price shocks, this assumption seems questionable (in particular given that one of Hall's instrumental variables is

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[3] Notice that Hall's analysis of scale economies did not explicitly consider deviations between price and marginal costs. Bartelsman et al. (1991) discuss an interpretation of Hall's scale estimates in terms of external economies. Hall (1990) also comments on this issue. Scale economies at the industry level (as considered by Hall) related to external economies will clearly not be closely related to the scale economies required to infer marginal costs of an individual firm.

[4] See also the study by Domowitz et al. (1988).

the oil price). The model presented in this paper allows technological change at the industry level to develop from one year to another without parametric constraints. A related advantage of the panel data model presented below is that the empirical model does not depend on outside deflators. This is comforting since input and output deflators for many industries are unreliable not least due to the problems of dealing with quality changes.

The empirical model is implemented on a comprehensive set of microdata covering most of Norwegian manufacturing over the period 1975-90. I find statistically significant, but quite small, deviations between price and marginal costs. For the non-competitive samples, estimated markups are in the interval 1.06-1.16 . In 9 out of 20 samples, perfectly competitive behavior can not be rejected. The analysis reveals a significant positive correlation between firm size and price cost margins.

The estimates of scale economies suggest that increasing returns to scale is not a pervasive phenomena in Norwegian manufacturing. In fact, I do not find significant scale economies in any of the samples examined in this study. In most industries constant returns to scale is an acceptable approximation. On the other hand, seven out of twenty samples seem to be dominated by plants with decreasing returns. In some of these cases, imposing constant returns to scale is shown to seriously bias the estimated price-cost ratio upwards.

The framework presented below is an endeavor to relax some of the rigid assumptions imposed on the production relationships in traditional production function studies. In a recent paper, Griliches and Mairesse (1990) found substantial heterogeneity and instability in the coefficients of their estimated production functions for US, French and Japanese firms. Motivated by this finding, the model presented in the current paper is consistent with an unconstrained pattern of technological change over time. Also, in the cross-sectional dimension, I have used a quite flexible approximation to model the technological constraints. Rather than using rigid functional forms, the study relies on the validity of first order conditions to infer the marginal productivities for the variable factors of production. Capital is treated as a quasi-fixed factor with a shadow price which might differ from the (long-run equilibrium) user cost of capital.

Section 2 presents the theoretical framework. Stochastic assumptions and other issues related to the econometric model are discussed in section 3. Section 4 examines the relationship between the econometric model presented in the present paper, and models of producer behavior used in related studies. Section 5 explains the construction of the applied sample. The empirical results are presented and discussed in section 6. This section also compares the results to related findings in other studies. Section 7 summarizes the results of the paper, and adds some final comments about future research.

2 The theoretical model

My strategy is to impose a minimal set of restrictive assumptions about functional forms to obtain a model expressed in terms of observables, and unobservables that can be represented by a limited number of parameters. Details about the empirical formulation, in particular the stochastic assumptions and estimation techniques, will be presented in the next section.

A factor share model of production

The firms within an industry are assumed to be constrained by a production function $Q_{it} = A_{it}F_t(X_{it})$. Q_{it} and X_{it} represent output and a vector of inputs for establishment "i" at year "t". A_{it} is a productivity factor. $F_t(\cdot)$ is the production (or aggregation) function common to all firms at a given year. The time subscript indicates that the function can change freely from one year to the next.

Using a version of the multivariate, generalized mean value theorem[5], the production function relationship can be expressed in terms of logarithmic deviations from a point of reference. That is to say, the production function relationship can be rewritten

$$\hat{q}_{it} = \hat{a}_{it} + \sum_{j \in M} \bar{\alpha}^j_{it}\hat{x}^j_{it}, \tag{1}$$

where

$$\bar{\alpha}^j_{it} \equiv \frac{X^j_{it}\,\partial F_t(X_{it})/\partial X^j_{it}}{F_t(X_{it})}\Big|_{X_{it}=\bar{X}_{it}} \quad \forall j \in M. \tag{2}$$

In equation (1), a lower case letter with a hat is the logarithmic deviation from the point of reference of the corresponding upper case letter. E.g., $\hat{q}_{it} \equiv \ln(Q_{it}) - \ln(Q_t)$, where Q_t represents the reference point. In the empirical part of the paper, this reference point will be the time specific mean value of output within the industry. A similar time-industry average is used as a reference point of expansion for each of the inputs. I will denote this reference

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[5] Cf. Berck and Sydsæter (1991), p. 11. for a statement of the generalized mean value theorem. The extension to the multivariate case is straight forward, as suggested in e.g. Thomas (1968, p.545).

vector for the inputs by $X_t = \{X_t^1, X_t^2, \cdots, X_t^m\}$. M denotes the set of (the m) inputs. The production function $F_t(\cdot)$ and its partial derivatives on the right hand side of equation (2) are evaluated at an internal point $(\bar{X}_{it})$ between X_{it} and the reference point X_t [6].

Let me emphasize the motivation behind the use of a mean value theorem rather than a first or second order Taylor approximation in the derivation above. In the *cross sectional* dimension in an industry, relative differences in, say, output can be of the magnitude of several hundred percents. Such large differences would undermine the argument for truncating a Taylor approximation after the first order term (or at any finite order for that matter). The point is that the model derived by using the mean value theorem is valid for samples with any size of the relative differences (not only small values for $\hat{q}_{it}, \hat{a}_{it}$ and $\hat{x}_{it}^j$). This is important when the model is applied to capture cross sectional variations, say, in output, based on a sample of firms or plants.

According to basic producer theory, profit maximizing behavior requires that marginal costs should be equal to the marginal revenue product. I will assume that the firm is a price taker in the input markets, while allowing for the possibility of imperfect competition in the output markets. It follows that

$$A_{it}\frac{\partial F_t(X_{it})}{\partial X_{it}^j} = \frac{W_{it}^j}{(1 - 1/\varepsilon_{it})P_{it}} \quad \forall j \in M, \tag{3}$$

where W_{it}^j is the factor price for input j[7]. P_{it} is the price of output, while ε_{it}

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[6] More precisely, the point $(\bar{X}_{it})$ belongs to the domain spanned by the coordinates $\{X_{it}\ ,(X_t^1, X_{it}^2, X_{it}^3 \cdots, X_{it}^m)\ ,(X_{it}^1, X_t^2, X_{it}^3 \cdots, X_{it}^m)\ , \cdots (X_{it}^1, X_{it}^2, X_{it}^3 \cdots, X_t^m)\ , X_t\}$. Cf. e.g. Thomas (1968, p.545).

[7] Deviations from this first order condition due to uncertainty about factor prices do

is the (conjectured) price elasticity of demand[8]. According to the theory of imperfect competition, the factor $1/(1 - 1/\varepsilon_{it})$ represents the ratio between price and marginal costs. Denoting this price-cost ratio (or markup) by μ_{it}, and using the set of first order conditions in equation (3), we have that

$$\begin{aligned} \bar{\alpha}_{it}^{j} &\equiv \frac{X_{it}^{j}\,\partial F_t(X_{it})/\partial X_{it}^{j}}{F_t(X_{it})}\Big|_{X_{it}=\bar{X}_{it}} \\ &= \mu_{it}\,\frac{\bar{W}_{it}^{j}\bar{X}_{it}^{j}}{\bar{P}_{it}\bar{Q}_{it}} \\ &= \mu_{it}\,\bar{s}_{it}^{j}, \end{aligned} \qquad (4)$$

where $\bar{s}_{it}^{j}$ is the cost share of input j relative to total revenue. This cost share should be evaluated at the internal point $(\{\bar{W}_{it}, \bar{X}_{it}, \bar{P}_{it}, \bar{Q}_{it}\})$. How to further express $\bar{s}_{it}^{j}$ in terms of observables will be explained in the next section, where we presents the details of the empirical framework. It follows that equation (1) can be rewritten as

$$\hat{q}_{it} = \hat{a}_{it} + \mu_{it} \sum_{j \in M} \bar{s}_{it}^{j} \hat{x}_{it}^{j}. \qquad (5)$$

Quasi-fixed capital

Various kinds of rigidities make it dubious to impute the marginal product of capital from observed prices on new equipment, tax rules, interest and

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not affect the analysis presented in this paper. However, I will neglect such an error term for convenience. Uncertainty about productivity shocks presents more subtle problems (see Zellner et al., 1966), which I intend to address in future research.

[8] This price elasticity should be interpreted in a broad sense, incorporating the "conjectured price and quantity responses" of the competitors. Bresnahan (1989) has emphasized the generality of this formulation in empirical work.

depreciation rates. For a competitive industry with constant returns to scale, it is now standard practice to handle this problem by estimating the shadow price, and thereby the factor share of capital, residually. This approach can in principle be easily extended to cases with imperfect competition and non-constant returns to scale, as will be shown in this section[9].

Let us return to the firm's short-run profit maximizing problem, considering the presence of a fixed amount of capital. Let the capital input be denoted by X_{it}^K. Capital inputs are assumed to be fixed at the level K_{it}. The Lagrangian associated with the profit maximizing problem is given by

$$\mathcal{L} = P_{it}Q_{it} - \sum_{j\in M, j\neq K} W_{it}^j X_{it}^j + \lambda_{it}^1(Q_{it} - A_{it}F_t(X_{it})) + \lambda_{it}^2(K_{it} - X_{it}^K), \quad (6)$$

where λ_{it}^1 and λ_{it}^2 are the Lagrange multipliers. The first order condition with respect to capital can be written

$$\lambda_{it}^1 A_{it}\frac{\partial F_t(X_{it})}{\partial X_{it}^K} + \lambda_{it}^2 = 0. \quad (7)$$

Multiplying the first order condition for input j by X_{it}^j, and summing up the resulting equations for all j, it follows that

$$\lambda_{it}^2 X_{it}^K + \sum_{j\neq K} X_{it}^j W_{it}^j = -\lambda_{it}^1 A_{it}\sum_{j\in M}\frac{\partial F_t(X_{it})}{\partial X_{it}^j}X_{it}^j \quad (8)$$

The first order condition with respect to output can be written $P_{it}(1 - 1/\varepsilon_{it}) + \lambda_{it}^1 = 0$. Furthermore, the elasticity of scale (η_{it}) is defined as

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[9] See Morisson (1986) for an extensive discussion of the issue of capacity utilization in a related context. She considers an alternative approach, which is applicable also in the presence of several quasi-fixed factors.

$\eta_{it} \equiv (\sum_{j \in M} X_{it}^{j} \partial F_t / \partial X_{it}^{j}) / F_t(X_{it})$ (Cf. Varian (1992, p.17)). Using these two expressions, equation (8) can be rewritten

$$\lambda_{it}^{2} X_{it}^{K} + \sum_{j \neq K} X_{it}^{j} W_{it}^{j} = \frac{\eta_{it}}{\mu_{it}} P_{it} Q_{it} \tag{9}$$

where again $\mu_{it} = 1/(1 - 1/\varepsilon_{it})$. Combining the first order condition with respect to output and equations (7) and (9), it follows that

$$\begin{aligned} \bar{\alpha}_{it}^{K} &= \frac{X_{it}^{K} \, \partial F_t(X_{it}) / \partial X_{it}^{K}}{F_t(X_{it})} \\ &= \eta_{it} - \mu_{it} \sum_{j \neq K} \frac{W_{it}^{j} X_{it}^{j}}{P_{it} Q_{it}}. \end{aligned} \tag{10}$$

Hence, in the presence of quasi-fixed capital, equation (5) can be rewritten

$$\hat{q}_{it} = \hat{a}_{it} + \mu_{it} \sum_{j \neq K} \bar{s}_{it}^{j} (\hat{x}_{it}^{j} - \hat{x}_{it}^{K}) + \eta_{it} \hat{x}_{it}^{K}. \tag{11}$$

Equation (11) is the final statement of the theoretical model which is estimated. To summarize; only mild regularity conditions are imposed on the production technology. The model is consistent with non-constant returns to scale and the presence of imperfect competition in the sense that price can exceed marginal costs. The model allows for the possibility that capital is not fully adjusted to its equilibrium value, but is considered (quasi-) fixed while the firm solves its short run profit maximizing problem. Hall (1990) stated a model similar to equation (11), but he did not examine it in his empirical analysis.

3 The empirical framework

This section discusses how to estimate the price-cost margins and the scale elasticity by applying the model presented above to a set of panel data. Four main issues will be considered: (i) The panel data structure and fixed effect estimation, (ii) the construction of the factor cost shares (iii) the appropriate orthogonality conditions and instrumental variable estimation, and (iv) parameterization of μ_{it} and η_{it}.

Output and inputs are measured relative to the average values for the industry (at the 5-digit ISIC-code level) to which the firm belongs. The industry mean values are estimated separately for each year. This approach has two benefits. First, it eliminates the need for deflating the nominal variables. Deflators for inputs and outputs in many, if not most, manufacturing industries are heavily contaminated by noise due to the problems of dealing with goods undergoing important quality changes over time. Second, by estimating the shares separately for each year and by using narrow industries we obtain a close approximation to the variables in the theoretical model that are derived on the basis of generalized mean value theorem.

Measuring the variables relative to industry time-means will tend to eliminate the role of time dummies. Consequently, the regressions presented below do not contain time-dummies[10].

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[10] Regressions not presented in this paper confirmed the non-significance of time-dummies when introduced into the regressions.

Fixed effects

The term $\hat{a}_{it}$ will be represented by a one-way error component structure; $\hat{a}_{it} = c_i + u_{it}$, where c_i is treated as a fixed (correlated) effect, while u_{it} is assumed to be a random variable with mean zero. Notice that technical change common across plants within an industry is captured by measuring all variables as deviations from time-industry means. Initial tests for the presence of fixed versus random (uncorrelated) effects strongly rejected the hypothesis of random effects, as is widely experienced with these kinds of data[11]. There can be several explanations for the presence of fixed effects as captured by c_i. Firms might differ in the effectiveness of the management, labour quality, the vintage of the capital and so fourth. Such differences will emerge as variations in productivity. More to the point, these productivity differences will tend to be correlated with the firm size, in the sense that more productive firms will gain larger market shares[12]. Another, and perhaps less interesting, potential explanation for fixed effects, is that some establishments do not have their own headquarter activities, while others do. This will show up in measured productivity. Furthermore, if there is a (negative) correlation between establishment size and the frequency of establishments incorporating their own headquarter services, a fixed (correlated) effect will appear in the regressions. Whatever the reason, the model and the data seem to require

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[11] Cf. e.g. Hsiao (1986, ch. 3) for a discussion of fixed effects versus alternative specifications for panel data models. Hsiao (1986, ch. 3.5) outlines the Hausman test for fixed effects, which has been applied in the preliminary stage of the present study.

[12] This idea was stated in the empirical production function literature already by Marschak and Andrews (1944). The theoretical literature on concentration developed by Demsetz (1974), Lucas (1978) and others has emphasized this point.

some sort of a fixed effect formulation.

To eliminate the fixed effect, we have used a transformation of the variables in the estimating model, as suggested by Arellano (1988). This transformation will be elaborated on below in the section on instrumental variable (GMM) estimation.

Constructing the shares

The theoretical model presented in the previous section included the factor costs' share in total revenue, evaluated at some internal point in the domain between the point of expansion (the time-industry mean values) and the observed point of operation for the establishment in question. Since we do not know the location of this particular point (or the corresponding shares), we have approximated the shares by taking the mean value of the share for the observed establishments and the time-industry average share[13]. This is clearly only an approximation, and consequently an errors-in-variable problem will be introduced by this construction.

In addition, plain measurement and recording errors reinforce this problem. The present study has tried to eliminate the problem by means of an instrumental variable approach, to be discussed below[14].

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[13] The reader will recognize that the index for variable inputs derived here is a Tornquist index, with time-industry mean values as the point of reference. Diewert (1976) has shown that the Tornquist index involves no approximation error if the production function ($F_t(\cdot)$) is of the translog type. One contribution of the current paper is to suggest why the Tornquist index is a useful approximation for a much larger class of functions than only the translog function. This is so since there is an infinite set of functions where the (logarithmic) derivative which enters the formula based on the mean value theorem (cf. equations (1) and (2)), is equal to the mean of the (logarithmic) derivative evaluated at the two endpoints.

[14] In separate work, I have used an alternative procedure to explore the importance of

To summarize our empirical formulation so far, the estimated model can be stated as

$$\hat{q}_{it} = c_i + \mu_{it} \sum_{j \neq K} \tilde{s}^j_{it}(\hat{x}^j_{it} - \hat{x}^K_{it}) + \eta_{it}\hat{x}^K_{it} + v_{it}. \tag{12}$$

$\tilde{s}^j_{it}$ is defined as $(S^j_{it} + S^j_t)/2$, where S^j_{it} and S^j_t are the factor cost shares in total revenue for factor j, referring to firm i and the average for the whole industry, respectively. v_{it} captures the productivity shocks (u_{it}), as well as the deviation between $\tilde{s}^j_{it}$ and $\bar{s}^j_{it}$. Plain measurement errors will also be contained in v_{it}.

GMM-estimation

As argued above, we would expect firms with higher productivity to obtain a larger market share and probably use more inputs. To avoid bias in our estimates, we have tried to deal with this correlation between the regressors and the error term by allowing for a fixed effect. However, this method might not solve the whole correlation problem. To the extent that a firm experiences *changes* in productivity over time, a positive productivity shock might be "transmitted" to inputs to the extent that the shock is recognized before the inputs are determined[15]. This will create a correlation between the right hand side variables and the error term. An instrumental variable approach is called for.

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measurement errors for a similar model; see Klette and Willassen (1993).

[15] The term "transmitted" is borrowed from the old production function literature which examined the case for a "fixed effect" along a similar line of reasoning. Cf. Mundlak and Hoch (1965).

I have carried out specification tests by considering alternative orthogonality conditions. In addition to OLS, GMM-estimation techniques have been employed based on lagged right hand side variables as instruments. The number of employees (lagged) is added as an additional set of instruments.

Formally, we assume that for some τ[16]

$$\text{plim}_{N\to\infty}\frac{1}{N}\sum_{i=1}^{N}\hat{z}_{it}v_{is}=0 \quad \forall\, s \geq t+\tau\,, \tag{13}$$

where $\hat{z}_{it}$ represents capital, the index of variable inputs or the number of employees dated time *"t"*.

The presence of fixed effects and the use of predetermined variables as instruments require some care. That is, standard dummy variable/"within" estimates will not provide consistent estimates, as pointed out by Keane and Runkle (1992) among others. In this case a consistent estimator can be obtained by using the "orthogonal deviation" transformation suggested by Arellano (1988) of both the dependent variable and the right hand side variables to eliminate the fixed effect. The "orthogonal deviation" transformation expresses each observation as the deviation from the average of current and future observations in the sample, and weights each observation to standardize the variance[17]. Orthogonality conditions as in equation (13) are still valid for the model expressed in terms of the transformed variables. A GMM-estimation method can then be carried out which utilizes all the orthogonality conditions stated in equation (13).

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[16] There might be a different τ for the different instruments. E.g. if investments are determined one period ahead of installation, one might expect capital lagged one period less than variable inputs to be predetermined.

[17] See Arellano (1988) for details.

Notice that if the measurement errors in the regressors are not autocorrelated of order higher than τ, this GMM-procedure will also eliminate the bias due to the errors-in-variables problem discussed above.

Since the model is overidentified, we can explore the validity of alternative orthogonality assumptions by means of a Sargan test, as discussed in Arellano and Bond (1991).

Parameterization of μ_{it} and η_{it}

The simplest approach is to assume that the markups (μ_{it}) and the elasticities of scale (η_{it}) are independently distributed random variables, and limit the focus to their average values. I have used this approach extensively in the first round of estimates.

The second approach is to parameterize μ_{it} and η_{it} as functions of observables. In particular, I have considered whether the price cost ratio depends on a *company's size*[18] relative to its competitors in the same (5-digit) industry. That is,

$$\mu_{it} = \mu + \Delta\mu_1\, m_{it} + \Delta\mu_2\, m_{it}^2 + e_{it}^{\mu}, \tag{14}$$

where m_{it} is the company size. e_{it}^{μ} is an independently distributed error term.

To explore the relationship between size and scale economies, I have examined models which allow for different scale elasticities depending on whether the plant belongs to the lower or upper third in the size distribution of *plants*. This specification of the scale elasticity can formally be stated as

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[18] Notice that we have used company size, and not plant size, in this representation, while plant is our unit of observation.

$$\eta_{it} = \eta + \Delta\eta_S \, D_{it}^S + \Delta\eta_L \, D_{it}^L + e_{it}^\eta, \qquad (15)$$

where D_{it}^S is a dummy variable which is unity if the plant belongs to the lower third, while D_{it}^L indicates whether the plant belongs to the upper third. e_{it}^η is an independently distributed error term. The estimating model for the second round of estimates is obtained by inserting (14) and (15) into equation (12).

4 A comparison to related models

The idea of inferring the output elasticity of labour from the first order conditions dates back to the original work on production functions by Cobb and Douglas. The use of this relationship in the estimation of the scale elasticity is attributed to Klein (1953) by Griliches and Ringstad (1971). Griliches and Ringstad, and Ringstad (1971, 1978), used this approach extensively in their analysis of scale economies in Norwegian manufacturing.

Hall (1988, 1990) has recently extended the approach of inferring the output elasticity from the cost share in total revenue, by incorporating the possibility of a positive margin between price and marginal costs. His empirical work used industry-level and macro data for US manufacturing. A model similar to equation (11) was stated by Hall (1990). However, he did not use this model in his empirical analysis of price-cost margins. His econometric studies of markups assumed constant returns to scale. Hall's empirical work on scale economies implemented a user cost formula to infer the shadow price of capital from dividend yields, effective tax rates, depreciation rates and deflators derived from prices on new investment goods. The present study avoids imposing the auxiliary assumptions required to validate Hall's approach. In the present paper the shadow price is estimated as a residual share adjusted for the presence of scale economies and price-cost margins, simultaneously with the rest of the model.

My study merges the two lines of research due to Klein and Hall by examining the possibility of a positive margin between price and marginal costs *simultaneously* with non-constant returns to scale. Clearly, such an integrated framework is essential if scale economies and imperfect competition are present. We cannot identify the output elasticity of variable inputs from the cost shares in total revenue without an estimate of the price-cost ratio, and conversely. For instance, with price and average costs as the observable point of departure, overestimating the scale economies will imply underestimated marginal costs, providing an overestimated price-marginal cost ratio. In some of the industries considered below, I show that the estimated price-cost margins would have been significantly upward biased if I had assumed constant returns to scale, rather than estimated the scale elasticity simultaneously.

Both Hall and the present study apply an instrumental variable approach to the estimation of the markups and other parameters of interest. Hall pointed out the need for instruments due to the possible transmission of productivity shocks to factor demand, as discussed in the previous section. However, as shown by Abbott et al. (1988), the instrumental variable estimates reported by Hall are in fact higher than the OLS estimates obtained from the same sample. Abbott et al. argue that this is because Hall's instruments are not valid, and that the IV-estimates are upward biased. A different explanation is implicit in the discussion presented in the previous section. That is, inferring the output elasticity of each of the variable inputs from the cost shares provides only an approximation and introduces an "errors-in-variable" problem. Other variables in the data might also be contaminated with noise. The "error-in-variable" problem creates a *downward* bias in the OLS estimate[19], which is removed by applying an instrumental variable technique.

Abbott et al. emphasize the omission of adjustment for capacity utilization in Hall's regressions. Their point is that this omitted variable problem creates biases since Hall's instruments are correlated with the degree of capacity utilization. But keep in mind that Hall does provide an attempt to adjust for changes in capacity utilization of capital by using a residual share to impute the output elasticity of capital. However, his procedure is only correct to the extent that constant returns to scale is a valid maintained hypothesis. In the present study, the constant returns to scale hypothesis is rejected and relaxing this hypothesis causes a significant reduction in the estimates of the price-cost margins. Both Hall and the present study use manhours as the measure of labour inputs, which should to a certain extent reduce the need to adjust for changes in utilization of the work force[20]. Let me emphasize that the instrument set used here is entirely different from Hall's instrument set. Using lagged variables as instruments should further

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[19] Cf. e.g. Griliches (1986, p. 1478) for a discussion.

[20] See Hall (1990) for a detailed discussion of different kinds of misspecification related to this point.

reduce the problem of omitted adjustment for capacity utilization.

5 The data

The applied sample covers seven of nine 2-digit (ISIC) manufacturing industries for the period 1975-90[21]. The sample was constructed from the "Panel data"-files for Norwegian manufacturing establishments[22]. These files are based on the annual census carried out by the Central Bureau of Statistics[23]. Separate analyses have been carried out for each of 10 different industry groups (corresponding to 2/3-digit ISIC classes).

In the current study, only operating establishments with at least five employees ("large" establishments) have been included. All observations which did not report the variables required have been eliminated. We also removed observations with an extreme value added per unit of labour input or extreme value added per unit of capital. Extreme values were defined as outside a 300 percent interval of the median values for each year and each 5-digit industry. Establishments which existed for less than three years within a period were eliminated. The sample for each (2-digit) industry was divided into two subsamples, covering the periods 1975-82 and 1983-90. This was done partly to obtain some stability checks for the estimates, and partly because some variables (in particular with respect to labour inputs) changed

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[21] I have left out the sector "Manufacture of food, beverages and tobacco" (ISIC 31), partly since it is very large, with almost 50 000 observations for the period considered, and partly because it is heavily regulated, questioning the validity of the behavioral model applied above. The industry "Other manufacturing" (ISIC 39) has also been eliminated as it is a rather small and heterogeneous collection of plants.

[22] See Halvorsen et al. (1991) for documentation.

[23] NOS (several years) reports a variety of summary statistics.

definitions between 1982 and 83.

Four inputs are treated separately in this study: Capital, energy, labour and materials. Details on the construction of the labour and capital variables are presented in appendix A. All costs and revenues are adjusted for taxes and subsidies, so that they should reflect the firm's revenues and expenditures[24]. Revenues are measured net of sales taxes and subsidies, and the wage payments incorporate salaries and wages in cash and kind, social security and other costs incurred by the employer. It is perhaps worth pointing out that the capital variable is constructed on the basis of fire insurance values for buildings and machinery[25]. Tables 1A and 1B report some summary statistics for each industry in the applied sample, separately for the years 1975 and 1990. Notice that the number of multiplant line-of-businesses/firms is low in most industries.

6 Results

Basic results

The first set of results refer to the model where we consider μ_{it} and η_{it} to be independently distributed random variables across plants within the same 2-digit industry. In this case we focus on the mean values of the distributions for the price cost ratios and the scale elasticity. The preferred regressions of

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[24] See NOS (several years) and Halvorsen et al. (1991) for details about these adjustments.

[25] This help us to overcome the criticism to scale estimates based on accounting measures of capital, raised by Friedman (1955). Friedman argued that accounting measures of capital would imply constant return by definition. See Griliches and Ringstad (1971, ch. 3.3 and p.59) for further remarks on the *pros* and *cons* of the use of fire insurance values to construct the capital variable.

Table 1A: Summary statistics for the 10 industry groups in applied sample in the year 1975. All nominal values are in 1000 N.kr.

	Sales per plant		Value-added per worker		Capital per worker		Residual share		#Plants	#Firms	Herfindahl Index[1]	
Industry (ISIC-code)	Mean	Std.dev.	Mean	Std.dev.	Mean	Std.dev.	Mean	Std.dev.			Mean	Std.dev.
Textiles and Leather products (32)	5 302	8 417	55	29	105	121	0.09	0.19	572	528	0.17	0.19
Wood products (33)	5 730	18 128	72	49	121	100	0.13	0.14	1 167	1 116	0.08	0.07
Paper products (34)	13 173	36 706	79	48	174	193	0.14	0.14	728	658	0.11	0.09
Chemicals (35)	25 535	116 233	113	92	251	242	0.15	0.17	372	303	0.28	0.23
Mineral products (36)	7 261	22 264	98	70	171	166	0.20	0.14	387	354	0.25	0.29
Basic metals (37)	102 679	190 052	125	89	232	179	0.16	0.14	103	103	0.26	0.14
Metal products (381)	6 645	14 622	77	27	120	100	0.13	0.18	654	625	0.14	0.08
Machinery (382)	12 846	41 058	82	39	110	88	0.10	0.20	453	384	0.18	0.13
Electrical equip. (383)	22 235	53 603	86	67	98	87	0.09	0.22	190	174	0.20	0.16
Transport equip. (384)	20 854	59 222	76	28	88	74	0.10	0.13	521	501	0.36	0.33

Footnote: [1] The statistics refer to Herfindahl-indicies at the 5-digit ISIC-level. One 5-digit industry is treated as one observation.

Table 1B: Summary statistics for the 10 industry groups in applied sample in the year 1990. All nominal values are in 1000 N.kr.

	Sales per plant		Value-added per worker		Capital per worker		Residual share		#Plants	#Firms	Herfindahl Index[1]	
Industry (ISIC-code)	Mean	Std.dev.	Mean	Std.dev.	Mean	Std.dev.	Mean	Std.dev.			Mean	Std.dev.
Textiles and Leather products (32)	14 809	20 853	189	83	595	655	0.05	0.21	272	250	0.25	0.17
Wood products (33)	21 323	37 032	232	98	803	613	0.08	0.14	759	715	0.10	0.07
Paper products (34)	44 939	145 014	313	167	781	1 011	0.12	0.16	827	769	0.18	0.17
Chemicals (35)	105 283	369 992	399	418	1 503	2 096	0.14	0.16	324	259	0.33	0.24
Mineral products (36)	29 922	59 785	335	210	1 269	1 523	0.14	0.13	226	195	0.27	0.30
Basic metals (37)	378 239	713 261	338	169	1 850	1 310	0.08	0.09	79	58	0.29	0.14
Metal products (381)	16 605	30 398	243	100	554	464	0.07	0.20	636	612	0.17	0.14
Machinery (382)	61 040	179 475	293	140	524	598	0.07	0.26	393	352	0.29	0.24
Electrical equip. (383)	54 479	99 949	285	153	657	867	0.07	0.17	220	195	0.14	0.12
Transport equip. (384)	55 301	114 239	252	100	524	358	0.09	0.10	347	328	0.33	0.33

Footnote: [1] The statistics refer to Herfindahl-indicies at the 5-digit ISIC-level. One 5-digit industry is treated as one observation.

of this specification are presented in tables 2A and 2B. Before I elaborate on the results, let me briefly examine the issue of specification testing. Appendix B presents the outcome of alternative specifications. In choosing the preferred regressions I have relied heavily on the Sargan statistic. That is, I have chosen estimates based on the largest possible instrument set (i.e. the instrument set incorporateing also the shortest lags) consistent with an acceptable value for the Sargan test statistic[26]. A conservative significance level (1 percent) has been employed for the Sargan test, since Arellano and Bond (1991) suggest that the Sargan test has a tendency to overreject in the presence of heteroscedasticity. A comparison of heteroscedasticity consistent and non-heteroscedasticity consistent standard errors clearly indicates the presence of heteroscedasticity. For a model with an acceptable outcome of the Sargan test, I have imposed the assumption of constant returns to scale if both the constant returns to scale hypothesis is not rejected and the Sargan test remains valid for the constrained model. Imposing constant returns to scale tends to significantly improve the precision of the estimated markup.

It is interesting to note that in all cases where there are significant differences between the OLS and the GMM estimates (according to a Hausman test) the GMM estimates are *higher* than the OLS-estimates. This suggests that the errors-in-variables problem is a more important econometric problem than the "transmission bias".

As shown in tables 2A and 2B, 11 of 20 samples reveal (statistically) significant market power. For the industries with significant market power, the estimated price cost margins are in the range 1.06-1.16 . For the period

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[26] In one of the twenty samples the Sargan test rejected even the least-constrained model.

Table 2.A: Preferred estimates of price-cost margins and scale economies. Fixed/correlated effect model. GMM-estimates[1]. See equation (12).

ISIC	32	33	34	35	36
1975-82	GMM[2]	GMM[2]	GMM[2]	GMM[2]	GMM[2]
Price-cost margin	0.94 (.049)	1.13 (.010)	1.11 (.016)	1.08 (.016)	0.91 (.070)
Scale coefficient	0.88 (.043)	1.00[3] (-)	1.00[3] (-)	1.00[3] (-)	0.81 (.056)
Sargan test[5]	79.0* (54)	80.8 (55)	69.4 (55)	65.1 (55)	37.0 (54)
Obs.	3787	7731	5181	2791	2677
# Plants	680	1386	906	496	481
1983-90	GMM[2]	GMM[6]	GMM[4]	GMM[6]	GMM[2]
Price-cost margin	1.06 (.017)	1.05 (.037)	1.02 (.069)	1.06 (.050)	1.01 (.037)
Scale coefficient	1.00[3] (-)	0.90 (.033)	0.90 (.056)	0.94[3] (.044)	0.85 (.029)
Sargan test[5]	62.8 (54)	63.1* (40)	120.1** (40)	60.5* (40)	57.9 (54)
Obs.	2373	5836	5928	2499	1989
# Plants	439	1067	1043	476	394

Footnotes:
[1] Asymptotic standard errors robust to general cross-sectional heteroskedasticity are presented in parentheses.
[2] Capital and number of employees at t-1 and earlier are used as instruments.
[3] Constant returns to scale imposed.
[4] Right hand side variables and number of employees at t-2 and earlier are used as instruments.
[5] Degrees of freedom in parentheses.
[6] Capital and number of employees at t-2 and earlier are used as instruments.
* Significant at a 5 percent level.
** Significant at a 1 percent level.

Table 2.B: Preferred estimates of price-cost margins and scale economies. Fixed/correlated effect model. GMM-estimates[1]. See equation (12).

ISIC	37	381	382	383	384
1975-82	GMM[2]	GMM[2]	GMM[2]	GMM[2]	GMM[2]
Price-cost margin	1.06 (.021)	1.03 (.044)	1.07 (.014)	1.08 (.016)	1.08 (.011)
Scale coefficient	1.00 (-)	0.92 (.037)	1.00 (-)	1.00 (-)	1.00 (-)
Sargan test	80.8* (55)	64.8 (54)	55.6 (55)	49.5 (55)	64.3 (-)
Obs.	703	4784	3295	1365	3754
# Plants	116	909	606	248	688
1983-90	GMM[6]	GMM[2]	GMM[2]	GMM[2]	GMM[2]
Price-cost margin	1.16 (.038)	0.99 (.035)	1.08 (.011)	1.09 (.014)	0.96 (.042)
Scale coefficient	1.06 (.036)	0.93 (.029)	1.00 (-)	1.00 (-)	0.90 (.039)
Sargan test	76.6** (40)	56.4 (54)	72.1 (55)	59.2 (55)	59.1 (54)
Obs.	598	4612	3022	1464	2779
# Plants	105	923	616	281	528

Footnotes: See Table 2.A.

1975-82, these industries with market power are "Wood products" (ISIC 33), "Paper products" (ISIC 34), "Chemicals" (ISIC 35), "Basic metals" (ISIC 37), "Electrical equipment" (ISIC 382), "Electrical equipment" (ISIC 383) and "Transport equipment" (ISIC 384). According to the estimates, the same industries remain imperfectly competitive for the period 1983-90, except for "Wood products" and "Transport equipment". "Textiles" (ISIC 32) reveals significant market power only in the second period.

If we consider scale economies, none of the samples reveals significant increasing returns. On the other hand, seven samples exhibit significant decreasing returns, but most of these have scale coefficients in the range between 0.9 and unity. Accross samples, there is clearly a positive correlation between the scale estimates and the markup estimates.

The significance of size

Tables 3A and 3B present the outcome of regressions which examine the relationship between firm size and markups, as well as plant size and scale economies. The tables present only the preferred regressions, i.e. regressions with an instrument set which provided an acceptable performance in the Sargan test, as before.

The Wald-statistics, which indicate the joint presence of both size-effects in price-cost margins and scale economies, are presented under the label "Wald test" in tables 3A and 3B. In all but one sample, this statistic reveals significant size effects. The rows labeled "μ(mean)" and "μ(m. + 4s.)" in the table show the predicted markups for two different firm sizes. The row labeled "μ(mean)" shows the predicted markup at the sample mean, while

Table 3.A: Size effects in price-cost margins and scale coefficients. See equations (12), (14) and (15). Fixed/correlated effect model. GMM-estimates$^{1)}$.

ISIC	32		33		34		35		36	
Period	75-82$^{2)}$	83-90$^{3)}$	75-82$^{3)}$	83-90$^{3)}$	75-82$^{3)}$	83-90$^{3)}$	75-82$^{2)}$	83-90$^{2)}$	75-82$^{2)}$	83-90$^{2)}$
μ_0	0.97 (.033)	1.06 (.022)	1.02 (.030)	1.08 (.022)	0.91 (.035)	1.00 (.039)	1.05 (.029)	1.01 (.026)	1.02 (.030)	1.00 (.018)
$\Delta\mu_1$	-0.18 (.205)	-0.40 (.111)	1.46 (.377)	-0.27 (.209)	0.81 (.303)	0.58 (.268)	0.21 (.138)	0.32 (.110)	-0.01 (.206)	-0.38 (.127)
$\Delta\mu_2$	0.60 (.028)	0.91 (.182)	-3.52 (.948)	-0.27 (.482)	-1.00 (.439)	0.11 (.427)	-0.28 (.128)	-0.50 (.139)	0.04 (.233)	0.75 (.140)
η_0	0.91 (.026)	0.99 (.018)	0.87 (.028)	0.97 (.021)	0.81 (.033)	0.94 (.032)	0.95 (.024)	0.93 (.020)	0.86 (.025)	0.84 (.014)
$\Delta\eta_S$	0.06 (.021)	0.08 (.017)	0.01 (.021)	0.01 (.019)	0.03 (.022)	0.01 (.019)	0.07 (.018)	0.01 (.013)	0.07 (.018)	0.03 (.015)
$\Delta\eta_L$	0.04 (.019)	0.02 (.009)	0.09 (.019)	-0.01 (.014)	0.12 (.026)	0.04 (.023)	0.08 (.021)	-0.01 (.015)	0.02 (.016)	0.02 (.011)
Wald test$^{4)}$	32.1 (4)	45.0 (4)	29.0 (4)	17.8 (4)	24.6 (4)	49.9 (4)	31.4 (4)	14.7 (4)	16.0 (4)	79.6 (4)
Sargan test$^{5)}$	190.6 (162)	214.7 (218)	162.3 (162)	209.6** (162)	170.0 (162)	401.2** (162)	239.3 (218)	239.2 (218)	206.5 (218)	225.9 (218)
Obs.	3787	2373	7731	5836	5181	5928	2791	2499	2677	1989
# Plants	680	439	1386	1067	906	1043	496	476	481	394
μ (mean)	0.98	1.04	1.03	1.07	0.92	1.01	1.06	1.03	1.02	0.98
μ (m. + 4s.)	1.00	1.07	1.15	1.03	1.04	1.15	1.08	1.01	1.02	1.02
$\bar{\eta}$	0.94	1.02	0.90	0.97	0.86	0.96	1.00	0.93	0.89	0.86

Table 3.B: Size effects in price-cost margins and scale coefficients. Fixed/correlated effect model. GMM-estimates$^{1)}$. See equations (12), (14) and (15)

ISIC	37		381		382		383		384	
Period	75-82$^{2)}$	83-90$^{2)}$	75-82$^{2)}$	83-90$^{2)}$	75-82$^{2)}$	83-90$^{2)}$	75-82$^{2)}$	83-90$^{2)}$	75-82$^{2)}$	83-90$^{2)}$
μ_0	1.08 (.056)	1.00 (.069)	1.02 (.025)	1.01 (.020)	0.99 (.026)	0.94 (.016)	1.09 (.029)	0.99 (.018)	1.07 (.017)	0.96 (.014)
$\Delta\mu_1$	0.30 (.361)	0.00 (.388)	-0.22 (.305)	-0.11 (.105)	-0.24 (.176)	0.26 (.083)	0.43 (.258)	0.75 (.178)	-0.12 (.133)	0.32 (.085)
$\Delta\mu_2$	-0.83 (.666)	0.15 (.504)	1.27 (.648)	0.08 (.205)	0.39 (.458)	-0.18 (.106)	0.35 (.365)	-0.82 (.267)	0.05 (.157)	-0.44 (.100)
η_0	1.00 (.048)	0.96 (.036)	0.87 (.022)	0.94 (.018)	0.87 (.023)	0.85 (.013)	1.01 (.028)	0.92 (.018)	0.99 (.016)	0.89 (.012)
$\Delta\eta_S$	0.02 (.020)	0.06 (.034)	0.04 (.014)	0.01 (.009)	0.08 (.013)	0.05 (.015)	0.04 (.011)	0.02 (.014)	0.03 (.011)	0.05 (.012)
$\Delta\eta_L$	0.03 (.017)	0.04 (.022)	0.06 (.015)	0.00 (.011)	0.07 (.018)	0.02 (.009)	0.02 (.021)	0.04 (.017)	0.02 (.012)	0.03 (.008)
Wald test$^{4)}$	6.4 (4)	10.0* (4)	45.4 (4)	19.5 (4)	59.3 (4)	40.8 (4)	814.3 (4)	82.0 (4)	30.1 (4)	70.5 (4)
Sargan test$^{5)}$	205.3 (218)	260.1* (218)	213.0 (218)	245.7 (218)	229.2 (218)	248.5 (218)	214.1 (218)	220.0 (218)	222.4 (218)	202.4 (218)
Obs.	703	598	4784	4612	3295	3022	1365	1464	2779	2779
# Plants	116	105	909	923	606	616	248	281	528	528
μ (mean)	1.10	1.00	1.01	1.00	1.00	0.95	1.11	1.02	1.07	0.98
μ (m. + 4s.)	0.91	1.13	1.05	0.98	0.95	1.00	1.34	1.16	1.02	1.01
$\bar{\eta}$	1.02	0.99	0.90	0.94	0.92	0.87	1.03	0.94	1.01	0.92

Footnotes to Tables 3.A and 3.B:

[1] Asymptotic standard errors robust to general cross-section and time series heteroskedasticity are presented in the parantheses.

[2] GMM-estimates based on variables lagged at least one period.

[3] GMM-estimates based on variables lagged at least two periods.

[4] Corresponds to H_0: $\Delta\mu_1 = \Delta\mu_2 = \Delta\mu_S = \Delta\mu_L = 0$.

[5] Number of degrees of freedom in parentheses.

* Significant at a 5 percent level.

** Significant at a 1 percent level.

the row "μ(m. + 4s.)" refers to a firm size four standard deviations above the mean. In 6 of 20 samples there are higher price cost ratios for the larger firms. The opposite pattern emerges in only one case. In most industries the differences are of negligible magnitude, although statistically significant.

Turning to the question of size dependent scale economies, we find that in 11 of 20 regressions, small plants have larger scale economies than medium sized plants. Somewhat surprisingly, large plants also seem to have larger scale economies than the medium-sized plants in 8 out of 20 samples. With one exception[27], the average scale elasticity across size classes (see the row labelled "$\bar{\eta}$" in tables 3A and 3B) corresponds quite well with the results presented in tables 2A and 2B.

A comparison to related results

There are not many recent publications addressing the question of scale economies and/or markups in Norwegian manufacturing. Griliches and Ringstad (1971) used a cross section of establishments from 1963 to estimate scale economies in Norwegian manufacturing. They found scale economies around 1.05-1.06 for total manufacturing and mining[28]. Ringstad (1978) repeated these regressions on the corresponding 1974 Census data, with very similar results. The results in Griliches and Ringstad (1971) and Ringstad (1978) differ substantially from the findings presented in this paper, as I do not find any presence of increasing returns. Since the study of Griliches and Ringstad, it has become a widely held view that scale estimates from cross sectional

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[27] The exception is 1983-90, "Paper products" (ISIC 34). But notice that the Sargan test suggests a very strong rejection of the estimated model for this sample.

[28] See Griliches and Ringstad (1971), tables 4.14 and B.7.

studies are upward biased as they do not account for persistent differences in efficiency between plants[29].

Ringstad (1971) examined scale economies by means of a set of panel data (as is done in the present study), covering large firms (with at least 100 employees) in Norwegian mining and manufacturing for the period 1959-67. In his covariance analysis, he found substantial decreasing returns in most of the industries considered. Ringstad concluded that such results were not reliable, as the estimates seem to be strongly biased due to measurement errors in his labour and capital variables.

The work of Hall (1988, 1990) suggested very high price cost margins and scale economies in U.S. manufacturing, using a similar methodology as presented above. Domowitz et al. (1988) confirmed Hall's conclusion about substantial market power, based on a richer data set than the one used by Hall. They showed that Hall's estimates were significantly upward biased by Hall's use of value added rather than gross output. Their average estimate of the price cost margin in U.S. manufacturing was about 0.36 (with standard errors of the magnitude 0.03 and smaller). This is still much higher than the estimates presented here.

Given the large differences in magnitude of the estimates of Hall (1988, 1990) and Domowitz et al. (1988) compared to the markups and scale coefficients presented here, it would clearly be interesting to conduct a more systematic comparison of the results, in order to unravel the causes of the

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[29] The differences between cross sectional and panel data studies of production functions is an old and extensively discussed issue. See e.g. Ringstad (1971), Mundlak (1978) and Mairesse (1990).

discrepancy. That is to say, are there genuine differences in the competitive environment in the U.S. and Norway, or is it the use of a different methodology which matters? In particular, it would be interesting to know to what extent the choice of the level of aggregation of the data affects the results (cf. the discussion of the benefits of plant or firm level panel data in the introduction). The differences in the instrument sets might also be important. A detailed look at these questions is part of my agenda for future research.

7 Final remarks

The results presented in this paper suggest that increasing returns to scale is not a widespread phenomenon in Norwegian manufacturing. Imperfect competition, on the other hand, seems to be prevalent. The smallness of the estimated markups and the scale economies indicate that there are small welfare gains to be obtained from a more pro-competitive policy for the manufacturing sector.

Another implication of these estimates is related to growth accounting. Hall's estimates (Hall, 1988 and 1990) of markups and scale economies imply that traditional growth accounting and TFP-estimates, based on perfect competition and constant returns to scale, are close to worthless. The magnitude of the estimates presented in this paper suggest that these standard assumptions in TFP-calculations may be acceptable in a number of cases, at least for Norwegian manufacturing. Still, the estimates presented here show that standard assumptions in growth accounting have a tendency to underestimate the growth contribution from labour and material inputs in most sectors in Norwegian manufacturing. Correspondingly, there is a general upward bias in the estimate of the growth contribution of capital. More generally, one will tend to obtain an inflated estimate of the marginal product of capital based on residual calculations using the assumptions of constant returns and perfect competition. In fact, the estimates presented in this paper imply marginal rates of return to capital very close to zero in all samples. To what extent this finding reflects an excessive physical capital stock is an interesting topic for future research. Such an excessive capital stock could be due to the favorable tax treatment of physical investment in Norway, or perhaps to chronic excess capacity acquired for strategical reasons (see Bulow et al. (1985)).

In joint work with Zvi Griliches (Klette and Griliches, 1992), I examined the bias in cost- and production function regressions caused by replacing output by deflated sales, where deflation is based on an industry-wide deflator. This bias might be important in an industry with price dispersion and price-setting firms. Notice that such a deflating procedure is essentially equivalent to the normalization approach used in the present study. The point is that if idiosyncratic productivity shocks are important determinants of firm growth, growth in deflated sales will systematically underestimate growth in real output. This causes the scale coefficient to be downward biased. Such a downward bias in the scale coefficient might well be present in the estimates presented above. But how to explore the empirical importance of this issue remains a unsettled research topic.

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Appendix A: Details on the construction of the labour and capital variables

This appendix presents details about the construction of the labour and capital input variables used in the present study.

Before 1982, manhours referred to blue collar workers only. Following Griliches and Ringstad (1971, p.24), total labour input (X_{it}^L) was estimated according to the formulae

$$X_{it}^L = H_{it}\left(1 + \frac{C_{it}^{wc}}{C_{it}^{bc}}\right), \tag{16}$$

where H_{it} is manhours for blue collar workers. C_{it}^{wc} and C_{it}^{bc} refer to total wage costs for white collar and blue collar workers. After 1982, the total number of manhours was reported (while manhours for blue collar workers alone were not), and used as the labour input variable.

Capital inputs are perhaps the most problematic of the variables used in this study (as in most studies). At the outset, our sample has an unusual advantage to most other production data sets, in that the establishments report total fire insurance values for machinery and buildings (separately). Rental costs for rented capital are also reported. One of the problems with the fire insurance values is that there are a lot of missing values. Also, these variables have not been used by the Central Statistical Bureau, and little effort has been spent on identifying and correcting erroneous reports. Once more, I have followed the spirit of Griliches and Ringstad (1971, p.27) and estimated the capital services as

$$X_{it}^{K} = R_{it} + (0.07 + \delta^{M})V_{it}^{M} + (0.07 + \delta^{B})V_{it}^{B} \qquad (17)$$

where R_{it} is rental costs, δ^{M} and δ^{B} are depreciation rates for machinery and buildings taken from the Norwegian National Accounts (0.06 and 0.02, respectively). V_{it}^{M} and V_{it}^{B} are the fire insurance values for machinery and buildings at the beginning of the year. Clearly, this procedure is a rough weighting of the different components of capital, and we would expect the validity of these weights to vary substantially across firms and over time. Notice that our framework allows the shadow price of this capital estimate to differ across observations. An interesting topic for future work would be to estimate the weights as an integrated part of the whole regression.

To avoid losing too many observations due to missing fire insurance values, and to perhaps eliminate some noise, three different estimates of the fire insurance value were calculated for each year. In addition to the reported fire insurance values for year t, the fire insurance values were also estimated by a perpetual inventory method on the basis of investment figures and fire insurance values for the years t+1, t and t-1 (if available). The mean value of the three different estimates was used as the final estimate.

Appendix B: Results from alternative specifications

Table B.1: Price-cost margins (μ) and scale coefficients (η) for "Textiles and leather products" (ISIC 32). Fixed effects.

	OLS[1]	GMM-IA[1,2]	GMM-IB[1,2,3]	GMM-II[1,4]	GMM-III[1,5]
1975-82					
μ	0.94	0.94	1.09	0.89	0.93
	(.022)	(.049)	(.019)	(.047)	(.057)
η	0.92	0.88	1.00	0.86	0.88
	(.020)	(.043)	(-)	(.046)	(.053)
Sargan[5]		79.0*	80.8*	81.3*	61.3*
		(54)	(55)	(61)	(40)
Obs.	3 787	3 787	3 787	3 787	3 787
# Plants	680	680	680	680	680
1983-90					
μ	0.96	1.08	1.06	1.13	1.15
	(.018)	(.036)	(.017)	(.042)	(.053)
η	0.94	1.03	1.00	1.02	1.06
	(.018)	(.035)	(-)	(.037)	(.044)
Sargan[6]		62.8	63.7	84.6*	48.2
		(54)	(55)	(61)	(40)
Obs.	2 373	2 373	2 373	2 373	2 373
# Plants	439	439	439	439	439

Footnotes:

[1] Asymptotic standard errors robust to general cross-sectional heteroskedasticity are presented in parantheses.

[2] GMM-estimates based on capital and number of employees lagged once and more, as instruments.

[3] Constant returns to scale imposed.

[4] GMM-estimates based on right hand side variables and the number of employees lagged twice and more, as instruments.

[5] GMM-estimates based on right hand side variables and number of employees lagged twice and more, as instruments.

[6] Degrees of freedom in parantheses.

[*] Significant at a 5 percent level.

[**] Significant at a 1 percent level.

Table B.2: Price-cost margins (μ) and scale coefficients (η) for "Wood products" (ISIC 33). Fixed effects.

	OLS[1)]	GMM-IA[1),2)]	GMM-IB[1),2),3)]	GMM-II[1),4)]	GMM-III[1),5)]
1975-82					
μ	1.02 (.015)	1.06 (.056)	1.13 (.010)	1.04 (.050)	1.03 (.066)
η	0.92 (.011)	0.93 (.053)	1.00 (-)	0.89 (.048)	0.87 (.065)
Sargan[5)]		82.0* (54)	80.8* (55)	61.1 (61)	44.8 (40)
Obs.	7 731	7 731	7 731	7 731	7 731
# Plants	1 386	1 386	1 386	1 386	1 386
1983-90					
μ	1.00 (.027)	1.05 (.025)	1.11 (.009)	1.08 (.030)	1.05 (.037)
η	0.94 (.015)	0.94 (.024)	1.00 (-)	0.95 (.028)	0.90 (.033)
Sargan[5)]		102.4** (54)	108.0** (55)	105.8** (61)	63.1* (40)
Obs.	5 836	5 836	5 836	5 836	5 836
# Plants	1 067	1 067	1 067	1 067	1 067

Footnotes: See Table B.1.

Table B.3: Price-cost margins (μ) and scale coefficients (η) for "Paper products" (ISIC 34). Fixed effects.

	OLS[1]	GMM-IA[1),2]	GMM-IB[1),2),3]	GMM-II[1),4]	GMM-III[1),5]
1975-82					
μ	0.90 (.018)	1.16 (.057)	1.11 (.016)	1.06 (.055)	1.05 (.072)
η	0.85 (.014)	1.05 (.048)	1.00 (-)	0.97 (.049)	0.96 (.061)
Sargan[5]		66.7 (54)	69.9 (55)	66.1 (61)	39.4 (40)
Obs.	5 181	5 181	5 181	5 181	5 181
# Plants	906	906	906	906	906
1983-90					
μ	0.93 (.014)	0.96 (.053)	1.12 (.011)	0.83 (.059)	1.02 (.069)
η	0.89 (.012)	0.86 (.045)	1.00 (-)	0.77 (.049)	0.90 (.056)
Sargan[5]		157.5** (54)	159.2** (55)	190.0** (61)	120.1** (40)
Obs.	5 928	5 928	5 928	5 928	5 928
# Plants	1 043	1 043	1 043	1 043	1 043

Footnotes: See Table B.1.

Table B.4: Price-cost margins (μ) and scale coefficients (η) for "Chemicals" (ISIC 35). Fixed effects.

	OLS[1)]	GMM-IA[1),2)]	GMM-IB[1),2),3)]	GMM-II[1),4)]	GMM-III[1),5)]
<u>1975-82</u>					
μ	1.06 (.017)	1.11 (.050)	1.08 (.016)	1.02 (.050)	1.08 (.060)
η	0.96 (.015)	1.03 (.048)	1.00 (-)	0.94 (.048)	1.03 (.063)
Sargan[5)]		64.0 (54)	65.1 (55)	52.3 (61)	37.3 (40)
Obs.	2 791	2 791	2 791	2 791	2 791
# Plants	496	496	496	496	496
<u>1983-90</u>					
μ	1.01 (.024)	1.03 (.037)	1.12 (.020)	1.07 (.039)	1.06 (.050)
η	0.92 (.019)	0.91 (.032)	1.00 (-)	0.96 (.036)	0.94 (.044)
Sargan[5)]		86.9** (54)	89.6** (55)	86.9** (61)	60.5* (40)
Obs.	2 499	2 499	2 499	2 499	2 499
# Plants	476	476	476	476	476

Footnotes: See Table B.1.

Table B.5: Price-cost margins (μ) and scale coefficients (η) for "Mineral products" (ISIC 36). Fixed effects.

	OLS$^{1)}$	GMM-IA$^{1),2)}$	GMM-IB$^{1),2),3)}$	GMM-II$^{1),4)}$	GMM-III$^{1),5)}$
1975-82					
μ	0.97	0.91	1.15	1.01	0.82
	(.019)	(.070)	(.018)	(.059)	(.099)
η	0.85	0.81	1.00	0.92	0.77
	(.017)	(.056)	(-)	(.047)	(.073)
Sargan$^{5)}$		37.0	40.4	46.6	25.5
		(54)	(55)	(61)	(40)
Obs.	2 677	2 677	2 677	2 677	2 677
# Plants	481	481	481	481	481
1983-90					
μ	0.99	1.01	1.18	1.08	1.06
	(.016)	(.037)	(.015)	(.039)	(.049)
η	0.89	0.85	1.00	0.90	0.89
	(.013)	(.029)	(-)	(.030)	(.036)
Sargan$^{5)}$		57.9	72.5	58.8	43.4
		(54)	(55)	(61)	(40)
Obs.	1 989	1 989	1 989	1 989	1 989
# Plants	394	394	394	394	394

Footnotes: See Table B.1.

Table B.6: Price-cost margins (μ) and scale coefficients (η) for "Basic metals" (ISIC 37). Fixed effects.

	OLS[1)]	GMM-IA[1),2)]	GMM-IB[1),2),3)]	GMM-II[1),4)]	GMM-III[1),5)]
1975-82					
μ	1.08 (.033)	1.12 (.051)	1.06 (.021)	1.14 (.049)	1.15 (.062)
η	1.01 (.030)	1.06 (.046)	1.00 (-)	1.08 (.043)	1.06 (.052)
Sargan[5)]		80.8* (54)	80.8* (55)	81.2* (61)	68.3** (40)
Obs.	703	703	703	703	703
# Plants	116	116	116	116	116
1983-90					
μ	1.06 (.031)	1.11 (.032)	1.05 (.017)	1.08 (.027)	1.16 (.038)
η	1.01 (.021)	1.05 (.029)	1.00 (-)	1.00 (.027)	1.06 (.036)
Sargan[5)]		83.3** (54)	85.4** (55)	99.4** (61)	76.6** (40)
Obs.	598	598	598	598	598
# Plants	105	105	105	105	105

Footnotes: See Table B.1.

Table B.7: Price-cost margins (μ) and scale coefficients (η) for "Metal products" (ISIC 381). Fixed effects.

	OLS1)	GMM-IA1),2)	GMM-IB1),2),3)	GMM-II1),4)	GMM-III1),5)
1975-82					
μ	0.99 (.023)	1.03 (.044)	1.12 (.015)	1.00 (.049)	1.00 (.061)
η	0.91 (.012)	0.92 (.037)	1.00 (-)	0.90 (.041)	0.91 (.048)
Sargan5)		64.8 (54)	68.0 (55)	74.7 (61)	58.8* (40)
Obs.	4 784	4 784	4 784	4 784	4 784
# Plants	909	909	909	909	909
1983-90					
μ	0.97 (.016)	0.99 (.035)	1.08 (.009)	0.94 (.043)	0.92 (.065)
η	0.93 (.014)	0.93 (.029)	1.00 (-)	0.89 (.036)	0.88 (.050)
Sargan5)		56.4 (54)	60.1 (55)	72.6 (61)	44.6 (40)
Obs.	4 612	4 612	4 612	4 612	4 612
# Plants	923	923	923	923	923

Footnotes: See Table B.1.

Table B.8: Price-cost margins (μ) and scale coefficients (η) for "Machinery" (ISIC 382). Fixed effects.

	OLS1)	GMM-IA1),2)	GMM-IB1),2),3)	GMM-II1),4)	GMM-III1),5)
1975-82					
μ	0.91 (.019)	1.04 (.055)	1.07 (.014)	0.91 (.051)	0.97 (.076)
η	0.85 (.015)	0.96 (.052)	1.00 (-)	0.86 (.050)	0.90 (.070)
Sargan5)		56.4 (54)	55.6 (55)	67.4 (61)	43.7 (40)
Obs.	3 925	3 925	3 925	3 925	3 925
# Plants	606	606	606	606	606
1983-90					
μ	0.96 (.021)	1.02 (.038)	1.08 (.011)	1.03 (.040)	1.01 (.057)
η	0.91 (.017)	0.94 (.036)	1.00 (-)	0.94 (.039)	0.91 (.050)
Sargan5)		74.1 (54)	72.1 (55)	84.3* (61)	55.8 (40)
Obs.	3 022	3 022	3 022	3 022	3 022
# Plants	616	616	616	616	616

Footnotes: See Table B.1.

Table B.9: Price-cost margins (μ) and scale coefficients (η) for "Electrical equipments" (ISIC 383). Fixed effects.

	OLS[1]	GMM-IA[1),2]	GMM-IB[1),2),3]	GMM-II[1),4]	GMM-III[1),5]
1975-82					
μ	1.05 (.025)	1.14 (.062)	1.08 (.016)	1.09 (.054)	1.16 (.074)
η	0.98 (.023)	1.05 (.057)	1.00 (-)	1.01 (.053)	1.07 (.070)
Sargan[5]		48.3 (54)	49.5 (55)	63.6 (61)	39.5 (40)
Obs.	1 365	1 365	1 365	1 365	1 365
# Plants	248	248	248	248	248
1983-90					
μ	1.03 (.017)	1.06 (.049)	1.09 (.014)	0.97 (.047)	0.97 (.068)
η	0.97 (.014)	0.97 (.042)	1.00 (-)	0.91 (.040)	0.91 (.054)
Sargan[5]		58.9 (54)	59.2 (55)	69.1 (61)	38.0 (40)
Obs.	1 464	1 464	1 464	1 464	1 464
# Plants	281	281	281	281	281

Footnotes: See Table B.1.

Table B.10: Price-cost margins (μ) and scale coefficients (η) for "Transport equipments" (ISIC 384). Fixed effects.

	OLS$^{1)}$	GMM-IA$^{1),2)}$	GMM-IB$^{1),2),3)}$	GMM-II$^{1),4)}$	GMM-III$^{1),5)}$
1975-82					
μ	1.01 (.011)	1.10 (.032)	1.08 (.011)	1.12 (.044)	1.19 (.060)
η	0.94 (.011)	1.03 (.031)	1.00 (-)	1.06 (.040)	1.12 (.052)
Sargan$^{5)}$		64.0 (54)	64.3 (55)	69.1 (61)	38.8 (40)
Obs.	3 754	3 754	3 754	3 754	3 754
# Plants	688	688	688	688	688
1983-90					
μ	0.99 (.011)	0.96 (.042)	1.06 (.011)	1.03 (.032)	0.96 (.056)
η	0.95 (.007)	0.90 (.039)	1.00 (-)	0.97 (.033)	0.90 (.054)
Sargan$^{5)}$		59.1 (54)	60.1 (55)	57.6 (61)	44.2 (40)
Obs.	2 779	2 779	2 779	2 779	2 779
# Plants	528	528	528	528	528

Footnotes: See Table B.1.

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