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Economics Department
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Time-Varying Markups

Empirical Analysis of Markups in Finnish Industries

SUOMEN PANKIN KESKUSTELUALOITTEITA • FINLANDS BANKS DISKUSSIONUNDERLAG

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Abstract

In this study, we analyse variation of markups in Finnish industrial sectors, both between industries and over time. The study finds evidence that:

- Since the beginning the 1980s, practically every Finnish industrial sector has been able to extract a positive markup.
- The average industrial markup has apparently declined over time. In addition to the declining trend, there seems to be procyclical movement in markups.
- Despite of the decline in average markups, most industries maintained positive markups in 1995.

The same reservations apply to these results as to corresponding macro-level analysis of markups, because the model relies on instantaneous adjustment of the factors of production. If, for any reason, firms are slow to adjust their factors to changes in demand conditions, it would bias our markup estimates upwards. Indeed, we believe this is the case, so we do not recommend giving too much weight to the level of our markup estimates.

Rather, we wish to note that the estimated time path for industrial markups is generally plausible. Thus, the decline in markups since 1991 may partly explain Finland's unexpectedly low inflation in recent years.

Key words: markup, imperfect competition

Tiivistelmä

Tutkimuksessa on analysoitu hintojen ja rajakustannusten erotuksen eli hinnoittelumarginaalin ajallista (1980–1995) ja teollisten toimialojen välistä vaihtelua. Empiiriset tulokset voidaan tiivistää seuraavasti:

- Lähes kaikilla teollisuuden toimialoilla hinnat olivat korkeammat kuin rajakustannukset.
- Teollisuuden keskimääräiset hinnoittelumarginaalit ovat kaventuneet ajan mittaan. Lisäksi ne näyttäisivät kasvavan noususuhdanteessa.
- Kapenevasta suunnastaan huolimatta hinnoittelumarginaalit olivat useimmilla teollisuuden toimialoilla positiivisia vuonna 1995.

Käyttämämme malli perustuu välittömään tuotannontekijöiden sopeutumiseen, joten saatuihin tuloksiin soveltuvat samat varaukset kuin vastaavien koko talouden tason marginaalien analyyseihin. Jos yritykset pystyvät sopeuttamaan tuotannontekijöitään hitaasti kysynnän vaihteluihin, arvioimamme hinnoittelumarginaalit ovat liian suuria. Koska ilmeisesti näin todellisuudessa on asianlaita, arviomme näiden marginaalien suuruudesta eivät ole kovin luotettavia.

Arviomme hinnoittelumarginaalin ajallisesta kehityksestä sitä vastoin on uskottava, ja marginaalien kaventuminen vuoden 1991 jälkeen osittain selittää myös viime vuosien hidasta inflaatiota.

Asiasanat: yritysten hinnoittelu, epätäydellinen kilpailu

Contents

1 Introduction

Recent years have been characterized by very low inflation in most of the developed world. Finland has been particularly successful in achieving low inflation. For the last three years, consumer prices have been virtually stable despite an average GDP growth rate of close to 4%. The rapid decrease in inflation apparently surprised economists, because forecasts have consistently overestimated Finnish inflation (see Hukkinen and Suvanto, 1997).

Part of the low inflation can undoubtedly be attributed to spare capacity available after the exceptionally deep recession in early 1990s. Furthermore, the Bank of Finland as well as several other central banks have adopted a direct inflation target to gear the monetary policy. Some argue, however, that most of the merit belongs to more profound structural changes that have taking place in the global business environment. One frequently encounters claims stating that globalization of the economy has irrevocably changed the pricing behaviour of firms, and that the developed world – and along with it, the Finnish economy – has entered an "era of zero inflation" in which fierce competition prevents firms from increasing prices.

In this paper we investigate whether evidence in support of the hypothesis of tightening competition can be found in the Finnish product market. More specifically, we investigate whether the markups have shrunk in Finnish industrial sectors over the last 15 years. We stop several of steps short from answering whether Finland indeed has entered an "era of zero inflation". There is a clear conceptual difference to be made between a one-off change in the price level, caused by a downward adjustment in firms' profit margins, and a permanent shift in inflation dynamics towards lower inflation. Competition certainly contributes to the former – it may or may not help to obtain the latter.

This paper continues the work of our earlier paper (Forsman, Saarenheimo & Terviö 1996) in which we compared industrial markups in seven OECD countries. In that paper, as in the present, we followed the general approach outlined by Roeger (1995). The thrust of that paper was the effects of measurement errors on markup estimates. We argued that the estimation of markup ratios is seriously plagued by poor measurement of the rental price of capital. The sensitivity of Roeger's model to specific kinds of measurement errors led us to suggest a different, but closely related, model formulation.

The novelty of the present paper is the measurement of time variation in markups. By assuming that the time variation in markups in different industries is due to a common time-varying component, we can utilize the panel (sectoral) dimension of the data and estimate the variation in the average markup over time. Again, the issue of time variation in the markup ratio is closely linked to measurement errors. We propose an estimation method to tackle the biases due to the most likely source of such errors, namely the poor measurement of the rental price of capital.

One particular question we are interested in is the behaviour of industrial markups during the historically deep Finnish recession in the early 1990s. Economic theory is inconclusive on the effects of business cycles on profit margins; depending on the theoretical model, markups can be either procyclical or countercyclical. Models by Rotemberg & Saloner (1986) indicate that price wars should take place in recessions whereas models of Green & Porter (1984) come to the opposite

conclusion, see also Bils (1987) and Rotemberg and Woodford (1991).

Our results indicate that there has been systematic variation in average industrial markups since the beginning of the 1980s. It appears that industrial markups started at quite high levels at the beginning of the 1980s, and came significantly down to bottom at around 1986. During the overheated economy of late 1980s, there was a temporary rebound, before the depression of 1990s brought the markups down again. Hence, our evidence is in favour of procyclical behaviour of markups.

This paper is organized as follows. We first provide a short overview of the two methods used most widely to estimate markups, ie those of Hall (1988) and Roeger (1995). We then describe a more general framework which encompasses Roeger's model as a special case and allows for time variation in the markup ratio. We also discuss the effects of measurement errors on the estimation of the models. Section 3 presents our empirical results: We first estimate constant markups for Finnish industrial sectors, and then proceed to analyse the time variation in those markups. Section 4 concludes the paper.

2 Theoretical framework

2.1 Hall-Roeger framework

In an our earlier paper (Forsman, Saarenheimo & Tervio 1996) we described the models of Hall (1988) and Roeger (1995) in some detail, so in what follows we will be brief. Hall found that by examining the relation between the Solow residual[1] and capital/output ratio one can extract information about the competitive conditions in an industry. Under perfect competition, the Solow residual should only reflect technological progress, and therefore be independent of changes in capital/output ratio, except when those changes reflect changes in technology. Under imperfect competition, however, the Solow residual and capital/output ratio should be negatively correlated. Hence, the higher the measured correlation between the two, the less competitive the industry. A major drawback of Hall's approach is that, in empirical applications, isolating that part of the correlation which is due to changes in technology requires the use of instruments which are not correlated with technological change. Such independent instruments are virtually impossible to identfy, and their absence necessarily undermines the results.

Roeger (1995) developed Hall's approach by utilizing the price-based dual of the Solow residual. Combining the Hall's model based on the Solow residual with its price-based dual leads to cancelling out of the technology term from the model.[2] Therefore, Roeger's model can be estimated with simple OLS without resorting to instrumental variables.

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[1] The Solow residual (also called total factor productivity) is the part of output growth which is left when the contribution of growth of inputs are taken away.

[2] In perfect competition nominal operating surplus should be equal to the rental cost of capital, ie pure profits should be zero.

While solving one problem, Roeger's model introduces new ones: Estimation of Roeger's model requires data not only on the real quantities, but also on prices. As we discussed in depth in our earlier work (1996), the rental price of capital is particularly likely to be poorly measured, and the variation of the measurement error can be so large as to dominate the estimation results. In the empirical part of our work, we estimated markups using two methods which, with correct theoretical model and data, should yield identical results, but under measurement errors should show systematic differences. Our estimation results for six OECD countries showed that in each country, the cross-industry distribution of markups corresponded very closely to what our hypothesis of mismeasured rental price of capital implied. We concluded that the measurement problem is so serious that estimates obtained with Roeger's model yield little or no information of true markups.

2.2 A general framework

Markup ratio μ can be defined as

$$\frac{1}{\mu} = \frac{\Sigma_i W_i M_i}{PY} \tag{1}$$

where W_i are the factor prices of inputs M_i, and P and Y are the price and quantity of output.[3] If all variables in the equation are known, finding the markup ratio is a question of calculation rather than estimation. If, on the other hand, there is reason to believe that the measurement of the variables is subject to errors with non-zero mean, then estimation of markups in the level form would lead to biased estimates.

As showed in our earlier paper, Roeger's model can be seen as (one representation of) the total differential of (1) under the assumption of time-invariant markup. In this paper we generalize the model by explicitly allowing for time variation in the markup ratios. We start by taking the total differential of (1) which yields

$$(dp + dy) = \mu \Sigma_i [\alpha_i (dw_i + dm_i)] + d\mu / \mu, \tag{2}$$

where $\alpha_i = (W_i M_i)/(PY)$ is a factor's output share and lowercase letters refer to natural logarithms. Note that the definition of μ in (1) implies that $\Sigma_i \alpha_i = 1/\mu$ or $\Sigma_i \alpha_i + B = 1$, where

$$B = 1 - 1/\mu \tag{3}$$

is the Lerner index representing the revenue share of markup. Noticing that $dB = d\mu/\mu^2$, we can substitute these in (2). After some rearranging we get for arbitrary j

$$\begin{aligned}(dp + dy) - \Sigma_{i \neq j} [\alpha_i (dw_i + dm_i)] - (1 - \Sigma_{i \neq j} \alpha_i)(dw_j + dm_j) \\ = B[(dp + dy) - (dw_j + dm_j)] + dB.\end{aligned} \tag{4}$$

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[3] The present paper includes three factors: labour, capital and intermediate goods.

This is the form used by Roeger in his estimations, with the subscript j referring to capital, and with the Lerner index B constant. Equation (4) can also be rearranged to

$$(dp + dy) - \Sigma_i[\alpha_i(dw_i + dm_i)] = B[(dp + dy) + dB, \quad (5)$$

which we will hereafter refer t as the "modified" model. As equivalent representations of the same economic relation, equations (4) and (5) both provide an appropriate basis for estimation and they should, in ideal conditions, yield identical estimates. In practice, this will not be the case. First, the theoretical model is, at best, an imperfect description of the true behaviour of firms; for example, rigidities preventing full adjustment of the inputs will lead to biased markup estimates, and the bias will show up differently in depending on the equation estimated. Second, measurement errors produce biases in the estimates, the direction and the form of which will also depend on the form of the equation.[4]

The two equations (4) and (5) will form the basis of the estimated equations in this paper. Equation (2) would likewise provide a feasible basis for estimation and is in fact the form we used in our earlier work (see Forsman, Saarenheimo and Terviö, 1996). In the current setup, however, we judged equation (5) to be the better candidate, mainly for two reasons. First, with time-varying markups, equation (2) would be non-linear in its parameters which would obviously complicate estimation. Second, it can be shown that unlike equation (2), equation (5) provides a framework which is robust with respect to the particular type of measurement error we believe may be prominent – namely, a zero-mean stochastic error in the measurement of the rental price of capital.

2.3 Estimation of time-varying markup

The novelty of this paper is that we estimate markup variation not only with respect to different industries, but also over time. Naturally, the estimation of unrestricted time varying markups for each industry is not possible – the number of parameters would exceed the number of observations. We thus impose the necessary additional restrictions by assuming that the markup for each industry consists of two components; one industry specific and the other time specific. That is, for industry k at time period t, the Lerner index is

$$B_{k,t} = B_k + B_t.$$

We assume that the industry specific component is constant over time, whereas the time specific component is constant over industries. Hence, taking discrete time approximation of (4) and (5) yields

$$y_k^R = (B_k + B_t)\Delta x_k^R + \Delta B_t \quad \text{for } k = 1,..., K \quad (4')$$

[4] See Forsman, Saarenheimo and Terviö (1996) for a discussion of biases and some constant markup estimates obtained by different forms of the equation.

$$y_k^M = (B_k + B_t)\Delta x_k^M + \Delta B_t \quad \text{for } k = 1,\ldots, K \tag{5'}$$

where

$$\Delta y_k^R = (\Delta p_k + \Delta y_k) - \Sigma_{i \neq j}[\alpha_{i,k}(\Delta w_{i,k} + \Delta m_{i,k})] - (1 - \Sigma_{i \neq j}\alpha$$
$$\Delta x_k^R = (\Delta p_k + \Delta y_k) - (\Delta w_{j,k} + \Delta m_{j,k})$$

and

$$\Delta y_k^M = (\Delta p_k + \Delta y_k) - \Sigma_i[\alpha_{i,k}(\Delta w_{i,k} + \Delta m_{i,k})]$$
$$\Delta x_k^M = (\Delta p_k + \Delta y_k)$$

Here, the superscripts *R* and *M* refer to Roeger's model in (4) and the "modified" model in (5). Following Roeger, we choose capital to be the input m_j in model (4`). Hence, w_j denotes the rental price of capital.

Estimation of the time varying component directly from (4') and (5') would make the estimates vulnerable to a specific kind of bias. The fact that the rental price of capital is approximated by the same time series for all industries means that errors in the measurement of the rental price at period *t* will affect *each* observation over the cross-section (sectoral) dimension of that period in the same manner. Such a systematic measurement error would be fully reflected in the means of the regression variables. In the lack of a real intercept term, this would show up as a bias in the term ΔB_t, which acts as a "quasi-intercept" in the regression. These biases would thus be cumulated in the markup estimate.

To prevent this, we include a time-varying intercept term in both equations to capture the measurement errors in rental price of capital. Hence, the final equations we estimate are of the form

$$y_{k,t}^R = (B_k + B_t)\Delta x_{k,t}^R + C_t + e_{k,t} \tag{4"}$$

$$y_{k,t}^M = (B_k + B_t)\Delta x_{k,t}^M + C_t + e_{k,t} \tag{5"}$$

where $E(e_{k,t}) = 0$, $E(e_{k,t}^2) = \sigma_k^2$, $E(e_{k,t}e_{l,t}) = 0$, for $k \neq l$, and $E(e_{k,t}e_{k,t}) = 0$ for $t \neq s$. In (4") and (5") the time-varying intercept *C* will capture both the measurement error and the term ΔB_t. At a practical level, the inclusion of a time-varying intercept amounts to disconnecting the linear dependency between the intercept term and the markup coefficient.

3 Markup estimates 1980–1995

3.1 Data

Our industrial level data comes from the National Accounts and runs from 1980 to 1995. We decided to discard the earlier data since due to credit rationing, interest rates prior to that period did not reflect the true cost of funding. We concentrate only on manufacturing industries; experience has shown that the methodology suits poorly for service sector. The classification of industries used in the National Accounts differs somewhat from the ISIC classification used in the OECD study Martins et al. (1996) (as well as in our earlier study) and the results are therefore not directly comparable. However, the quality of National Accounts data for Finland was clearly better, and therefore more suitable for the study.

3.2 Time-invariant markups

Estimation results for time-invariant markup were calculated for two methods of approximating the rental price of capital. The first alternative, the "cost-based" rental price was calculated as follows: The nominal rate of interest was calculated by dividing interest expenses of the corporate sector by its gross nominal debt. From this, an adaptive measure of inflation expectations was deducted, and a constant rate of depreciation equal to 4% was added.

The second set of estimates was obtained under the assumption of a constant rental price. The motivation behind this alternative is that we believe that the measurement of the true rental price of capital is subject to measurement errors of a considerable scale. In our view, it is likely that most of the variation in the normal proxies of rental price is likely to be due to measurement error. If this is the case, then assuming a constant rental price is likely to lead to less biased estimates.[5]

3.2.1 "Cost-based" rental price

Estimation results obtained using the cost-based measure of rental price are presented in Table 1 and Charts 1 and 2. As throughout the paper, we use the Lerner index as the measure of markup. The Lerner index represents the share of revenues allocated to excess profits – the value 0 corresponds to perfect competition.

The estimates obtained with Roeger's model are generally somewhat higher than those obtained with the modified model. With Roeger's model, the markup estimates range from 0.10 (food, beverages and tobacco) to 0.29 (paper and pulp), the average markup standing at 0.22. All markup estimates differ significantly from zero with

[5] For a thorough discussion of measurement problems related to rental price of capital, see our cross-country study (Forsman, Saarenheimo, Terviö 1996). We show that when using the normal proxy of rental price, the type variation exhibited by the markup estimates is symptomatic to what would be produced by a serious measurement problem. Estimates obtained assuming constant rental price of capital were more plausible.

normal significance levels, ie perfect competition can be rejected in each case.

With the modified model, the range was wider, from the low of 0.03 (again food, beverages and tobacco) to 0.33 (wood products). The average markup was 0.18. Evidence for imperfect competition was still strong, but not as overwhelming as with Roeger's model: of the 15 sectors, 11 had markup estimates significantly above zero. The two methods yield similar, though not identical results for the relative level of competition of different industries. Correlation between the two sets of markup estimates was 0.79.

We showed in our earlier paper that if the proxy for rental price of capital is subject to a random measurement error with zero mean, then the estimate of markup obtained with Roeger's model is biased towards $1-\alpha$, where α is the aggregate output share of all inputs other than capital. Our modified model, on the other hand, can be shown to be robust against by this particular type of measurement error, although it is sensitive to systematic measurement errors in the level of the rental price.

Graph 1 plots the relation between $1-\alpha-\beta$ and the markup estimate for different sectors. A positive relationship between the two is apparent with both methods. For Roeger's method, the relationship is stronger, with a correlation coefficient of 0.54, compared with 0.40 for the modified model. Although the differences between the two sets of estimates are qualitatively what we expect to find in the presence of measurement problems, their magnitude is relatively small. Hence, we interpret the results as not pointing to serious measurement problems.

3.2.2 Constant rental price

With constant rental price, the markup estimates increase for both models, and more significantly for Roeger's model. Now the range for Roeger's model is from 0.11 (food, beverage and tobacco) to 0.40 (both forestry industries). The average markup stands at 0.26. The statistical significance of the coefficients remains generally high, although this time perfect competition could not be rejected at 1% level for three of the 15 industries.

For the modified model, the increase in estimates is modest. The average markup is only marginally higher at 0.19, with the extremes at 0.06 (once again, food, beverages and tobacco) and 0.34 (wood products). The number of industries for which perfect competition can be rejected increases by one to 12. Correlation between the two sets of markup estimates increases noticeably, and is now very high at 0.96.[6]

When compared with the estimates obtained with cost-based rental price, changes in the variation of markup over industries are modest for Roeger's model (correlation 0.84), and small for the modified model (correlation 0.92). This is as expected, since the latter is less sensitive to measurement errors in rental price.

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[6] The close correspondence between the two markup estimates in this case is not unexpected. Once changes in rental price are set to zero, the only remaining difference in the variables of the two models comes from changes in the value of the capital stock, which is fairly steady.

The relationship between $1-\alpha$ and the markup estimate is plotted in Chart 1B. The correlation coefficient between the two drops to 0.47 for Roeger's model and is virtually unchanged at 0.41 for the modified model. We interpret this as indicating that there is little evidence of a bias in our results.

3.2.3 Comparison with other studies

Perhaps the most widely applied method for estimating industrial markups has been the instrumental variables method developed by Hall (1988). In his seminal work, Hall obtained markup estimates which were very variable and sometimes extremely high. His estimates for the sectoral markup ratios – defined as 1/(1–B) – ranged from below 1 to more than 20, with the average at around 3. In terms of the Lerner index B, this would translate to a markup share of 0.67. Hall attributed the estimates to excess capasity and/or labor hoarding. Similarly, Haskel et al. (1995), using UK data, obtained markup ratio estimates of around 2 – ie prices were twice as high as the unit cost. Part of the explanation for the high markup estimates of these two studies can be found from the omission of intermediate inputs from the input list; hence, the markup share is measured in relation to value added rather than as a fraction of total revenue.

Among studies on Finnish data, Vaittinen (1994) applied Hall's method except that his estimated equations included intermediate inputs. As a result, the markup estimates obtained by Vaittinen were noticeably lower than in the other two studies. It may also be that for a small open economy such as Finland, it is easier to find a set of truly exogenous instruments than for larger economies.

In several industries, the markup estimates by Vaittinen are considerably lower than we obtained. The results are, however, not directly comparable, since he used markedly different estimation periods (1960–89 in Vaittinen's study) and the data come from different sources. It would be interesting to check our results by estimating the markup ratios for comparable data using Hall's method.

Three other studies also seek to identify sectoral markups for Finnish industries. Torsti (1993), using a different methodology based on cost funtions (see Bresnahan 1989) obtained markup ratio estimates in the range 1.3–1.5 for manufacturing. Torsti's estimate for markup ratio in aggregate manufacturing is slightly higher than ours. Torsti also found that markup ratios tended to be higher in sheltered industries than in those industries exposed to competition. A similar methodology has been used by Alho (1993) and Honkatukia (1995) who analysed the pricing behaviour separately in exports and in sales to domestic clients. According to Honkatukia's estimations, average markup ratio in the export sector is in the range 1.1–1.2, which is well in line with our results.

Martins et al. (1996) used Roeger's method to estimate markup ratios for 14 OECD countries, including Finland. Their study also takes one step further and analyses how market structure affects markup. The range of markup estimates in the study of Martins et al. is slightly wider than ours: from a minimum of 0 to a maximum of 0.5 compared with the range of 0.1 to 0.26 in our study. The average markup, at close to 0.16, is slightly lower than ours.

Detailed comparison is hampered by two differences in the setups used. First, the estimation period in Martins et al. covers 1970–92 (as compared to 1980–95 in our study). Further the sectoral definitions do not coincide: Martins et al. use Finnish

ISIC data from the OECD database to estimate sectoral markups for Finland, whereas our data comes from the National Accounts. However, for some industries the match of definitions is good enough for comparison. Such industries include manufacturing of wood, paper, and pulp; printing and publishing; metal products; and manufacturing of machinery and equipment. Table 3 compares our markup estimates (estimated using the cost-based measure of rental price) with those obtained by Martins et al. of (within) the above mentioned industries. For comparison, the estimates obtained by Martins et al. in a number of other countries are also included.

As can be seen in Table 3, for those industries the two sets of markup estimates are quite similar in terms of the overall magnitude, although cross-industry variation differs to some extent. One interesting feature is the high markup estimates obtained for Finnish metal industries. In their study, Martins et al. found that markups in Finnish metal industries are considerably higher than in most other countries. Our markup estimates for those industries are actually even higher than those obtained by Martins et al. We conjecture that this may be related to the former Finnish-Soviet trade in which Finnish firms faced little competition and which is considered having been very beneficial for Finnish companies. This may not be the whole story, however – one would expect that the collapse of the former Soviet trade in the 1990s to show up as lower markup estimates in our study, which extends further into the post-Soviet-trade era than that of Martins et al. As noted above, the case is actually the opposite.

3.3 Time-varying markups

In this section we allow the average markup in Finnish industries to vary over time, following the approach outlined in section 2. The purpose of this exercise is twofold. First, the nature of time variation in industrial markups, and how it coincides with business cycles, is of interest in itself. In particular, it may offer insight to the behaviour consumer prices in the recent years. Secondly, allowing for time variation may enable more accurate estimation of cross-industry variation. If markups are estimated under the assumption of a time invariance when they actually include a significant time-varying element, the results are likely to be biased. Accounting for time variation in the estimation technique may enable one to extract the cross-industry differences more clearly.

As in the previous section, we estimated the time-varying markups both for Roeger's model and the modified model, using the two different proxies for the rental price of capital. Hence, we report the estimates for four different cases. Although we would like to be more concise in terms of the amount of results reported here, we feel that in this particular context, the need to verify the robustness of the results based on different methods overrides these considerations.

3.3.1 Estimation method

The estimation of the time-varying markup model was based on equations (4") and (5"); i.e. as discussed in section 2, we accounted for measurement errors in the rental

price of capital by including a time-variant intercept in the estimated equation.[7]

Our preliminary estimations showed that there was serious cross-industry heteroscedasticity present in the residuals, and hence pooled estimation was not appropriate. Maximum likelihood method was not available either, since the combination of industry specific error variances and time-varying intercept violates the regularity conditions required for maximum likelihood estimation.[8]

Therefore, the estimation was performed with a two-step GLS estimator. In the first step, industry-specific error variances were estimated using the residuals from a constant-parameter pooled regressions. These variance estimates were then used in the second step to obtain the final GLS estimates.

3.3.2 Results

Estimation results for time-varying markup are presented in Table 2 and in Chart 3–4. Table 2 presents the actual estimated parameters, consisting of the industry-specific and time-specific components of the markup (B_i and B_t), and the time varying intercept term C_t. The industry specific components are estimated markups (Lerner indices) in 1995. For any other year, the markup can be obtained by adding the time-specific component. The variables of the form "C-1981" denote the time-varying intercept term. Charts 3 and 4 present the variation over time of the (unweighted) average industrial markup over the relevant period, together with a confidence interval of ±2 standard errors. Charts 5 and 6 plot the cross-industry variation in the markups, averaged over the estimation period. Again, ±2 standard error bounds are included.

The general pattern that emerges is quite similar in each of the four cases, both with respect to the cross-industry markup variation as well as with respect to the time path of the average markup. In general, allowing for time variation increases the estimate of average markup. In each of the four cases, the average Lerner index (over time and over industries) is close to 0.31, as compared with the estimates ranging from 0.18 to 0.26 obtained with the time-invariant models.

The estimated time paths of the average markup (Charts 3 and 4) are intuitively mostly sensible, although some anomalies exist. In each case, average markup starts from fairly high levels in early 1980s, declines towards the latter part of the decade, before peaking again steeply around 1990. After 1991, markups come again rapidly down at a level lower than found in the early 1980's.

Before jumping to conclusions, one should notice that the standard errors around the time-varying markup are relatively wide. For example, a constant markup of 0.3 would fit within any of the four confidence intervals for almost any year. There are two reasons why we are nevertheless willing to interpret the behaviour of the time-

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[7] We also tried estimating the equation without the intercept term. The resulting time paths for the average markup were implausible, and there was no consistency between the estimates obtained with different methods. Hence, we do not report those results.

[8] With a suitable choice of the intercept time path, any one industry can be fitted perfectly, resulting in zero residual variance for that industry, in which case the value of the likelihood function would be undefined. For each industry, there is one such pathological parameter combination for which maximum likelihood method breaks down.

varying component as something more than just random noise. First, since there is nothing inherent in the estimation method that ties successive time varying parameters together, the fact that each of the time-paths shows a high degree of autocorrelation (ie is relatively smooth) argues against randomness. Second, it appears that assigning an independent average markup parameter for each year results in a heavily overparametrized representation of the true time variation. Experiments with more parsimonious parametrizations suggest that the decline of markups in the 1990s is a robust and statistically significant phenomenon.

Our cautious interpretation is that the estimated time variation in the average markup is a result of both cyclical factors and structural factors. The overall downward trend in the average markup is consistent with a gradual increase in competition, both at home and from abroad, faced by Finnish industries since the beginning of the 1980s. At the same time, average markup variation seems to reflect cyclical conditions. Particularly, we attribute the increase in the average markup in the late 1980s to the overheated economy and capacity constraints rather than to a temporary decrease in the competitive pressures faced by Finnish industries.

We cannot offer a good explanation why, in three of the four estimates, the average markup still increases in 1990 and peaks in 1991– right in the midst of the deepest economic slump in Finnish economic history! The result is counterintuitive, so we are inclined to classify it as an artefact produced by the estimation method.[9]

Although the estimation method does not enable a rigorous statistical comparison of the estimates for the time paths of average markups between the four cases, informal observation suggests that the differences are vanishingly small. In only one occasion does the average markup estimate obtained by one method not fit in the confidence intervals estimated by the other three method: In 1986 the average markup estimate, estimated with the modified model and under cost-based rental price, is higher than the upper bound obtained with Roeger's model under cost-based rental price.

The intercept terms do play a considerable role in the estimation. In each equation, 5–9 of the 15 intercept parameters are significantly different from zero. Furthermore, as we anticipated, the intercepts indeed mirror to a considerable degree variations in the measured rental price of capital. In the two equations estimated with the cost-based rental price, the correlation of the intercept with the variation in the measured rental price of capital was 0.66 for Roeger's equation and 0.59 for the modified model. Obviously, no such correlation could be calculated for the equation estimated with constant rental price.

Apart from the increase in average markups, allowing for time variation does not have a major effect on the estimated cross-industry markup variation (Charts 5 and 6). In general, the ranking of industries as low-markup or high-markup industries remains unchanged, although minor changes in the relative positions do take place. The correlation between the industrial markups estimated with the time-varying model and those obtained with the corresponding time-invariant model ranges from 0.69 to 0.85.

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[9] One possible explanation is that due to the exceptionally steep changes in the model variables in 1991 – value-added in manufacturing fell 15 % while operating surplus roughly halved, with huge differences between industries – the accuracy in which the estimated difference equations (4") and (5") approximate the theoretical differential equations (4) and (5) is likey to be particularly poor for that year.

Looking at industry-specific markups averaged over the estimation period, practically all industries seem to have exercised some market power. Only in four estimates was the deviation from perfect competition found to be statistically insignificant. Three of these four results were obtained for the transport equipment industry.

As the average markup decreases towards the end of the estimation period, the situation is slightly different in 1995. An overwhelming majority of the markup estimates are still statistically significantly greater than zero. However, a clearer pattern now emerges about those industries in which firms do not seem to possess significant market power. None of the four results find significant deviation from perfect competition for the transport equipment industry. Refining of oil was found competitive in three out of four estimates, and textiles industry by two out of the four estimates.

We proposed earlier that allowing for time variation might improve the precision of the individual industry markup estimates. Our results do not confirm this hypothesis. Although t-values are generally higher with time-varying markups, this is due to the increase in the size of the point estimates rather than to an improvement in precision. Further, the cross-industry correlation between the markup estimates obtained with Roeger's model and the estimates from the modified model decreases slightly when time variation is allowed. Although we do not find evidence that allowing for time variation improved the precision of the industry-specific markup estimates, we find the high degree of consistency between the two sets of estimates reassuring.

4 Concluding remarks

In this study, we analyse variation of markups in Finnish industrial sectors, both between industries and over time. The study finds evidence that:

- Since the beginning the 1980s, practically every Finnish industrial sector has been able to extract a positive markup.
- The average industrial markup seems to have declined over time. On the top of the declining trend, there seems to be procyclical movement in markups.
- Despite of the decline in average markups, most industries maintained positive markups in 1995.

The same reservations apply to these results as to corresponding macro-level analysis of markups. The model relies on instantaneous adjustment of the factors of production. If, for whatever reason, firms are slow to adjust their factors to changes in demand conditions, then our markup estimates are biased upwards. We are inclined to believe that this is indeed the case. Therefore, we do not recommend giving too much weight on the level of our markup estimates.

The estimated time path for industrial markups is generally plausible, and the decline in markups since 1991 may partly explain the unexpectedly low inflation of recent years.

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Table 1. Markup estimates

	Cost-based rental price		*Constant rental price*	
	Roeger	Modified	Roeger	Modified
Food, beverages and tobacco	0.10	0.03	0.11	0.06
	(6.23)	(0.62)	(2.10)	(1.67)
Textiles and textile products	0.22	0.26	0.25	0.21
	(8.04)	(3.17)	(6.31)	(3.15)
Wood and wood products	0.27	0.33	0.40	0.34
	(4.67)	(4.95)	(6.87)	(5.25)
Pulp, paper and paper products	0.29	0.21	0.40	0.29
	(5.16)	(2.11)	(8.81)	(3.72)
Publishing, printing and reproduction	0.20	0.13	0.18	0.13
	(11.87)	(2.42)	(5.50)	(4.67)
Manufacture of refined petroleum, coke, nuclear	0.18	0.10	0.12	0.10
	(3.57)	(1.31)	(1.90)	(1.48)
Chemicals, chemical products	0.20	0.06	0.17	0.12
	(3.67)	(1.03)	(2.43)	(2.25)
Rubber and plastic	0.20	0.16	0.29	0.20
	(6.42)	(2.67)	(4.54)	(3.64)
Manufacture of non-metallic mineral	0.31	0.28	0.38	0.24
	(8.67)	(2.77)	(5.42)	(3.68)
Basic metals	0.20	0.18	0.29	0.21
	(4.95)	(2.52)	(5.82)	(3.60)
Fabricated metal products	0.24	0.16	0.23	0.18
	(10.92)	(4.15)	(6.99)	(6.85)
Machinery and equipment	0.27	0.21	0.29	0.22
	(8.57)	(4.44)	(6.53)	(5.63)
Electrical and optical equipment	0.24	0.20	0.29	0.22
	(3.77)	(4.00)	(3.98)	(4.43)
Transport equipment	0.21	0.10	0.18	0.10
	(3.08)	(0.93)	(1.62)	(1.10)
Other construction	0.24	0.27	0.35	0.27
	(7.78)	(5.04)	(6.43)	(6.61)

T-values in parenthesis

Table 2. Parameter estimates for time-varying markup model

	Cost-based rental price		*Constant rental price*	
	Roeger	Modified	Roeger	Modified
Food, beverages and tobacco	0.16 (4.09)	0.21 (3.34)	0.22 (3.14)	0.19 (3.65)
Textiles and textile products	0.23 (4.82)	0.19 (2.29)	0.25 (4.10)	0.14 (1.78)
Wood and wood products	0.25 (3.89)	0.33 (4.64)	0.33 (4.53)	0.30 (3.98)
Pulp, paper and paper products	0.30 (4.85)	0.32 (3.78)	0.38 (7.31)	0.33 (4.33)
Publishing, printing and reproduction	0.24 (5.66)	0.24 (3.68)	0.25 (4.42)	0.21 (4.15)
Manufacture of ref. petroleum, coke, nuclear	0.27 (3.94)	0.11 (1.25)	0.21 (2.39)	0.12 (1.47)
Chemicals, chemical products	0.27 (4.36)	0.23 (2.66)	0.27 (2.57)	0.22 (2.73)
Rubber and plastic	0.22 (4.49)	0.25 (3.90)	0.27 (3.79)	0.23 (3.62)
Manufacture of non-metallic mineral	0.32 (6.26)	0.33 (3.63)	0.35 (4.48)	0.26 (3.63)
Basic metals	0.19 (3.54)	0.21 (3.32)	0.25 (4.04)	0.20 (3.26)
Fabricated metal products	0.23 (5.46)	0.24 (4.60)	0.20 (4.35)	0.20 (4.57)
Machinery and equipment	0.29 (5.99)	0.29 (5.62)	0.30 (5.41)	0.26 (5.43)
Electrical and optical equipment	0.23 (3.25)	0.27 (5.11)	0.25 (3.28)	0.24 (4.25)
Transport equipment	0.18 (2.52)	0.17 (1.99)	0.16 (1.50)	0.14 (1.55)
Other construction	0.28 (5.85)	0.38 (5.74)	0.37 (5.38)	0.35 (5.89)
1981	0.10 (1.08)	0.13 (1.48)	0.05 (0.57)	0.12 (1.40)
1982	0.19 (2.40)	0.14 (1.56)	0.11 (1.50)	0.21 (2.48)
1983	0.09 (0.85)	0.13 (1.14)	0.08 (0.75)	0.18 (1.62)
1984	0.22 (2.37)	0.15 (1.25)	0.13 (1.55)	0.16 (1.52)
1985	0.06 (0.54)	0.07 (0.60)	0.05 (0.43)	0.13 (0.96)
1986	-0.15 -(1.83)	0.01 (0.11)	-0.10 -(1.15)	-0.01-(0.10)
1987	0.02 (0.28)	-0.01 -(0.15)	0.00 (0.02)	0.03 (0.36)
1988	0.05 (0.59)	0.09 (1.00)	0.02 (0.22)	0.11 (1.27)
1989	0.00 -(0.04)	-0.06 -(0.66)	-0.02 -(0.28)	0.01 (0.14)
1990	0.07 (0.83)	0.20 (1.99)	0.09 (0.96)	0.16 (1.69)
1991	0.18 (2.70)	0.13 (1.70)	0.17 (2.31)	0.18 (2.61)
1992	0.05 (0.79)	0.06 (0.75)	0.06 (0.87)	0.09 (1.26)
1993	-0.03 -(0.45)	-0.02 -(0.33)	-0.02 -(0.25)	0.00 (0.06)
1994	0.03 (0.49)	-0.08 -(0.96)	0.01 (0.12)	-0.01-(0.15)
C-1981	0.01 (1.18)	-0.04 -(4.37)	0.00 -(0.62)	-0.04-(3.43)
C-1982	-0.03 -(2.68)	-0.01 -(1.02)	0.01 (2.61)	-0.03-(3.27)
C-1983	0.02 (1.88)	-0.03 -(2.73)	0.02 (2.37)	-0.03-(2.68)
C-1984	0.03 (2.84)	-0.04 -(3.60)	0.00 (0.69)	-0.03-(3.13)
C-1985	0.00 (0.29)	-0.01 -(1.53)	0.00 (0.94)	-0.02-(2.01)
C-1986	-0.01 -(0.77)	-0.02 -(2.96)	0.00 (0.88)	0.00-(0.40)
C-1987	0.01 (1.55)	-0.01 -(1.75)	0.01 (2.30)	-0.01-(1.18)
C-1988	0.01 (1.72)	-0.02 -(2.17)	0.00 (1.12)	-0.01-(1.84)
C-1989	0.00 (0.47)	-0.01 -(1.12)	0.00 (0.64)	-0.01-(1.66)
C-1990	0.01 (0.51)	-0.04 -(6.77)	0.00 (0.08)	-0.02-(5.20)
C-1991	0.02 (2.37)	0.00 -(0.22)	0.01 (1.76)	0.01 (0.74)
C-1992	0.03 (2.74)	-0.01 -(2.39)	0.02 (4.48)	0.01 (3.04)
C-1993	0.01 (3.04)	0.00 -(0.39)	0.01 (3.59)	0.01 (2.40)
C-1994	-0.01 -(0.97)	0.02 (3.04)	0.00 -(0.38)	0.00-(0.27)
C-1995	-0.01 -(1.67)	-0.03 -(5.38)	-0.01 -(2.14)	-0.01-(2.04)

Table 3. Markup ratios in some industries Roeger's method (1980–1992)

	National Accounts		Martins et al. ISIC classification				
	Modified Finland	Roeger Finland	Finland	Sweden	Canada	USA	Germany
Wood	0.34	0.27	0.14	0.19	0.19	0.15	..
Paper-pulp	0.29	0.29	0.19	0.16	0.27	0.11	0.19
Printing publishing	0.13	0.20	0.17	0.13	0.15	0.18	0.13
Metal products	0.18	0.24	0.18	0.11	0.12	0.09	0.17
Machinery equipment	0.22	0.27	0.18	0	0.14	0	0

Chart 1 A

ROEGER'S model, cost based r

Correlation, B and 1-α–β, 1980-1995

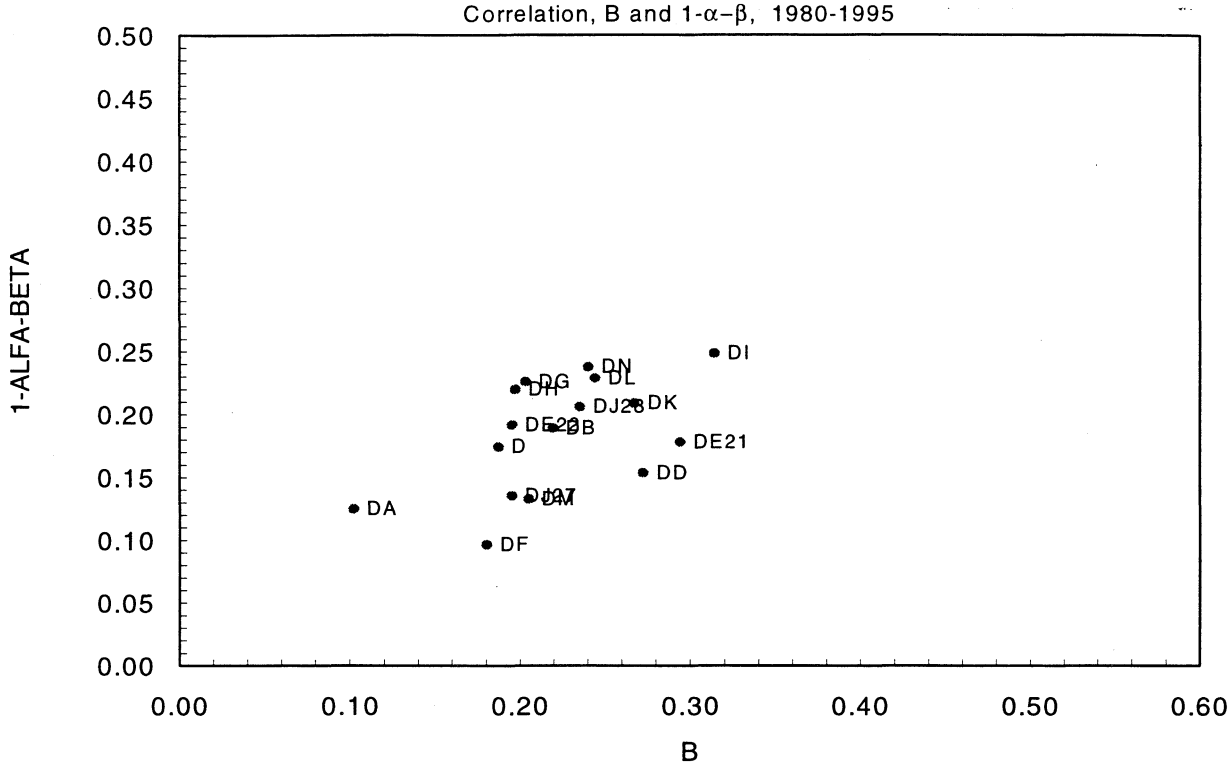


Chart 1 B

ROEGER'S model, costant r

Correlation, B and 1-α–β, 1980-1995

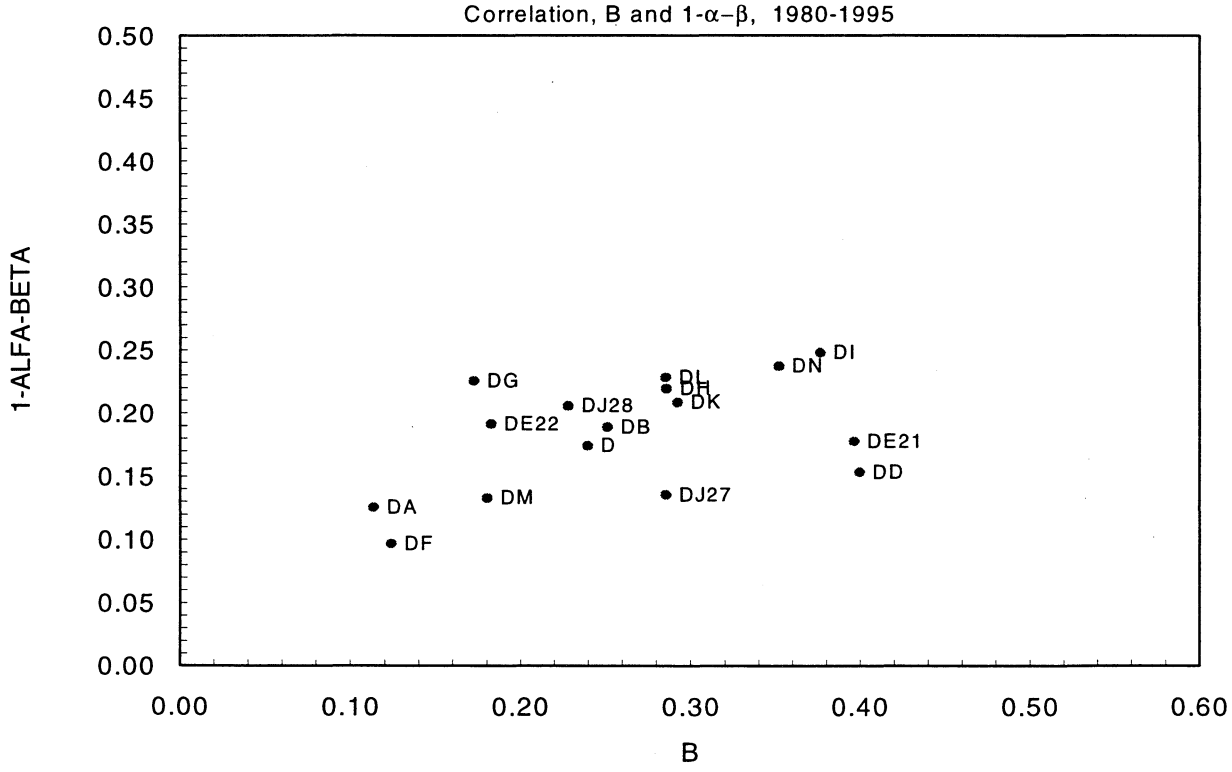


Chart 2 A

Markups in various manufacturing industries
cost based rental price

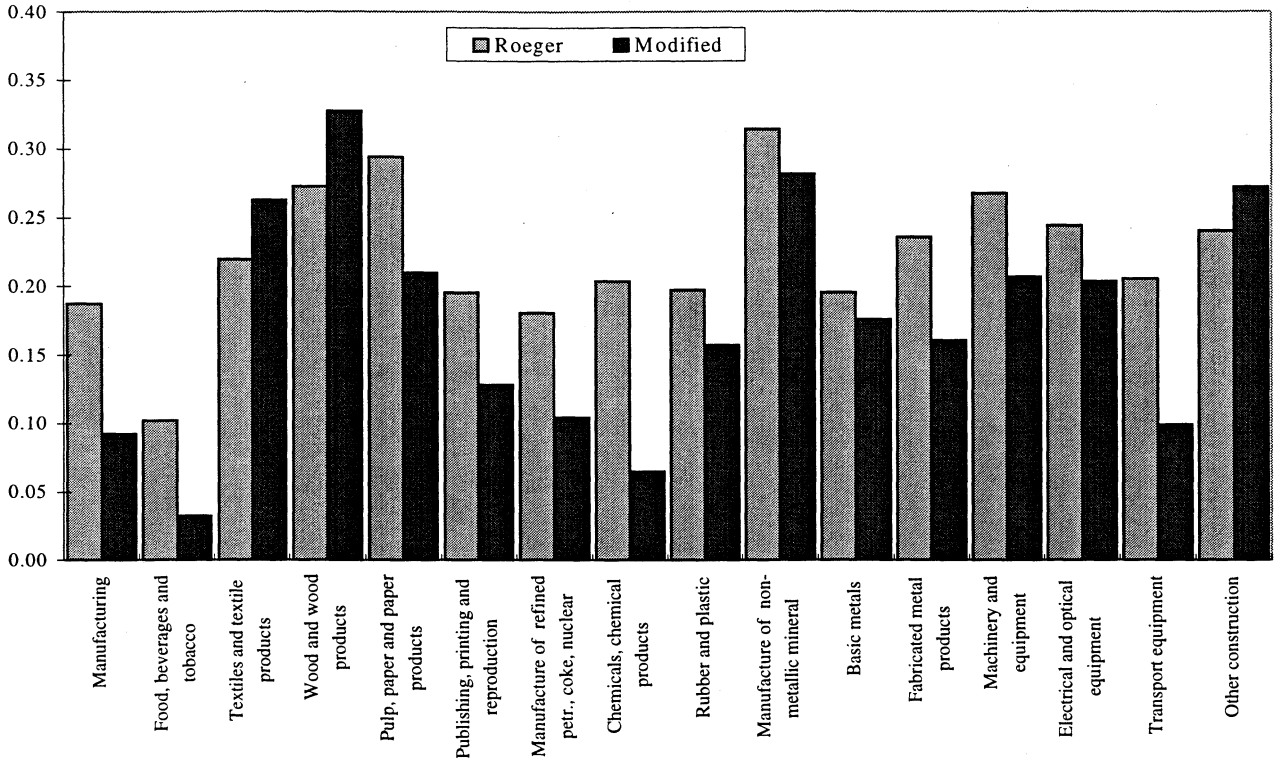


Chart 2 B

Markups in various manufacturing industries
constant rental price

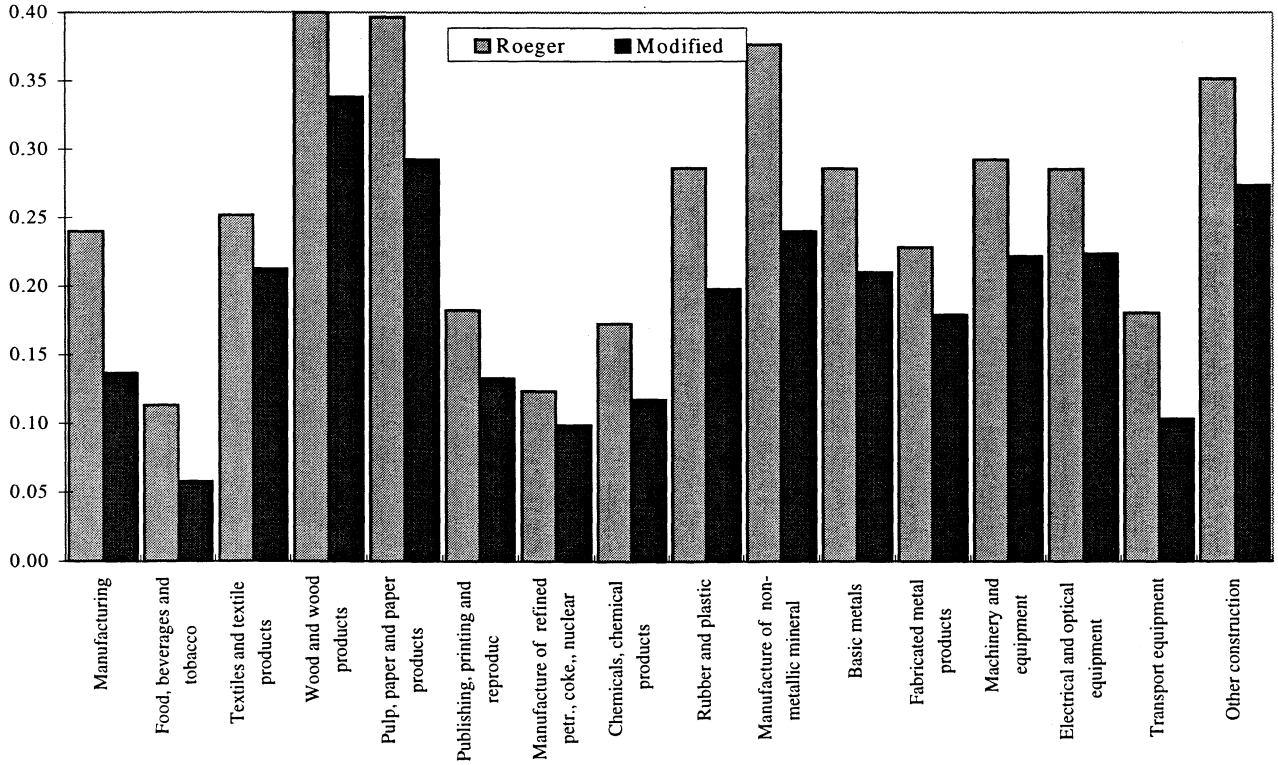


Chart 3. **Time-varying average markup (cost-based rental price)**

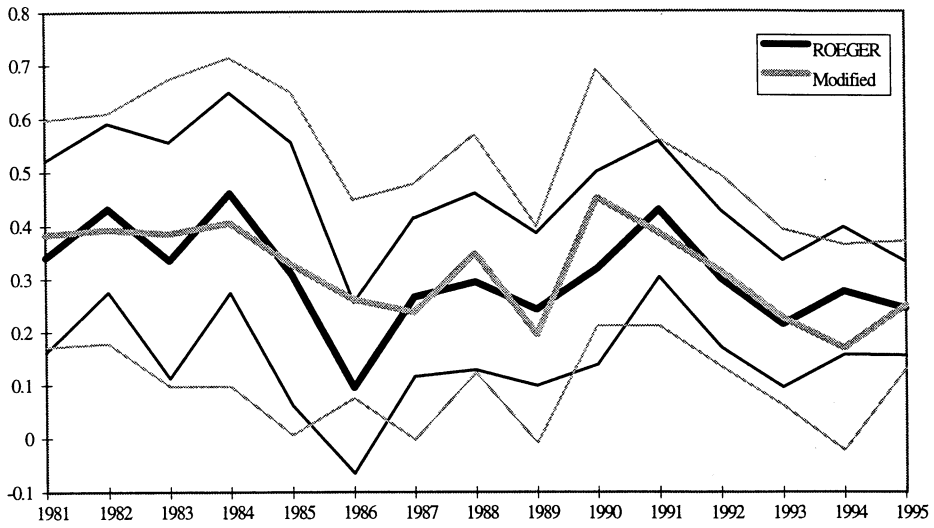


Chart 4. **Time-varying average markup (constant rental price)**

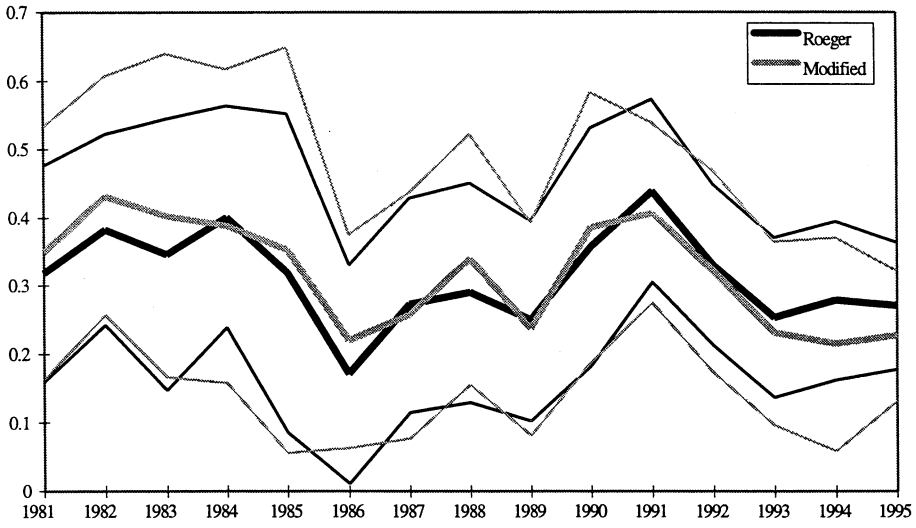


Chart 5. **Average markups in industries with range, cost based rental price**

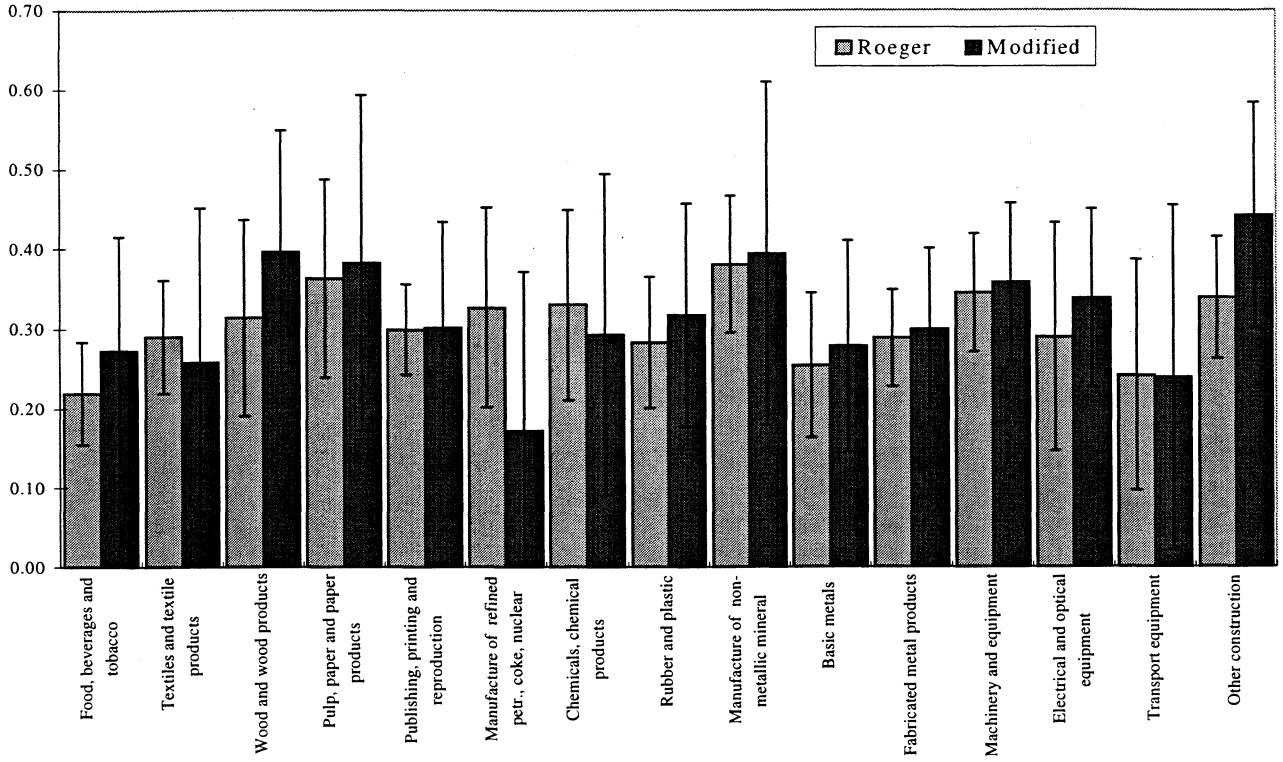
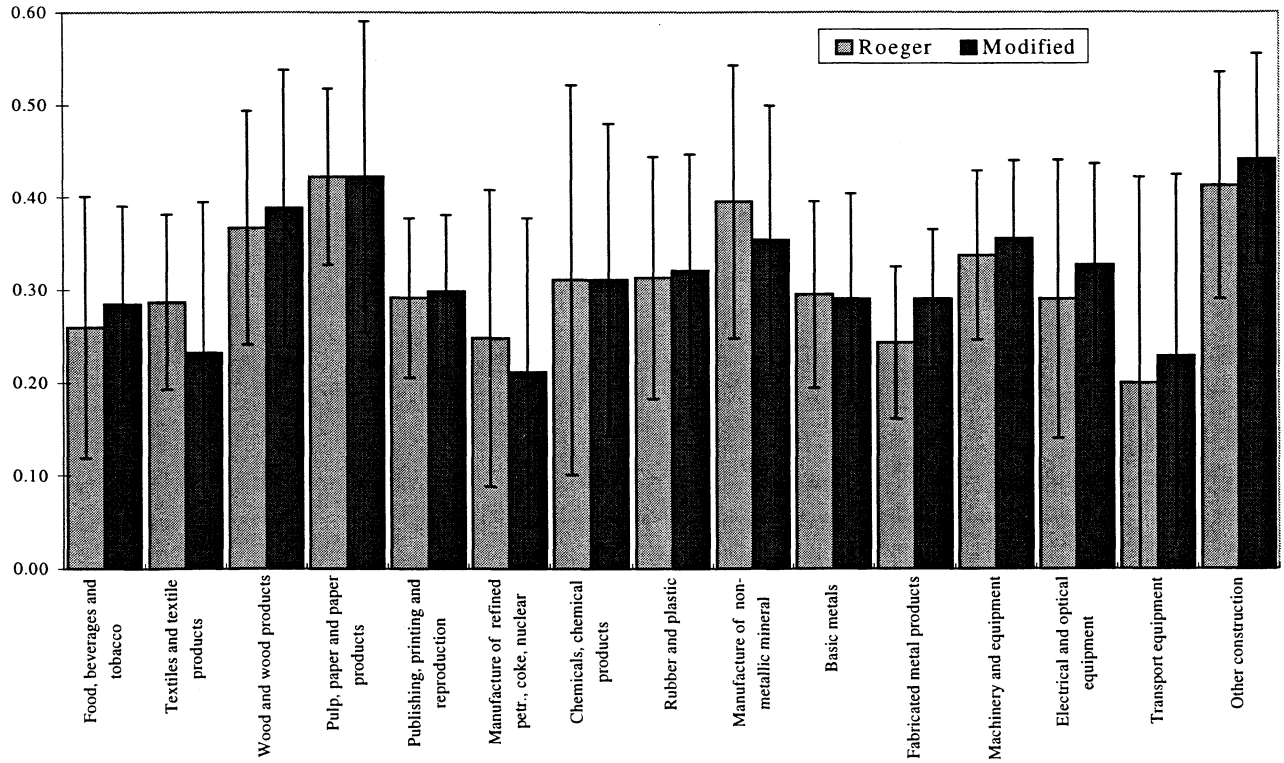


Chart 6. **Average markups in industries with range, constant rental price**



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