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PRICE-COST MARGINS IN FINLAND: STATIC AND DYNAMIC APPROACHES

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ABSTRACT: In this paper a model based on production theory is used to measure firms' oligopoly power in the Finnish industry. Oligopsony power in labour markets is also tested and discussed. Translog cost and profit functions are used, and one-output and two-output cases are studied. Both static and dynamic optimization approaches are used. The results show that there are significant signs of pricing over marginal costs in the Finnish industry. No clear sign for the oligopsony power in the labour market was found. The results also give an indication of over-investment in Finland.

KEY WORDS: Oligopoly power, cost functions, profit functions, production theory, industrial organization

Hintamarginaalit Suomessa staattisten ja dynaamisten mallien valossa

Tutkimuksessa tarkastellaan hintojen ja rajakustannusten välistä suhdetta Suomen teollisuudessa. Tarkastelu perustuu sekä staattisiin että dynaamisiin mallitäsmennyksiin. Edellisessä pääomakanta oletetaan kiinteäksi tuotannontekijäksi, jota lyhyellä aikavälillä ei voi muuttaa. Jälkimmäisessa mallissa pääomakannan muuttamiseen ajatellaan liittyvän sopeuttamiskustannuksia, jotka estävät pääomakannan nopean sopeuttamisen halutulle tasolle. Molemmat mallit perustuvat oletukseen yritysten optimointikäyttäytymisestä. Staattinen malli olettaa kustannusten minimoinnin ja dynaaminen malli voiton maksimoinnin. Nämä kaksi lähestymistapaa ovat tiettyjen ehtojen vallitessa identtisiä ns. duaalisuuden perusteella.

Perinteisen talousteorian mukaan yritysten on optimaalista asettaa hinnat yhtäsuuriksi rajakustannusten kanssa. Rajakustannukset kertovat, kuinka paljon yrityksen kustannukset kasvavat, kun tuotantoa lisätään yhdellä yksiköllä. Perusteorian mukaan täydellisen kilpailun vallitessa yrityksen kannattaa lisätä tuotantoaan niin kauan kun tuotteen hinta on rajakustannuksia suurempi. Rajakustannukset oletetaan kasvaviksi, joten tuotannon määrää ei kannata kasvattaa rajatta.

Käytännössä täydellisen kilpailun mukainen hinnoittelu ei läheskaan aina ole voimassa, vaan usein yritykset voivat vaikuttaa hinnanmuodostukseen. Tällöin yritykset eivät ota hintoja annettuina, vaan heillä on vapautta päättää tuotteidensa hinnoista. Aiemmin Suomessa ei juuri ole tutkittu, kuinka paljon hinnanasetanta poikkeaa perusteorian esittämästä ideaalihinnasta, jonka mukaan rajakustannukset ja tuotteen hinta ovat yhtäsuuria. Usein tutkimusten lähtökohdaksi on otettu täydelliseen kilpailuun ja tehokkaaseen hinnanasetantaan perustuva talous, vaikka tämä lähtökohta on tämän tutkimuksen mukaan epärealistinen.

Tutkimusasetelman tekee hankalaksi se, että rajakustannukset eivät ole suoraan havaittavissa, vaan ne on estimoitava empiiristä aineistoa käyttäen. Rajakustannusten tarkasteleminen edellyttää niin ikään myös tuotantorakenteen perusriippuvuuksien täsmentämistä tuotantoteoreettisten lähtökohtien avulla. Tässä tutkimuksessa käytetään tuotantoteoriaan perustuvaa mallia, joiden avulla johdetaan epälineaariset yhtälöt hintamarginaalien estimoimiseksi. Aineistona käytetään Suomen teollisuutta koskevaa neljännesvuosiaineistoa vuodesta 1976 vuoteen 1991.

Tulosten mukaan hintojen ja rajakustannusten välinen marginaali on tilastollisesti merkitsevä, ja eri malleilla saadut arviot vaihtelivat koko aineistolla estimoituina noin 30-40 prosentin välillä. Kun mallia lisäksi laajennettiin siten, että hinnoittelukäytännön sallittiin poikkeavan vienti- ja kotimarkkinoiden välillä, todettiin, että kotimarkkinoilla hintamarginaalit olivat suurempia kuin vientimarkkinoilla. Estimointitulosten mukaan voitiin lisäksi päätellä, että todellinen pääomakanta Suomen teollisuudessa on suurempi kuin mallien avulla laskettu optimaalinen pääomakanta. Edelleen pääomakannan jousto hintansa suhteen havaittiin pieneksi. Tällä tuloksella on merkitystä arvioitaessa, kuinka paljon investointeja voidaan lisätä esimerkiksi verohelpotuksilla. Tulosten mukaan elvytyksen vaikutukset jäisivät sangen vähäisiksi.

Contents

1 Introduction

An important measure of the efficiency and the competiveness of an economy or an industry is the degree by which firms' price setting exceeds their marginal costs. The Finnish economy is going through a remarkable change in its structure. For example, European integration, the recession especially in the sheltered sector, the enormous foreign debt and the cut in exports to the former Soviet Union area are once again emphasizing the importance of a competitive industrial production structure for the economy. A price-cost margin can be used to measure the underlying inefficiencies in the production market, and the adjustment pressure of the Finnish industry in the near future can be anticipated.

In this paper a model based on production theory is used to measure firms' oligopoly power in the Finnish industry. The model is formulated for both one-output and two-output cases using cost and profit functions. Four inputs are used: labour, capital, import goods and intermediate goods. Capital is treated as a quasi-fixed factor, and intermediate goods are connected to variable factors of production - labour and import goods - in fixed proportion. A translog functional form is chosen for both the cost function and the profit function. This function allows for flexible interactions between various inputs and outputs. The first model is based on a hypothesis of a partial static equilibrium, and dynamic aspects of the firm behaviour and the specification of the dynamic adjustment of a capital stock are not taken into consideration. The basic static model is similar to that of Bernstein and Mohnen (1991). In the static case estimations are carried out with both one-output and two-output cases. In the two-output case the industrial production is split into foreign and domestic markets.

The second model incorporates a dynamic capital adjustment behaviour, which is specified by defining the corresponding Euler equations and estimating them directly, as suggested by Bernstein (1992)[1]. The actual adjustment paths for capital are not derived, although the dynamic behaviour is taken into consideration. In the dynamic model the assumption of rational expectations is maintained, and the present value maximization problem is solved. The stochastic Euler equations for this optimization problem are then estimated together with the two-output profit function and the short-run equilibrium conditions. The model allows for comparing the differences in the markups between

[1]See also e.g. Pindyck and Rotemberg (1983) and Papagni (1990).

the open and sheltered sectors. Inefficiencies in input markets are also studied, and oligopsony power in the labour market is tested.

The model gives an empirical characterization of the production technology, and the estimates are consistent with the assumption of rational expectations. The firms are expected to utilize the solution to the stochastic control or dynamic optimization problem. The model is, however, restricted to the solution of the first-order conditions, and the optimal trajectories for capital cannot be solved. In spite of this the model characterizes the equilibrium condition imposed by the stochastic control problem.

The data is from the period 1976/1 to 1991/4, although the shorter time span from 1982/1 to 1991/4 was found to be much more stable than that of the whole data period. The estimation of the models is carried out using quarterly manufacturing data for Finland.

The results show that there are significant signs of pricing over marginal costs in the Finnish industry: the aggregate estimates vary between 30 and 40 per cent. The hypothesis of a partial static equilibrium of capital is tested with the static model, and it is strongly rejected. This implies that capital can not be treated as an input factor, which faces a traditional static optimization behaviour. The results also give an indication of over-investment in Finland. The own price elasticity of capital was found to be low. This result is in line with the earlier studies, and this issue is of particular significance, when the effects of an economic policy operating through the cost of capital are evaluated.

The paper is organized as follows: first the basic setup for markup-studies is introduced, and different approaches in this research area are discussed. In the next section a static non-competitive model is derived, and in the following section the characterization of the corresponding dynamic model is introduced. After that the data is introduced followed by the sections describing the estimation results. At the end of the paper inter-study comparisons are made and some basic conclusions are drawn.

2 Empirical studies with oligopoly power

The problem of markup-pricing is that of detecting the difference between the competitive and actual prices. The neoclassical basic assumption for the firm behaviour is that of profit maximization. If the assumption of an aggregate firm is maintained, the problem of profit maximization can be written as

$$\max_{y} \Pi = py - C, \tag{1}$$

where Π is the profit, p is the output price, y is the output quantity and C is the cost function. The first order conditions describe the equilibrium condition between the marginal revenue and the marginal cost: $p + (\partial p/\partial y)y = \partial C/\partial y$. If the pricing rule of the firm is consistent with the competitive pricing condition, the term $(\partial p/\partial y)y$ is zero and the marginal revenue (the product price) equals the marginal cost $\partial C/\partial y$. On the other hand, if the term $(\partial p/\partial y)y$ significantly deviates from zero, the first order condition can be written in the form $p(1 + (\partial p/\partial y)y/p) = \partial C/\partial y$, where $(\partial p/\partial y)y/p$ is the markup-coefficient, designated by θ. The coefficient θ for the firm j can be split into the effects of the conjectural elasticity θ_j^* and the inverse market demand elasticity ξ, such that $\theta_j = \theta_j^*\xi$ by definition[2]. The degree of oligopoly power of the whole industry can be achieved by aggregation: $\theta = \sum_j [(p - MC_j)/p](y_j/y) = \sum_j \theta_j^*\xi(y_j/y)$, where MC_j is the marginal cost of the jth firm. In the case of Cournot-behaviour $\partial y/\partial y_j = 1$ and θ_j^* is the output share of the jth firm. Naturally, on the aggregate level $\theta^* = 1$ in this case. Alternatively, under perfect competition θ^* is 0.

If the competitive pricing assumption is not correct, it is important to have a framework within the non-competitive behaviour which can be analyzed and modelled. There is a large body of literature on testing and modelling the price-taking behaviour, although in Finland these studies are quite rare. The markup-studies have mostly rejected the hypothesis of competitive price-taking behaviour. For example, Appelbaum (1979) rejected price-taking for the U.S. petroleum and natural gas industry, Sumner et al. (1981) for the cigarette industry, Iwata (1974) for the Japanese flat glass industry, Cubbin (1975) for the United Kingdom automobile industry, Appelbaum (1982) for the U.S. electrical machinery and tobacco industries, Hall (1988) for the U.S. industries, Bernstein and Mohnen (1991) for the Canadian industries, Bernstein (1992) for the Canadian pulp and paper industries, Papagni (1990) for the Italian manufacturing, and Morrison (1992) for the U.S. and Japanese industries[3]. In Finland markup-pricing has been studied by, for example, Alho (1992).

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[2]The term $\theta_j^* = (\partial y/\partial y_j)(y_j/y)$ is the conjectural elasticity of total industry output with respect to the output of the jth firm. The term ξ is the inverse of the price elasticity of demand $\xi = -(\partial p/\partial y)/(p/y)$.

[3]See also the surveys by Bresnahan (1989) and Geroski (1988).

The intrinsic problem in markup-studies is that although the prices can be observed the corresponding marginal costs cannot. The pioneering work in price-margin studies by Bain (1951) and the studies following this tradition assumed that economic price margins could be directly observed in the firm level accounting data. This structure-conduct-performance paradigm (SCPP) approach was applied to estimating the reduced-form equations describing the industry structure, and the relationship between the empirical equations and the behavioural relations were in many cases left unclear (Bresnahan, 1989).

In the middle of the 1970's a new paradigm to markup-research raised its head. It was called the 'new empirical industrial organization' - NEIO (Bresnahan, 1989). The central idea in this new approach was that economic marginal costs were not directly observable, which led to more advanced model specification and estimation of the unobserved parameters. In addition, the inference of the existence of the market power was made explicit by constructing tests for a perfectly competitive hypothesis. The main topics covered by this approach were the formation of collusions, the nature of oligopoly interactions and the determinants and size of market power in different industries.

There are several ways to identify market power in empirical research. They can be grouped into comparative statics in demand, comparative statics in cost, supply shocks and econometric estimation of marginal costs and price-cost margins, which is applied in this study. Comparative statics in demand approach consists of specifying the demand and supply relationships and estimating them. With these empirical relationships one can approximate the response in the marginal revenue when the elasticity of demand is changed by changing an exogenous variable in the demand relation. If an exogenous variable in the demand relationship is shifted, this will rotate the demand curve. In the competitive equilibrium this will have no effect on the equilibrium, because the location of the intersection of the supply and demand curves does not alter. In the non-competitive case the corresponding exogenous shift the marginal revenue, and the equilibrium will change. This approach has been discussed by Bresnahan (1982).

The second approach - that of comparative statics in cost - can be applied by estimating the revenue function directly by conditioning the observed revenue on all observable shifters of supply and demand. With this empirical revenue function one can calculate the H_R statistic, which gives the change in equilibrium revenues when all of the firm's factor prices are increased. When a monopoly is considered, it is known that the optimal revenue will fall when costs rise. So, if H_R is negative, an indication of the monopoly case is detected (Bresnahan, 1989).

The approach of supply shocks is based on a switching conduct assumption. Under this assumption there are two kinds of conduct periods: price wars and collusions. When there is a price war, the pricing rule is closer to the competitive solution than in the collusion regime. If one can specify the constant probability of these two regimes, the market structure can be described. If the two-regime assumption is valid, empirical bimodal distribution techniques, such as switching regression modelling, can be used to specify the equations. The approach is not very robust, because the inference is based on identifying the certain component in the error term, and existence of non-switching errors can easily confuse the analysis.

When direct estimation of marginal costs is carried out, one usually applies flexible functional forms to characterize the cost technology of a firm or an industry. The approach is directly based on neoclassical economic theory and the basic results of production theory. In the pioneering works by Gollop and Roberts (1979) and Appelbaum (1979, 1982) the cost function and the factor demand functions are specified together with the price setting relationship. The key point in this approach is that from the firm's cost technology it is possible to derive the factor demand and the price equations. All these equations can then be estimated together as a system and the accuracy of the estimation can be increased. Furthermore, in many cases the cross-equation restrictions guarantee the proper identification of the nonlinear markup-relationships. This group of models has a large amount of variations. For example, Hall (1988) measured marginal costs by inspecting the increase in the costs when output was raised. By comparing the changes in inputs with movements in output it was possible to approximate the progress in marginal costs. In other words, Hall used data to reveal the incremental costs, which are not directly observable.

The direct estimation approach has also been used by Borooah and van der Ploeg (1986) with a generalized Leontief cost function applied to British industry. Bernstein and Mohnen (1991) used this approach to study the difference of the oligopoly power between the foreign and domestic sectors in the Canadian industries. Later Bernstein (1992) used the profit function and the dynamic specification to describe and test the competitive position of the Canadian paper and pulp industries. In this paper the Euler equations were estimated directly, but no explicit adjustment paths for the dynamic problem were obtained. Morrison (1992) applied a generalized Leontief function to U.S. and Japanese industrial data. In her approach the cyclical movement or the non-constancy of the markup-coefficients was taken into consideration, and the variation of these coefficients was found to be significant.

3 The static model

The static model in this study is based on a cost function approach. The variable cost function of an aggregate firm can be defined as a solution to a restricted cost minimization problem

$$c^v(w, y, K) = \min_{v \geq 0}[w\ v\ : v \in L(y, K)], \qquad (2)$$

where c^v is the variable cost, y is output, w is a vector of variable factor prices and v is a vector of variable inputs. L is a restricted input requirement set and K is a quasi-fixed factor of production - capital. The usual assumptions of the cost function are made: it is twice differentiable, concave, non-negative when factor prices are positive and non-decreasing in variable factor prices and output when output is positive. Also a homogeneity assumption of degree one in variable factor prices has been made. It is assumed that the whole industry can be described by an aggregate cost function. This assumption is valid if the distribution of firm specific variables can be taken as fixed. This allows for the use of an industry-level variable cost function that depends only on industry variables (Diewert, 1977).

When a logarithmic function is used, factor demand equations specified in cost shares can be derived by Shephard's Lemma from the cost function.

$$s_i = \frac{\partial lnC^v}{\partial lnw_i}, \qquad (3)$$

where $s_i = w_i v_i / C^v$, and v_i is the quantity of the input i. Product market equilibrium can be determined from a profit maximization problem

$$max_y D_i(y_i, z_i)y_i - C^v(y, w, K), \quad i = 1, 2, \qquad (4)$$

where $p_i = D(y_i, z_i)$, p_i is the output price on market i and z_i is a vector of factors having an effect on output demand on market i. The term D_i denotes the inverse product demand function on market i. It is assumed to be twice differentiable, non-negative and non-increasing in output quantity. It is assumed that the production can be allocated using optimal price discrimination to two separate markets - to the domestic markets or to the foreign markets.

The equilibrium condition for the price setting and the markup equation can be derived by taking partial derivative of the (logarithmic) cost function with respect to the (logarithmic) output quantity (Bernstein and Mohnen, 1991):

$$s_{yi}(1+\theta_i) = \frac{\partial lnC}{\partial lny_i}, \tag{5}$$

where s_{yi} is the ratio of revenue to variable cost on market i and θ_i is the markup parameter on market i[4]. The degree of oligopoly power is given by the parameters θ_x and θ_d for foreign and domestic markets. If the hypothesis of perfect competition is maintained, it is set to zero. It is assumed that $0 \leq -\theta_i < 1$.

The equations (3) and (5) define the short-run equilibrium of the aggregate firm. The long-run equilibrium is achieved when the quasi-fixed input - capital - is on its optimal level. The model is static and it is not possible to calculate the adjustment speed of the quasi-fixed input. This can be calculated if a model based on explicit dynamic optimization is used (Berndt, Fuss and Waverman, 1980; Ilmakunnas and Törmä, 1991). Because the key point in this study is the measurement of the oligopoly power and not the investment behaviour, the lack of optimal trajectories for capital is not a crucial shortcoming. Furthermore, even the static model can be used to describe the validity of the pricing rules and the long-run equilibrium conditions of the quasi-fixed factors.

When the long-run equilibrium is reached, the marginal reduction in the variable cost due to a unit's increase in the quasi-fixed input must be equal to minus the ratio of capital cost per unit to variable cost, see equation (6) (Bernstein and Mohnen 1991;

[4] When the output markets are separated, the revenue-cost ratio of one market is naturally smaller than that of the aggregate market. The partial market revenue-cost ratio has to be corrected upwards to be on par with the aggregate cost. For example, for the export market x the one market short-run profit ($\Pi = p_x y_x - C$) maximization can be written as $\partial\Pi/\partial y_x = p_x + p'_x y_x - C' = 0$, and $p_x(1 + p'_x y_x/p_x) = C'$, where C' is the marginal cost function. If the latter condition is multiplied by the ratio y/C, which is the inverse of the average cost, the right-hand side part of the equilibrium condition becomes $\partial lnC/\partial lny$, which is the equation (5). In other words, the revenue cost ratio must be corrected by the ratio y/y_x.

Schankerman and Nadiri, 1986)[5]. The long-run equilibrium is a special case of the short-run (partial) equilibriums. In other words, the long-run equilibrium is nested by short-run equilibriums, and equation (6) can also be called as an envelope condition, because it defines the lower envelope for the short-run equilibriums.

$$s_k = -\frac{\partial lnC^v}{\partial lnK} \tag{6}$$

The long-run equilibrium is described by the short-run factor demand equations (3), the pricing equation (5) and the equilibrium condition (6) for capital. Equation (6) gives the shadow price of capital.

Before the model can be estimated, a functional form must be specified. In this study a translog functional form (6) is used,

$$\begin{aligned} ln(c^v/w_m) &= \beta_0 + \beta_y ln\ y + \beta_v ln\ \omega + \beta_k ln\ K + \beta_t t \\ &+0.5[\beta_{yy}(lny)^2 + \beta_{vv}(ln\omega)^2 + \beta_{kk}(lnK)^2 + \beta_{tt}t^2] \\ &+\beta_{yv} ln\omega\ lny + \beta_{yk} lny\ lnK + \beta_{yt} lny\ t + \beta_{vk} ln\omega\ lnK \\ &+\beta_{wt} ln\omega\ t + \beta_{kt} lnK\ t. \end{aligned} \tag{7}$$

In the translog cost function (7) homogeneity in variable factor prices is achieved by using the relative price $\omega = w_l/w_m$, where w_l is the price of labour and w_m is the price of import goods. The variable cost c^v is in turn divided by the numeraire price w_m.

There are two variable factors in the model: labour and import goods. Capital is assumed to be a quasi-fixed input and intermediate goods are assumed to be applied in a fixed proportion to the variable costs. This simplification is made because it is empirically almost impossible to distinguish between an intermediate goods price and a gross output price. On the other hand, because the different cost components must sum up to the total costs - the value of gross output - all components must be taken into consideration. Otherwise the parameter describing the oligopoly power might be biased.

The inverse of the demand function is an additional part of the model,

[5] By definition $\frac{\partial lnC}{\partial lnK} = \frac{\partial C}{\partial K}\frac{K}{C}$, and in equilibrium $-\frac{\partial C}{\partial K}$ must be equal to the user cost of capital UCC. This implies that $\frac{\partial lnC}{\partial lnK} = -\frac{UCC\ K}{C} = s_k$.

$$lnp_i = \alpha + \xi_i lny + \Psi^T lnz_i. \tag{8}$$

The term ξ_i is the inverse price elasticity on market i, Ψ is a parameter vector and z_i is a collection of variables that describes important demand and additional supply factors on market i[6].

For example, if the assumption of perfect collusion is maintained, the parameter ξ_i of the output variable is exactly the same as the parameter in the supply-driven pricing equation [7]. Demand equations (8) describe the effects reflecting the behaviour of the purchasers.

The demand equation is not derived from the firms' behaviour while the translog based equations reflect the firms' supply decisions. The translog-based labour demand equation (9), solved from minimizing of (7), produces the following cost share equation.

$$s_L = \beta_v + \beta_{vv} ln\omega + \beta_{yv} lny + \beta_{vk} lnK + \beta_{vt} t \tag{9}$$

Because the cost shares always sum up to a unity, only one of the variable factor equations need to be estimated. The other - that of import goods - can be calculated as a residual as $s_M = 1 - s_L$, where s_L is the labour input's cost share.

Respectively, the translog-based price setting equation can be written in the form

$$s_{yi}(1 + \theta_i) = \beta_y + \beta_{yy} lny + \beta_{yv} ln\omega + \beta_{yk} lnK + \beta_{yt} t, \tag{10}$$

The coefficient θ can be identified by using the inverse demand equations (8) and the cost function (7). Equations (10) are non-linear in parameters, and a non-linear estimation method must be used to calculate the parameters of the model. Finally, the corresponding capital demand equation describing the long-run equilibrium of the capital stock can be written as

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[6] E.g. import prices for the domestic markets and foreign competitors prices for the export markets.

[7] The measure of the oligopoly power is the conjectural elasticity of the product multiplied by the inverse price elasticity: $\theta_i = \theta_i^* \xi_i$. Under perfect collusion the conjectural elasticity θ_i^* is one, and the oligopoly power can be described by the inverse price elasticity. Respectively, if a unity assumption of the price elasticity is maintained, the oligopoly power can be described by the estimate of the conjectural elasticity.

$$s_k = -[\beta_k + \beta_{kk} lnK + \beta_{yk} lny + \beta_{vk} ln\omega + \beta_{kt} t], \tag{11}$$

where s_k is the ratio of capital costs to variable costs. The model to be estimated consists of equations (7),(8),(9),(10) and (11). An error term is added to all equations. They describe e.g. aggregate level measurement errors and random optimization errors of the firms.

If the assumption of the long-run equilibrium is valid, the optimal capital stock does not deviate significantly from the observed capital stock. If this is not the case, the firms adjust their capital stock towards the optimal level of capital. The model does not tell anything about the adjustment path to the optimal level of the quasi-fixed factor, but its target level can still be calculated. The static equilibrium test formed by Kulatilaka (1985) is based on the deviation between the optimal and the observed capital. If the deviation is significant, the null hypothesis of the static equilibrium is rejected, and the partial equilibrium approach is suggested. Another approach, used in this study, is based on the modification of a Hausman (1978) specification test. The test is based on the change in the parameters when the envelope condition for capital is added to the estimation (Schankerman and Nadiri, 1986). In this test the model is estimated twice, once with the envelope condition (11) excluded and once included. Because the number of parameters and the dimension of the parameter space in these two modifications is the same, the test statistic T may be written

$$T = (\beta_e - \beta_i)' V^{-1} (\beta_e - \beta_i), \tag{12}$$

where β_e is the parameter vector when the envelope condition is excluded from the estimation and β_i is respectively the parameter vector when this condition is included in the estimation. The term V is the difference between the covariance matrices in the two estimations. The test statistic is asymptotically χ^2 distributed with q degrees of freedom, where q is the number of restrictions being tested. In our case five parameter restrictions are imposed, which equals the number of parameters in the demand for capital equation.

4 The dynamic model with capital adjustment

In the previous section the inference of markup pricing behaviour was based on a static model which does not allow for possible adjustment costs when the optimal capital stock changes. It is, however, possible to make misleading inferences on the market power if adjustment costs exist and they are not taken into consideration. If adjustment costs exist, this may cause short-run marginal costs to exceed long-run marginal costs. If conclusions are drawn on the basis of the long-run equilibrium condition, an indication of excessive markup pricing may be drawn.

If firms have significant adjustment costs in their capital accumulation process and if the capital stock deviates from the optimal level of capital, the process of capital adjustment increases firms' marginal costs. The adjustment path to the global optimum goes through successive short-run equilibria. Adjustment costs are a part of firms' technology. They may affect, for example, scale economies and technical progress, so it is important to have an opinion of their role in the pricing behaviour, technology and factor demand.

In this section a model incorporating non-competitive behaviour both in product and factor markets is derived. The model is based on a translog profit function, and it allows for capital adjustment costs. Non-competitive behaviour is allowed also in input markets, and the measure of oligopsony power can be attained. Because adjustment costs are involved, a dynamic model must be constructed to describe firms' optimal behaviour. The model is similar to that of Bernstein (1992).

The technology of an industry can be represented with a profit function Π, which is the solution to an economic agent's profit maximization problem. The aggregate level short-run variable profit function can be written as

$$\Pi^v(p, v, K_{-1}, I, T) = \max_{y \geq 0}[p'y - c(v, y, K_{-1}, I, T)] \tag{13}$$

where y is a vector of outputs, K describes capital, p is an output price vector and v is a vector of variable input prices. It is assumed that the new capital can be utilized only in the next period. The term I denotes gross investment and T is an indicator of the level of technology. The term c designates the cost function. The usual assumptions of the function Π^v are made: it is positive, nondecreasing in p, nonincreasing in v and continuous and convex in (p, v). The adjustment costs are associated with the gross investment I, and they are internal to the production process. This means that adjustment of the capital stock temporarily decreases the efficiency of capital[8].

In this study the output markets are divided into domestic and export markets. This division is quite natural, because in a small open economy like Finland the competitive position of the open or the tradeable-goods sector plays a key role, when the long-run success of an economy is considered. In addition, the institutional structures and earlier studies support the view that the domestic and especially the open sector may suffer from medium-term over-pricing both in product and input markets, which has led to a repeated devaluation cycle. The approach in this study allows for comparing different product markets in a framework in which both output and input decisions are modelled simultaneously. This makes it possible to allow for interactions between non-competitive behaviour in product markets and input markets.

The accumulation of the capital stock occurs via net investment, which is defined as a gross investment minus a constant rate of depreciation,

$$K_t = I_t + (1 - \delta)K_{t-1}. \tag{14}$$

The term δ is the constant rate of depreciation. The actual production and input decisions are based on a dynamic maximization problem, where the present value of current and future revenues is maximized by choosing the optimal capital stock, the optimal output and the optimal level of the variable factors. The present value can be written as

$$J_t = \sum_{s=t}^{\infty} E_t \alpha_{t,s}[P_s' y_s - W_s' v_s - Q_s I_s], \tag{15}$$

where E_t designates expectations at time t, P is the vector of output prices, W is the vector of variable input prices, Q is the purchase price of capital - price of investment, and α is the discount factor. In other words, the decisions of the firm can be divided into two stages. In the first stage the short-run equilibrium is considered, which refers to the selection of the output quantities and the variable factor demand. A restriction

[8] This may occur when, for example, the installation of new machinery prohibits the efficient use of existing machinery or when investment planning prohibits the proper functioning of the organization. See Lucas (1967a,1967b) or Treadway (1971,1974).

in this short-run optimization is the level of the capital stock, which - by definition - cannot be changed rapidly. The short-run profit or variable profit can be denoted as

$$\Pi^v = P'y - W'v. \tag{16}$$

When assumptions of efficient pricing rules are relaxed, the prices are endogenized. This pertains to the output prices and the input prices. One way to allow for price-setting behaviour and deviations between the prices and the marginal rules is to introduce the concept of a shadow price, which characterizes the possible over-pricing compared to the marginal rule pricing. These shadow prices can be written for output and input prices as follows:

$$\begin{aligned} P^s &= P(I + \Gamma) \\ W^s &= W(I + \Theta), \end{aligned} \tag{17}$$

where I is an identity matrix, $\Gamma \leq 0$ is a diagonal matrix of price marginals for output prices and $\Theta \geq 0$ is a respective matrix for input prices. The elements of these matrices depend on product demand, input demand and interdependencies among the suppliers. For example, the elements of the matrix Γ can be separated into two components: the price elasticities of product demand and the conjectural elasticities, which describe the interdependence between the suppliers in the product markets. Alternatively, the elements of Θ describe the price elasticities in the factor supply and interdependencies with respect to variable factor demand in the form of conjectural elasticities. If Γ and Θ are functions of exogenous variables, a monopolist or a monopsonist can be viewed as making decisions parallel to profit maximization (Diewert, 1982 and Roberts, 1984). If the variable profit is evaluated with the shadow prices defined above, a concept of a shadow variable profit function is achieved, denoted as

$$\Pi^s = \Pi^s(P^s, W^s, K, I, T). \tag{18}$$

By applying Hotelling's Lemma with respect to these shadow prices, short-run supply and variable demand functions can be derived.

$$y = \Delta\Pi_p^s(P^s, W^s, K, I, T)$$
$$v = -\Delta\Pi_w^s(P^s, W^s, K, I, T) \qquad (19)$$

The second stage in the firm decision making is the determination of the capital stock. Because capital faces to the convex adjustment costs, it is not be optimal to adjust it instantenously to the optimal level of capital. The second stage of decision making can be characterized by maximizing the shadow present value function by selecting the optimal path for the capital stock K [9]. The dynamic maximization problem in discrete time leads to the dynamic first order conditions, the Euler equation[10]:

$$E(s)[\Delta\Pi_k^s(s+1) - (1-\delta)\Delta\Pi_i^s(s+1) + \alpha(s,s+1)^{-1}\Delta\Pi_i^s(s) - W_k(s)] = 0, \qquad (20)$$

where $W_k(s) = \alpha(s,s+1)^{-1}Q(s) - (1-\delta)E(s)Q(s+1)$ is the rental rate of capital, a measure of the user cost of capital. The first order condition states that the marginal return on capital must equal the marginal cost of capital, which is the user cost of capital plus the marginal cost of adjustment. Furthermore, the marginal profit term can be divided to two components: the marginal profit and the reduction in the marginal adjustment cost. The latter term consists of the reduction in marginal adjustment cost when the capital stock is brought over to the next period unchanged. In other words, the long-run equilibrium condition - the Euler equation - states that the benefit of an additional unit of capital must be equal to the shadow rates defined earlier. The key issue to be pointed out is that any deviation between the shadow rental rate and market rate of interest is equal to the marginal adjustment cost. If shadow rental rates and market rental rates are equal, the expected marginal profitability and market rental rate are equal. In this case the long-run equilibrium is achieved. There is a crucial difference between the shadow rate of capital and variable factors, on the one hand,

[9] The present value function discussed earlier, in which the variable factor prices are replaced with their shadow prices and the short-run optimal level for the variable factor prices and the product supply, is solved.

[10] The Euler equation is formed by simply calculating the first order conditions $\frac{\partial J_t^s}{\partial K_s}$ for every $s = t, ..., \infty$. Because the partial derivatives are zero after two periods, the Euler equation collapses to a group of a few terms.

and output price shadow rental rates, on the other. While the former arises from the production technology, the latter terms describing the short-run optimum derive from the non-competitive behaviour on the market. The existence of the adjustment costs of capital may easily imply that prices exceed the long-run marginal costs. Still, there may not be pure over-pricing, but rather a deviation between the short-run and long-run marginal costs.

In order to estimate the dynamic model described earlier, one must choose a functional form to apply it with empirical data. When the model is parametrized and estimated, it is possible to investigate the pricing and production structure of the aggregate technology and test hypotheses concerning the non-competitive behaviour.

In this study a translog profit function is chosen:

$$\begin{aligned} ln\Pi^s = \beta_0 + \textstyle\sum_{i=1}^{3} \beta_i lnP_i(1+\gamma_i) + \beta_k lnK + \beta_t lnT \\ +0.5[\textstyle\sum_{i=1}^{3}\sum_{j=1}^{3} \beta_{ij} lnP_i(1+\gamma_i) lnP_j(1+\gamma_j) + \beta_{kk}(lnK)^2 + \beta_t t(lnT)^2] \\ +\textstyle\sum_{i=1}^{3} \beta_{ik} lnP_i(1+\gamma_i) lnK + \textstyle\sum_{i=1}^{3} \beta_{it} lnP_i(1+\gamma_i) lnT \\ +\beta_{kt} lnP_i(1+\gamma_i) lnT \end{aligned} \tag{21}$$

The term P designates the vector of input and output prices. It is assumed that the cross effects are equal, $\beta_{ij} = \beta_{ji}$. The homogeneity in prices is imposed by normalizing the variable factor prices[11] by the import price. Because there are only two variable inputs - labour and import goods[12] - the normalization reduces the number of variable factors to one. Because the function is defined for the shadow variable profit, which includes γ unknown parameters, the profit function needs some extra parameters. In other words, because the shadow variable profit and the variable profit are related as follows - $\Pi^v(1 + \sum_{i=1}^{3} \gamma_i s_i) = \Pi^s$ - and the empirical implementation has been carried out using the Π^s, the variable profit function (or its logarithm) can be used as a left-hand side variable, if the term $ln(1 + \sum_{i=1}^{3} \gamma_i s_i)$ is added to the right-hand side of the function. The term s_i denotes the revenue and input costs related to the variable profit. The problem raises from the fact that the function now includes both the logarithm of sums and sums of logarithms. This may be a complicated setup for estimation, and

[11] Also the profit Π^s is normalized in the same way.

[12] The intermediate goods are in a fixed proportion to the gross output: see the data section for more details.

the function might be simplified by, for example, omitting the term $ln(1 + \sum_{i=1}^{3} \gamma_i s_i)$ from the estimation. This means that the setup is not quite correct compared to the theoretical starting point, but in many cases simplifications have to be made.

The possible price-discrimination between the domestic market and the export market is allowed. The interesting question is to compare pricing behaviour in these two markets while simultaneously allowing for oligopsony power and slow adjustment in the input markets. The parameters γ_d and γ_x for the markup pricing are expected to be negative, while the respective parameter in the labour market γ_l is expected to be positive.

The adjustment costs must also be specified. Because the actual profit function is already quite multi-parametric, it is reasonable to keep the adjustment cost behaviour as simple as possible. Anyway, the adjustment cost function must share certain features: it has to be convex, zero when the gross investment is zero. For example, the specification

$$c_a = 0.5\beta_{ii}(\Delta K)^2 \tag{22}$$

shares these features. In the empirical implementation the adjustment cost function can be added to the profit function, but one should bear in mind that while the cost function is defined in absolute terms, the profit function is defined in logarithms. On the other hand, because the adjustment costs are included in the empirical specification for the Euler equation, one possibility is to have them only there, and simplify the actual profit function and exclude adjustment costs from it (Bernstein, 1992).

When the short-run equilibrium conditions are derived from the profit function by Hotelling's Lemma, the following nonlinear equations can be achieved:

$$s_i^s = (1 + \gamma_i)^{-1}[\beta_i + \sum_{j=1}^{3} \beta_{ij} ln P_j (1 + \gamma_j) + \beta_{ik} ln K + \beta_{it} ln T], \tag{23}$$

where $s_i^s = P_i y_i / \Pi^s$ for export and domestic markets, and $s_i^s = -P_i v_i / \Pi^s$ for labour input. The model is closed by constructing the translog based Euler equation, which is consistent with the rational expectations hypothesis, if it is conditioned on a proper set of information:

$$E(s)[\beta_k + \beta_{kk}lnK(s+1) + \sum_{i=1}^{3}\beta_{ik}lnP_i(s+1)(1+\gamma_i) + \beta_{kt}lnT(s+1)] \quad (24)$$
$$\Pi^s(s+1)/K(s+1) + E(s)\beta_{ii}\Delta K(s+1) - (1+r(s))\beta_{ii}\Delta K(s) - W_k(s) = 0,$$

where $\alpha(s, s+1)^{-1} = (1 + r(s))$, and r is the discount rate. The parameter $\beta_{ii} \geq 0$ describes the short-run technology based deviation between the shadow and market rental rates for capital. Because the Euler equation includes leads to the next period, direct estimation by using the observed values for the expectations variables causes bias. This raises the demand for an instrumental estimation, in which lagged values are used as instruments for the future variables. In the empirical specification an error term is added to the equations to be estimated. They describe, for example, measurement and optimization errors.

5 The data

The empirical data consists of a set of quarterly time series running from 1976/1 to 1991/4. The total number of observations is 64. The data is constructed for the whole Finnish industry including the manufacturing, mining and electricity-gas-water industries. The reason for using the whole industry instead of the often used manufacturing was the availability of quarterly data.

The import factor consists of imports by Finnish industry. Import prices are measured with a unit value index, and import values are constructed by multiplying the volumes and the prices.

The labour input is measured by total working hours in the industry. The wage sum is not directly available as quarterly data, but the series is constructed by splitting the annual observations with a quarterly level-of-earnings index and with a labour input index. Because changes in the wage sum can in principle be divided into changes in the earnings and changes in the labour input, the approximation can be expected to be accurate. The quarterly social security contributions of employers are constructed by adjusting the annual observations by the changes of the quarterly wage sum. The total labour cost is the wage sum plus the social security contributions. The approximation method guarantees that there is no possibility for a systematic deviation between the approximated and the real data points.

The capital cost is constructed by multiplying the fixed price net capital stock with an user cost of capital. The quarterly capital stock is constructed by interpolating the changes in the annual capital stocks. Quarterly information about the private investment is also used in the approximation, and a constant rate of depreciation is assumed. The dynamics in the capital accumulation is formed by using the quarterly private investment data. Because a change in the capital stock is new gross investment minus the constant depreciation, the investment behaviour accurately describes the evolution of the capital stock. Both nominal and real measures of the user cost of capital have been used in the estimation [13]. In the user cost calculations an approximation of five per cent constant annual depreciation was maintained. The tax effects suggested by Jorgenson (1963) were not taken into consideration, because the contributions of these effects were deemed to be of minor importance compared with the price and the interest rate effects. The interest rate used was the banks' new-credit average rate [14].

Because the total costs can be thought to sum up to the value of gross output, the value of gross output minus capital, import and labour costs was considered as an intermediate input. It was connected to other variable inputs in constant share. The share of this residual input related to other variable costs is stationary, and a multiplier of 1.55 was used to calculate the costs of the intermediate goods: I=1.55(M+L), where I is the cost of intermediate goods, M is the cost of import and L is the labour cost[15]. The intermediate goods factor can be thought to be a scale factor, which corrects the relation between revenues and variable costs. The quarterly gross output series were constructed adjusting the annual observations in accordance with quarterly value added production information.

The gross output was split into export and domestic market production by using quarterly data on the exports of Finnish industry. The unit value index of the corresponding export was used as an export price variable. The domestic market production was obtained by subtracting exports from the gross output. The implicit price deflator for

[13] E.g. Morrison (1992) and Bernstein-Mohnen (1991) used the nominal measure of the user cost of capital UCC=q(r+d), and the real measure of the user cost of capital UCC=q(r-p+d) has been used by e.g. Torsti (1992a). The q is a price index of investment goods, r is a nominal rate of interest, d is a constant depreciation rate and p is an inflation rate of investment goods.

[14] Before 1986/1 the average lending rate was used because of the availability of statistics produced in Finland.

[15] In principle better approximation for the intermediate goods would have been the use of period-wise calculations, but then the relation between revenues and total costs had collapsed to one in empirical data. In addition to that it is empirically difficult to distinguish between output price and intermediate goods price. The value of the constant multiplier was the average ratio between the intermediate component and the sum of the import and labour factors in the data.

domestic market prices was obtained by dividing the value of the gross output by the volume of the gross output. The variable profit data was constructed by subtracting labour costs, intermediate costs and import costs from the gross output.

6 Estimation results - the static model

Because of the non-linearity in the parameters, the non-linear least squares method was used in the estimation. Several variants were estimated: one with the nominal user cost of capital (two estimations using different time spans) and one with the real user cost of capital. Also an estimation without the envelope condition was carried out. The short time span and the nominal user cost variable were used in this estimation.

Severe difficulties were encountered in the estimation of the inverse demand function, and the inverse price elasticity parameter was found to be strongly positive. In aggregate time series data the proper identification of inverse price elasticity was found to be impossible with an aggregate inverse demand function, and equation (7) was first dropped out of the estimations. The proper identification of the non-linear markup parameter was still guaranteed through the cost function (6), but the division of the markup parameter into the conjectural elasticity and the demand elasticity was not possible.

In the second stage the output market was split into the exports and the domestic production. Because the empirical specification of the inverse price elasticities of demand was found to be difficult, a priori information was used to characterize these elasticities. For the export market the inverse price elasticity of -0.8 was used, and for the domestic market the respective elasticity of -1.4 was used (see Torsti, 1992a and Torsti, 1992b for the details). Naturally the choice of the numerical values of the constant elasticities did not have any effect on the markup results, but these numerical values reflect the former empirical research in this field. The elasticities fixed ex ante do not alter the overall markup-coefficients, but only the split between the inverse price elasticities and the conjectural elasticities.

Because of the strong collinearity between the variables, the parameters β_{tt}, β_{wt} and β_t were restricted to zero in the estimation. All variables including the time trend [16] were

[16]This pertains to the time trend, the square of the time trend and the cross effects with the time trend.

Table 1: **Estimation results - the static model**

Variable	Nom.UCC, 82-91, nec	Nom.UCC, 82-91	Nom.UCC, 77-91	Real UCC, 77-91	Nom. UCC, 82-91, exp and domest
β_0	114.60 (0.6)	1.45 (0.2)	18.76 (4.7)	19.17 (3.7)	-70.88 (0.4)
β_y	16.39 (2.7)	-3.75 (10.1)	-2.94 (6.8)	-2.58 (5.6)	17.18 (2.7)
β_w	1.92 (3.1)	0.41 (1.9)	0.91 (8.0)	0.56 (3.6)	4.00 (7.2)
β_k	-34.17 (1.1)	3.86 (3.2)	0.10 (0.1)	-0.11 (0.1)	-6.28 (0.2)
β_{yy}	0.29 (8.0)	0.28 (8.6)	0.25 (7.9)	0.19 (4.9)	0.22 (5.6)
β_{ww}	0.08 (6.7)	0.05 (7.8)	0.06 (14.4)	0.05 (10.6)	0.13(11.9)
β_{kk}	4.36 (2.7)	-0.44 (4.4)	-0.08 (1.1)	-0.08 (0.8)	2.29 (0.9)
β_{yw}	0.01 (0.5)	0.03 (1.7)	-0.00 (0.2)	-0.02 (2.6)	
β_{yk}	-1.58 (3.1)	0.12 (6.8)	0.07 (3.6)	0.10 (4.5)	-1.59 (2.9)
β_{ty}	0.01 (2.9)	-0.00 (2.5)	-0.00 (1.1)	0.00 (1.4)	0.00 (3.0)
β_{wk}	-0.15 (2.6)	-0.04 (3.3)	-0.06 (6.4)	-0.01 (0.9)	-0.31 (6.8)
β_{kt}	-0.01 (2.9)	0.00 (2.2)	0.00 (0.3)	0.00 (1.4)	-0.01 (3.4)
θ	-0.29 (3.3)	-0.28 (3.8)	-0.37 (4.2)	-0.32 (4.0)	
$ln(C^v/w_m)_{-1}$	0.28 (5.1)	0.28 (6.6)	0.40 (10.6)	0.26 (4.7)	
$s_{k,-1}$		0.46 (7.2)	0.66 (11.5)	0.85 (13.7)	
d1	0.02 (8.5)	0.02 (7.7)	0.02 (9.9)	0.02 (9.3)	0.02 (9.8)
d2	0.02 (6.3)	0.01 (5.6)	0.02 (8.5)	0.02 (8.7)	0.01 (6.6)
d3	0.01 (2.9)	0.01 (1.8)	0.01 (4.4)	0.01 (4.6)	0.01 (3.2)
θ_d^*					0.25 (4.7)
θ_x^*					0.47 (5.2)

highly correlated with each other, and these three restrictions were needed to guarantee a proper estimation.

The seasonal dummies were added to the labour share equation, and the lagged endogenous variables were added to the cost function and the capital share equation. The estimation results are presented in the table 1. The t-statistics are in the parenthesis. The first column results are calculated without the envelope condition[17].

The choice of the user cost of capital measure had an effect on the estimation results, but the differences in the key parameters were not crucial. The short- and long-run substitution and price elasticities were calculated from the first and the second estimation results[18] as suggested by Brown and Christensen (1981). The optimal level of the capital

[17]No envelope condition (nec)

[18]The estimation with the span from 1982 to 1991 and with the nominal user cost of capital was used.

Table 2: **R^2's of the static equations and the values of the likelihood functions**

Equation	Nom.UCC, 82-91, nec	Nom.UCC, 82-91	Nom.UCC, 77-91	Real UCC, 77-91	Nom. UCC, 82-91, exp and domest
$ln(C^v/w_m)$	0.94	0.94	0.90	0.91	0.94
s_l	0.81	0.80	0.76	0.76	0.78
s_y	0.53	0.46	0.54	0.55	
s_k		0.94	0.87	0.92	
s_{yx}					0.60
s_{yd}					0.39
Log-likelih.	340.9	492.0	669.8	634.9	406.0

stock was calculated from the envelope condition by an iterative solution technique[19]. The first estimation without the envelope condition was used in these calculations. The calculations suggested that the size of the capital stock was suboptimal. The capital stock was found to be on average about 20 per cent larger than the optimal one when the marginal pricing rule was used. This may imply that producers in the Finnish industry do not make their investment and capital accumulation decisions in the manner suggested by the primary marginal pricing rule.

If the full model had been used in the optimal capital calculations, the capital share equation or the envelope condition would have forced the optimality condition for the capital to apply on average. The key question is, however, does the three equation model satisfy the optimality condition without forcing it. This was also the basic setup for testing the existence of the full static equilibrium. The formal test was done by using the approach suggested by Schankerman and Nadiri (1986). The null hypothesis of the full static equilibrium was strongly rejected, and the value of the χ^2 distributed test statistic was found to be 23.1 with 5 degrees of freedom, while for example the 5 per cent critical level is 11.1. The result suggests that capital should not be treated as a static equilibrium factor of production. Previously in the Finnish factor demand research the full static nature of capital has been accepted too easily (e.g Törmä, 1987 and Torsti,

The elasticities of both the three and the four equation systems were calculated, which allows for the inspection of the distortion in the parameters when the optimality condition for the capital is added to the system.

[19]Because the envelope condition does not have a closed form solution for capital, the optimal capital was solved by iterating the cost function and the envelope condition until the solution was found, see e.g. Dargay (1988).

Table 3: **Price and substitution elasticities**

	Nom.UCC, 82-91, no env. cond.	Nom. UCC, 82-91
Own price elasticity of labour, short-run	-0.41	-0.55
Own price elasticity of labour, long-run	-0.47	-0.62
Own price elasticity of imports, short-run	-1.28	-1.11
Own price elasticity of imports, long-run	-1.45	-1.20
Own price elasticity of capital, long-run	-0.03	0.28
Allen partial elasticity of substitution between labour and capital, short-run	-0.57	-0.05
Allen partial elasticity of substitution between labour and capital, long-run	0.15	-0.10

1992a). This may point out the crucial role of expectation formation in investment decisions instead of marginal pricing rules. Furthermore, this leads to the implication of a small increase in investment when the marginal price of capital is decreased, for example with a tax policy. Also the problems of possibly integrated or co-integrated time series data may have an effect on the estimation results[20].

The long-run own price elasticity of capital was found to be slightly positive when the envelope condition was used in the estimation. This is an indication of a violation of the basic properties of the cost function[21]. In the three equation estimation the own price elasticity of capital was slightly negative, which did not violate the ex ante assumptions. The peculiar own price elasticity of capital in the extended estimation gives further support to the rejection of the null hypothesis of the full static equilibrium.

[20]The existence of the unit roots in the variables were tested, and in most cases the null hypothesis of non-stationarity was maintained. This gives support to the approach of co-integration. Although the cross-equation restrictions in the system may cause some severe difficulties, the approach could be a promising one

[21]When the parameter β_{kk} is negative, the own price elasticity of this quasi-fixed factor is always positive. See appendix A for the detailed explanation.

The envelope condition forces artificial restrictions to the model, which also distorts the parameter estimates. Although the fit of the capital share equation is reasonable, the estimates of the elasticities and the specification tests give parallel information of the distortion forced by the long-run envelope condition.

The short-run own price elasticity of labour was found to be negative, about -0.5. The substitution elasticity between capital and labour was noticed to be zero in the four equation estimation, both in the short- and long-run. In the three equation estimation capital and labour were even found to be complements. The results confirm the earlier results obtained in the measurement of the substitution possibilities between labour and capital in Finland (e.g. Torsti, 1992a and Tarkka, 1984).

The markup-coefficient indicated that pricing over marginal costs amounted to about 30 per cent in the Finnish industry. Although the markup-parameter varied a little in the different estimations, the parameters were found to be quite stable. In the earlier studies the empirical results cover quite a wide range of different approaches and data. This complicates the comparison of different studies, and the implications of relative inefficiencies can not necessarily be made. On the other hand, there seems to be clear evidence of significant markup-pricing in Finland.

The θ_i parameters were also estimated separately for the domestic and the export markets. The lagged endogenous variables were not included in the estimation, and the model was estimated without the envelope condition. Conjectural elasticity estimates of 0.25 and 0.47 were obtained for the domestic market and the export market, respectively. These estimates correspond, when multiplied by the a priori inverse price elasticity estimates -1.4 and -0.8, to the markup-coefficients 0.35 and 0.38. In the static estimation the wedge between the markups in the two markets was not large. The statistical significance of the difference between the markups was tested with a likelihood ratio test, and the χ^2 test statistic obtained the value of 34.4 with one degree of freedom. The null hypothesis of the same markup-coefficient in the two sectors was then strongly rejected. One feature of the estimation that was a little confusing was that the markup-coefficient was larger in the export sector than in the domestic sector. This result is in conflict with a priori expectations, and the odd finding sheds a light of suspiciousness to the reliability of this static model. One should also point out that the markup-coefficients achieved with the separate market estimation were larger than in the one market estimation.

7 Estimation results - the dynamic model

The dynamic model was estimated by using a nonlinear least squares method. Because the model includes expectations variables, a nonlinear three stage least squares method should have been used (Hansen and Singleton, 1982). The estimation problem was, however, simplified, and two approaches in the estimation were used[22]. First, the model was estimated without instruments by using observed values, and in the other approach the expectations variables were instrumented by constructing the instruments separately. These instruments were then used in the nonlinear system estimation. The variable factor prices and the output prices were normalized by the import price[23] and the intermediate goods were assumed to be applied in a fixed proportion to the gross output[24].

The adjustment cost relation was left out from the actual profit function, but it was included in the Euler equation. Because the Euler equation is an equilibrium condition and not a causal relation, it was actually estimated as an implicit equation, in which an arbitrary variable was chosen to be the left-hand side variable. In the estimation the user cost of capital $W_k(s)$ was chosen to be the left-hand side variable. Because the static model estimations in the previous section indicated non-constancy of the parameters in the whole time span estimation, only a subset from 1982 to 1991 was chosen as a time span in the estimation. The parameters β_{hk}, β_{xx}, β_{hh} and β_{kt} were restricted to zero, because they were statistically zero in all the estimations.

The results indicate - along the lines in the static estimation - that there is clear evidence for oligopoly power in the pricing behaviour of the Finnish industry. If the estimation results of the competitive model[25] are compared to the results obtained with the non-competitive model[26], the differences are found to be significant. It seems to be clear that the profit function model with the competitive market assumption does not fit very well with the data used in this study. The results also reveal how crucial the pricing

[22] Three stage nonlinear least squares was not available in the Gaussx 2.2 package.

[23] The omission of the import factor did not do any harm to the estimation, because the import cost component can be calculated by the summability condition $\sum_{i=1}^{3} s_i^s(1+\gamma_i) = 1 - s_M^s(1+\gamma_M)$, where s_M^s is the import cost to shadow variable profit component.

[24] This assumption is quite reasonable, because in the 1980's the intermediate goods share of the gross output in the Finnish industry varied only between 50 and 53.5 per cent.

[25] In the competitive model parameters γ_1 and γ_2 are set to zero.

[26] The model with a possibility for markup-pricing in output markets, but a possibility for oligopsony power in labour markets was not allowed.

Table 4: **Estimation results - the dynamic model**

Variable	No instruments, competitive model	No instruments, oligopoly power	Instrument estimation, competitive model	Instrument estimation, oligopoly power
β_0	-2.42 (0.6)	-4.43 (1.4)	2.74 (0.8)	-4.94 (1.4)
β_h	4.54 (1.8)	13.43 (7.4)	2.24 (0.9)	12.77 (7.3)
β_x	5.13 (4.6)	7.64 (6.2)	3.22 (2.7)	9.49 (6.3)
β_w	-3.53 (3.5)	-8.61 (6.3)	-1.36 (1.4)	-9.55 (6.9)
β_k	0.02 (4.5)	0.02 (4.5)	-0.01 (1.0)	-0.00 (0.0)
β_t	6.30 (2.7)	5.96 (3.6)	3.64 (2.0)	6.16 (3.3)
β_{ww}	-2.11 (4.8)	-2.90 (5.1)	-1.26 (2.8)	-3.06 (5.4)
β_{kk}	-0.00 (4.5)	-0.00 (4.5)	0.00 (1.1)	0.00 (0.0)
β_{hx}	-11.71(10.9)	-5.74 (4.8)	-12.77(11.8)	-4.09 (3.9)
β_{hw}	1.97 (4.4)	3.10 (4.6)	1.68 (3.5)	3.45 (5.8)
β_{wx}	3.43 (7.9)	2.26 (5.0)	3.19 (7.0)	1.95 (4.1)
β_{xk}	-0.00 (8.3)	-0.00 (7.0)	-0.00 (7.1)	-0.00 (5.1)
β_{wk}	0.00 (7.9)	0.00 (7.9)	0.00 (3.1)	0.00 (3.4)
β_{ht}	0.67 (1.0)	-2.60 (4.7)	1.32 (1.9)	-2.77 (6.4)
β_{xt}	-0.60 (1.9)	-1.60 (4.8)	-0.07 (0.2)	-2.02 (4.8)
β_{wt}	0.45 (1.6)	1.90 (4.9)	-0.15 (0.5)	2.17 (5.6)
β_{ii}	2.08 (1.4)	2.83 (2.0)	-1.48 (0.9)	-1.93 (1.1)
β_{tt}	-1.80 (2.9)	-1.28 (2.9)	-1.09 (2.2)	-1.29 (2.7)
γ_d		-0.38 (7.0)		-0.57 (8.0)
γ_x		-0.33 (4.4)		-0.20 (2.8)

behaviour assumptions may be. If the simplified marginal pricing rules are accepted as a starting point, the results may be quite misleading. The same implication applies for both non-instrument and instrument estimations.

The instrumentation of the expectation variables had a significant impact on the markup coefficients γ_d and γ_x. The no-instrument estimation indicated that there was no large difference between the price-margins of the export and domestic sectors, while the difference in the markups between the two sectors was about 40 percentage points in the instrument estimation. The markup-pricing was estimated to be 38 per cent in the domestic sector and 33 per cent in the export sector, when the no-instrument method was used. Respectively, in the instrument estimation the markup-coefficient was found to be

Table 5: **R^2's of the dynamic equations and the values of the likelihood functions**

Equation	No instruments, competitive model	No instruments, oligopoly power	Instrument estimation, competitive model	Instrument estimation, oligopoly power
Π^s	0.382	0.785	0.356	0.754
s_{domest}	0.279	0.467	0.199	0.411
s_{export}	0.267	0.411	0.120	0.320
s_{labour}	0.166	0.379	0.000	0.338
Euler	0.711	0.706	0.665	0.700
Log-likelih.	140.9	179.1	140.3	176.5

57 per cent in the closed and 20 per cent in the open sector. It should also be pointed out that the weighted average of the markup-coefficients was larger in the instrument estimation than in the non-instrument estimation.

The oligopsony power test was conducted by estimating the model with all the γ parameters released. The γ_l parameter for the labour input was found to be negative, although a priori assumptions suggested a positive sign for this parameter. The significance of this additional γ_l parameter was tested with a likelihood ratio test, and the value of the χ^2 test statistics was 3.4, while the 5 per cent critical value with one degree of freedom was 3.8. The results indicate that the null hypothesis of no oligopsony power could not be rejected when the no-instrument estimation results were considered. When the instrument estimation results were considered, the corresponding null hypothesis was rejected, but also in this estimation the sign of the γ_l parameter was against a priori assumptions. The overall conclusion of the oligopsony power in the labour market could not be drawn.

The parameter estimate β_{ii} allowed for investigating the deviation between the shadow and market rental rates. The wedge between these two was calculated as $\beta_{ii}\Delta K/W_k$. If this measure is greater than zero, it is an indication of short-run marginal profit exceeding the short-run market rental rate. The results suggested an average of a 16 per cent gap between the marginal profit and the market rental rate. The standard deviation for this gap was about 10 per cent. These calculations were based on the non-instrument estimation with no oligopsony power. In the instrument estimation the parameter β_{ii} was negative, but the zero null hypothesis of this parameter could not be rejected.

8 Inter-study comparison of markup parameters

The markup-estimates reported by Hall (1988) indicated that pricing exeeded marginal costs in U.S. manufacturing by over 60 percent on average. Respectively, Bernstein and Mohnen (1991) reported about 50 per cent markups in the non-electrical machinery industry in Canada. On the other hand, the results of Morrison (1992) suggested markups between 11 per cent and 22 per cent in the U.S. industry, while in the Japanese industry the range of markups varied between 7 per cent and 48 per cent. Morrison's approach allowed for time-varying markup determination, and the variations were found to be large. This may indicate the interrelation between changes in capacity utilization and markup-pricing. If the capacity utilization is low, the fixed costs of unused capital must be passed on into prices, if possible. So the conclusion of large over-pricing cannot be necessarily made, because the excess profitability of the markups may be counteracted by excess capacity or returns of scale (Hall, 1988). Also cyclical variations in markups should be taken into consideration (Rotemberg and Saloner, 1986). Despite the different industries used in different studies, indication of remarkable markups is clear.

A common feature in many markup-studies is that the hypothesis of competitive pricing has been rejected. On the other hand, also opposite findings has been found. For example, Ilmakunnas (1985) did not reject the competitive hypothesis for the West German road vehicles and paper and pulp industries, and Bernstein (1992) maintained the competitive hypothesis with Canadian pulp and paper industries. It seems, however, that the frequent rejection of the competitive pricing rule leaves no alternative for serious study of the competitive position when empirical modelling concerning price-setting is done.

9 Conclusions

The paper studies markup-pricing in Finland. The research area is an important one, because it is clearly connected to the base questions of competitiveness, market structure and structural adjustment in Finland. Earlier there has been little discussion about supply-driven factors having a effect on the pricing rules in Finland, and the role of the non-competitive behaviour has not been clearly addressed.

The static model results of this study are twofold. First, there seems to be remarkable markup-pricing in Finland. However, the results must be conditioned on the approach

Table 6: **Oligopoly power estimates in different studies**

When		Author	Markup estim.
1993	Manufacturing/Finland	Torsti	0.28-0.37
1993	Exports/Finland	Torsti	0.20-0.38
1993	Domestic manuf/Finland	Torsti	0.38-0.57
1992	Export/Finland	Alho	0.16
1992	Manuf (no exp.)/Finland	Alho	0.90
1992	Sheltered/Finland	Alho	0.27
1992	Manufacturing/USA	Morrison	0.11-0.22
1992	Manufacturing/Japan	Morrison	0.07-0.48
1991	Non-electrical machinery, domestic sector, Canada	Bernstein-Mohnen	0.46
1991	Non-electrical machinery, foreign sector, Canada	Bernstein-Mohnen	0.83
1991	Electrical machinery, domestic sector, Canada	Bernstein-Mohnen	0.32
1991	Electrical machinery, foreign sector, Canada	Bernstein-Mohnen	0.32
1991	Chemical industry, domestic sector, Canada	Bernstein-Mohnen	0.17
1991	Chemical industry, foreign sector, Canada	Bernstein-Mohnen	0.00
1988	Construction/ USA	Hall	0.55
1988	Durable goods/ USA	Hall	0.51
1988	Nondurable goods/ USA	Hall	0.68
1988	Finance, insur. etc / USA	Hall	0.70
1988	Services / USA	Hall	0.46
1986	Food industry / UK	Borooah and Ploeg	0.45
1986	Mechan. engineering/ UK	Borooah and Ploeg	0.32
1986	Electr. engineering/ UK	Borooah and Ploeg	0.53
1986	Textiles / UK	Borooah and Ploeg	0.23
1982	U.S. rubber industry	Appelbaum	0.06
1982	U.S. textile industry	Appelbaum	0.07
1982	U.S. electrical machinery	Appelbaum	0.20
1982	U.S. tobacco industry	Appelbaum	0.65
1979	U.S. crude petr. industry	Appelbaum	0.06

and the model used. The markups estimated in earlier studies cover a wide range of pricing power estimates, and partly the differences in the estimates are due to the different choices in the model selection.

Secondly, the hypothesis of a partial static equilibrium was strongly rejected. This implies that the simple pricing rule plays no key role in the capital formation and the investment behaviour. This leads to crucial conclusions that with an expansionary economic policy recovery effects of only minor importance can be achieved if the future expectations remain unchanged. The price elasticity estimates in this study support this view. The absence of the pricing rule has led to over-investment in Finland. The estimation span used in this study goes back to the time of the credit-rationing regime. This may partly explain the over-investment behaviour in Finland. On the other hand, if the restricted capital movements and credit-rationing have led to suboptimal accumulation of the capital stock, the liberalization of the capital markets should now lead to a permanent decrease in the investment ratio in Finland. This would slow down the short-run recovery possibilities in Finland, which is now suffering from a severe period of recession.

The dynamic model estimations give an extended view to the pricing behaviour in the Finnish industry. The estimation results without the instrumentation for the endogenous variables are approximately in line with the static model estimations. On the other hand, when auxiliary estimations were used to construct instruments for the expectations variables, the difference between the markups in the domestic and foreign sectors enlarged significantly. In the dynamic model the relationship between the domestic and foreign market markup-estimates were similar to ex ante expectations: the oligopoly power was found to be larger in the domestic market compared to the export market.

No clear sign for the oligopsony power in the labour market was found in the dynamic estimations. In the no-instrument case the null hypothesis of no oligopsony power was maintained. The dynamic model allowed for inspecting the difference between the shadow and market rental rates for capital.

The estimation results in this study give clear evidence for markup-pricing in Finland. Although the estimates between the different estimations gave somewhat different markup-estimates, there were significant signs of non-competitive behaviour in the Finnish industry.

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A Short- and long-run elasticities

Because the model is written in a cost share form, the elasticities of substitution and the price elasticities can not be observed directly. The appendix describes the key elasticities used in this study [27]. The index symbols i and j stand for variable inputs[28]. The index symbol K stands for capital input.

Short-run Allen partial elasticity of substitution between the variable factors

$$\begin{gathered}\sigma_{ij} = (\gamma_{ij} + S_i S_j)/(S_i S_j) \\ and \\ \sigma_{ii} = (\gamma_{ii} + S_i^2 - S_i)/S_i^2\end{gathered} \tag{1}$$

Short-run price elasticity of demand between the variable factors

$$\varepsilon_{ij} = S_j \sigma_{ij} \tag{2}$$

Long-run substitution elasticities for the variable factors

$$\begin{gathered}\sigma_{ii}^L = \frac{C_T}{C_V}[\sigma_{ii}^s - \frac{(S_i S_K + \gamma_{iK})^2}{(\gamma_{KK} + S_K^2 - S_K)S_i^2}] \\ and \\ \sigma_{ij}^L = \frac{C_T}{C_V}[\sigma_{ij}^s - \frac{(S_i S_K + \gamma_{iK})(S_j S_K + \gamma_{jK})}{(\gamma_{KK} + S_K^2 - S_K)S_i S_j}]\end{gathered} \tag{3}$$

Long-run substitution elasticities between capital and the variable factors

[27] See e.g. Brown-Christensen (1981).

[28] In this study labour is the only variable input, because the import factor can be calculated as a residual.

$$\sigma^L_{KK} = -\frac{C_T}{C_V}\left[\frac{1}{\gamma_{KK}+S_K^2-S_K}\right]$$

$$and \qquad (4)$$

$$\sigma^L_{iK} = -\frac{C_T}{C_V}\left[\frac{\gamma_{iK}+S_i S_K}{(\gamma_{KK}+S_K^2-S_K)S_i}\right]$$

Long-run price elasticity between the factors [29]

$$\varepsilon = S_j^T \sigma_{ij}^L \qquad (5)$$

The S_j^T designates the input shares at the long-run total costs.

[29] Applies also to capital

B Unit root tests

Tests of the unit root hypothesis are of interest when time series data is used, because the nature of nonstationarity in macroeconomic data can be evaluated with them. The unit roots in the data, if present, imply a stochastic nonstationarity. This means that the random shocks have a permanent effect on the future values of a variable, while in deterministic nonstationarity cases the effects of the shocks are of a vanishing nature. If a time series has a unit root, it is said to be integrated of degree one. The variable is then a I(1) variable.

If a regression model includes I(1) variables, the basic assumptions of a classical regression model do not apply, except in particular cases. For example the t-statistics may be biased. Although the distribution of the estimates is not known exactly, the classical inference is still often used. One reason for this simplification might be that the small sample properties of the more sophisticated co-integrating methods are subject to some suspicion. By definition the study of long run properties demands long-run data, and in most cases it is not available. In addition, for example, in cases where regression residuals are autocorrelated, the normal t-statistics should not be used, but a usual choice is to use them anyway. There is still a need to examine the properties of the empirical data, which helps to make the overall judgement of empirical results. This raises the demand for the unit root tests.

Three different unit root tests have been used: the Augmented Dickey Fuller test (Said and Dickey, 1984) and the Z_α and Z_t tests by Phillips (1987). In all these test the H_0 is that there is a unit root in a time series. So, if the H_0 is rejected, an indication of a stationary time series is given. In general, the power of ADF, Z_α and Z_t tests is quite low, which limits their range of application. Especially, when values of α are less than, but close to, unity, the test power can be expected to be extremely low.

In the augmented Augmented Dickey Fuller test (ADF) one takes account of any serial correlation present by entering enough lagged values of the dependent variables in the regression:

$$\triangle x_t = \mu + \beta\, t + (\alpha - 1)x_{t-1} + \sum_{i=1}^{n} \gamma_i \triangle x_{t-i} + u_t \tag{1}$$

Table 1: **Unit root tests, no time trend**

Variable	ADF	Z_α	Z_t
5 % cr.value	2.94	13.88	2.94
Gross output	2.07	1.67	1.48
Total costs	0.95	1.90	1.00
Relative price w_l/w_m	0.22	0.76	0.58
Capital stock	0.52	0.49	1.23
Labour cost share	1.25	9.76	2.32
Price-cost share	0.96	*16.04	*3.13
Capital cost share	1.04	2.89	2.16

N is chosen to ensure that the residuals are white noise. The t-statistics on $(\alpha - 1)$ is used, but Dickey-Fuller (1979, 1981) critical values are used instead of normal t reference distribution. The term $\beta\ t$ captures the possible deterministic time trend.

The Phillips (1987)[30] test procedure includes a nonparametric approach in order to take account of the serial correlation in unit root testing. This test statistic is referred to as the Z-statistic. The asymptotic critical values of these tests are the same as the asymptotic critical values produced by Dickey and Fuller.

All tests were executed by using seasonally adjusted data. In the estimations the unadjusted data was used, but because the standard tests of unit roots can not be applied under seasonal movement, a moving average method was used to to adjust the seasonal variation. All tests were carried out twice, with and without a deterministic trend. All variables are in logarithms.

All series except the price-cost variable seemed to be nonstationary. In most cases the null hypothesis was not rejected. The ADF-test did not reject the null hypothesis with the price-cost variable, either. With the Z-tests, however, the null hypothesis of nonstationarity was rejected at the 5 per cent level.

[30]See also Perron (1988)

Table 2: **Unit root tests, time trend of first degree**

Variable	ADF	Z_α	Z_t
5 % cr.value	3.46	20.48	3.46
Gross output	0.22	7.53	1.45
Total costs	2.20	10.94	2.47
Relative price w_l/w_m	2.19	4.28	2.04
Capital stock	2.94	12.52	2.54
Labour cost share	2.07	13.64	3.11
Price-cost share	2.72	**55.49	**7.31
Capital cost share	0.77	1.07	0.53

C Auxiliary estimations for the expectation variables

In order to construct instruments for the expectations variables P_L^e (relative price of labour), ΔK^e (change in the capital stock), K^e (the capital stock), P_X^e (relative export price) and P_H^e (relative domestic market price), the ordinary least squares method was used and the fitted values of the auxiliary estimations were used as instruments. The lagged values of the other variables in this group, the logarithmic time trend lnT and lagged values of the user cost of capital W_k were used as instruments.

Table 1: **Auxiliary estimations for the expectation variables**

Variable	P_L^e	ΔK^e	K^e	P_X^e	P_H^e
constant	-6.27 (0.8)	-0.12 (0.2)	11.69 (103)	10.82 (1.7)	7.36 (1.1)
P_L		-0.04 (1.6)	0.20 (2.3)	0.67 (3.0)	0.40 (1.9)
ΔK	-1.47 (0.5)		1.13 (1.6)	1.57 (0.7)	0.68 (0.3)
K	0.41 (0.6)	0.01 (0.2)		-0.91 (1.6)	-0.62 (1.0)
P_X	0.37 (2.4)	0.03 (1.5)	-0.05 (0.6)		0.07 (0.3)
P_H	0.83 (2.9)	0.04 (1.6)	-0.19 (1.8)	-0.09 (0.3)	
W_k	0.40 (1.4)	-0.04 (1.4)	0.04 (0.5)	-0.43 (2.2)	-0.10 (0.4)
lnT	0.35 (2.4)	0.01 (1.0)	0.12 (3.7)	0.08 (0.7)	0.07 (0.5)
Durbin-Watson	2.02	1.33	0.33	1.62	1.63
R^2	0.98	0.48	0.98	0.95	0.90

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