# BANK OF FINLAND DISCUSSION PAPERS

30/96

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Economics Department
18.12.1996

# Markups and Measurement Errors in Six EU Countries

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ISBN 951-686-539-9
ISSN 0785-3572

Suomen Pankin monistuskeskus
Helsinki 1996

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# Abstract

This study of markups, ie prices over marginal costs in manufacturing industries, builds on the work of Robert Hall and Werner Roeger. We analyze several methods used in estimating sectoral markups, and then apply them to empirical analysis of the industrial sectors of six EU countries (Germany, France, Italy, the UK, Sweden and Finland). We argue that measurement errors in the model variables, particularly in the rental price of capital, are likely to be a major problem in markup estimation, and show that due to measurement errors, the approach developed by Roeger is likely to produce markup estimates with an upward bias. Such biased results are particularly deceiving since the outcome tends to produce artificially good fits, high t-values, and markup estimates which are "sensible" in magnitude.

We also introduce a "modified" model for markup estimation, which would, if all assumptions were fulfilled and variables correctly measured, yield results identical to those obtained with Roeger's model. Yet, in contrast to Roeger's model, in the presence of measurement errors the markup estimates produced by this model have downward bias. Comparison of these two sets of estimates enables us to assess the seriousness of the measurement problem. We found that the estimates produced by the two models differed in a systematic fashion which is symptomatic of measurement errors. All in all, our results provide strong support for our hypothesis that the markup estimates obtained with Roeger's method are likely to be artifacts created by measurement errors mainly in the rental price of capital.

Key words: markup, imperfect competition

# Tiivistelmä

Tutkimuksessa selvitetään rajakustannukset ylittävää hinnoittelua teollisuudessa eli ns. markuppeja. Analyysi rakentuu Robert Hallin ja Werner Roegerin töiden pohjalle ja työssämme arvioidaan eri menetelmiä estimoitaessa toimialoittaisia markuppeja. Menetelmiä sovellettiin empiirisessä analyysissa kuuden EU-maan, Saksa, Ranska, Italia, Iso-Britannia, Ruotsi ja Suomi, toimiala-aineistoon. Tulostemme mukaan mittausvirheet muuttujissa ovat keskeinen ongelma markuppien estimoinnissa, erityisesti pääoman vuokran mittaamiseen liiittyvät ongelmat ovat vaikeita. Osoitamme, että Roegerin menetelmällä estimoidut markupit ovat harhaisia ylöspäin eli liian korkeita mittausvirheiden vuoksi. Tulosten harhaisuus korostuu erityisesti, koska estimaatit näyttävät järkeviltä korkeine selitysasteineen ja t-arvoineen.

Työssämme sovellettiin myös Roegerin menetelmästä poikkeavaa, "modifioitua" mallia. Jos kaikki oletukset ovat voimasssa, tämän mallin pitäisi tuottaa identtiset parametriestimaatit Roegerin menetelmään verrattuna. Verrattuna Roegerin metodiin modifioitu malli tuottaa kuitenkin alaspäin harhaisia estimaatteja, mikäli muuttujissa on mittausvirhettä. Siten mallien tuottamia estimaatteja vertaamalla voidaan arvioida mittausvirheen haitallisuutta. Havaisimme, että mallit tuottavat estimaatteja, jotka poikkeavat toisistaan systemaattisesti, kuten mittausvirheiden olemassa olo edellyttää. Tutkimuksessamme saadut tulokset tukevat voimakkaasti hypoteesia, että Roegerin menetelmällä estimoidut markup-tekijät ovat seurausta erityisesti pääoman vuokraan liittyvästä mittausvirheestä.

Asiasanat: yritysten hinnoittelu, epätäydellinen kilpailu

# Contents

# 1 Introduction

Markups, ie prices over marginal costs, have been a central theme in the debate over Keynesian vs. real business-cycle models (see, for example, the discussion in Brookings papers 1986/2). A high markup implies that a firm's production is below its efficient (socially optimal) level. Robert Hall's very high markup estimates for US industries raised the question whether vast overcapacity or labor hoarding were dominant phenomena. The cyclical developments of real wages and markups has also been a subject of intense study (NBER Macroeconomic Annual 1991).

Markups are not directly observable, so a variety of approximation methods have been developed. These range from micro-oriented econometrics based on partly detailed firm-level data (Bils 1993, Bresnahan 1989, and Domowitz at al 1988) to macro-oriented empirical approaches (Rotemberg and Woodward 1991). This paper uses industrial-level data to calculate sectoral markups for a number of industrialized countries.

In his framebreaking papers Hall (1986 and 1988) demonstrated that the Solow residual (SR) can exhibit information about markups under conditions of imperfect competition, and proved the "Invariance of the Solow residual" which holds that when technical progress (or the change of Total Factor Productivity, TFP) is constant (or a stochastic variable with constant mean) and there is perfect competition with constant returns to scale, then the Solow residual should be independent from exogenous demand shocks.[1] If pure demand shocks are observed to affect the Solow residual, ie cause changes in output without corresponding responses in the factors of production, then the industry must be imperfectly competitive. In his empirical work, Hall found that the Solow residual was indeed strongly correlated with demand shocks, so he concluded that imperfect competition and considerable excess capacity were present in the US economy (see also Shapiro, 1987).

Roeger (1995) developed Hall's approach further by exploiting the fact that the Solow residual can be determined either as the residual of the production function (as Hall did), or through its dual, as the residual of the corresponding cost function. If these two measures, the quantity-based SR and the price-based SRP, of the Solow residual correctly measure true productivity, then they should be identical. Particularly, the difference between the two should not be cyclical under the maintained assumptions, including that of perfect competition. In his empirical analysis of US industries, Roeger showed that the difference between the two measures of the Solow residual exhibit systematic behavior, and this behavior can be well explained by any model that allows for a constant, non-zero markup. As a by-product, his analysis provided estimates for markup ratios in US industries. As a rule, these were considerably lower than the ones presented by Hall. The generally very good fit of the model led Roeger to infer that imperfect competition may be the cause of the observed anomalies in the behavior of the Solow residuals. Roger's framework was recently used in an OECD study by Martins et al (1996), who estimated the markup ratios for several industries in 14 OECD countries.

In this paper, we argue that in addition to (or instead of) imperfect competition, the observed discrepancies between the two measures of the Solow residual are likely

[1] In Hall's work, these were proxied by military spending and changes in government.

the result of measurement errors, and that particularly sizable distortion arises from errors in the measurement of the rental price of capital. These measurement errors introduce a bias towards a particular value in the markup estimates, and a downward bias in the estimates of parameter standard errors.

We start by presenting some theoretical background and a summary of the results by Hall, Shapiro and Roeger. Then we proceed to discuss the likely causes of measurement error in the data used to estimate markups, and how these measurement errors affect the results. We show that measurement errors create a bias against the null hypotheses, ie perfect competition. Next we follow Martins et al (1996) in estimating industry-level markups for several industrial countries using a different data set. We estimate markups using two slightly different versions of the model. As measurement errors affect the two models differently, the differences in the estimates obtained by the models enable us to assess the seriousness of the measurement problem. We find that the differences in the markup estimates as well as their inter-industry distributions strongly support our hypothesis that measurement errors – particularly those in the rental price of capital – have a significant effect on the markup estimates and may have produced spurious results in some earlier studies. When we use a model version which is more robust with respect to measurement errors in the rental price, we obtain markup estimates that are generally much lower than those obtained with Roeger's method. In most cases, we are unable to reject perfect competition.

# 2 Markups, Solow residuals and production function

## 2.1 Roeger's method

In growth accounting, the growth of output is divided between factors of production using a general production function. Under perfect competition and constant returns to scale, changes in output should be accompanied by proportional changes in the use of inputs where the factors of proportionality are determined by the income shares of the inputs. The residual of output growth that remains after accounting for the contributions of changes in inputs is called the Solow residual, SR, or total factor productivity, TFP. If perfect competition and constant returns to scale prevail in an industry, then SR should be a function of technological progress and, in particular, independent of demand shocks. When this is not the case, one can deduce that competition in the industry is imperfect. This, in short, is Hall's contribution.

Roeger (1995) developed Hall's idea further and utilized factor prices in the estimation on markup ratios. To illustrate this, consider the linear and homogenous production function

$$Q_t = F(L_t, M_t, K_t)E_t \tag{1}$$

where Q is gross output produced using labor L, intermediate input M and capital K as factors of production. E is a shift factor representing technical progress.

We allow for the possibility of imperfect competition and measure markup by the Lerner index B,

B = (P - MC)/P,

where P is price and MC marginal cost. Under perfect competition B = 0. Hall shows that the (ordinary) Solow residual can be written in log differences as

$$
\begin{aligned}
SR_t &= \Delta q_t - \alpha_t\, \Delta l_t - \beta_t\, \Delta m_t - (1-\alpha_t-\beta_t)\, \Delta k_t \\
&= B(\Delta q_t - \Delta k_t) + (1-B)\Delta e_t
\end{aligned}
\qquad (2)
$$

where $\alpha$ = WL /PY is labor's share of income, and $\beta$ is the corresponding share of intermediate inputs. Lowercase letters refer to logarithms of the corresponding variables in (1).[2] Note that under perfect competition (ie when B=0) the bottom line of (2) is reduced to $\Delta$e, ie the Solow residual is determined solely by the change in technology. Under imperfect competition (B > 0), the Solow residual is correlated with changes in capital/output ratio.

Alternatively, the Solow residual can be calculated from the dual cost function. Constant returns to scale and Hicks-neutral technological change imply a cost function which is linear in output and technology:

$$
C(W,\, P_m,\, R,\, Y,\, E) = \frac{G(W_t,\, P_{m_t},\, R_t)Y_t}{E_t} \qquad (3)
$$

where, as before, W is wage level, $P_m$ is the price of intermediate inputs and R is the rental price of capital. Marginal cost is simply

$$
\frac{\partial C_t}{\partial Y_t} = MC_t = \frac{G(W_t,\, P_{m_t},\, R_t)}{E_t} \qquad (4)
$$

Assuming constant markup, taking the total differential of (4), applying Shephard's lemma, and arranging, we have the price-based Solow residual, SRP,

$$
\begin{aligned}
SRP_t &= \alpha_t\, \Delta w_t + \beta_t\, \Delta P_{m_t} + (1-\beta_t - \alpha_t)\Delta r_t - \Delta p_t \\
&= -B(\Delta p_t - \Delta r_t) + (1-B)\Delta e_t
\end{aligned}
\qquad (5)
$$

where $\alpha$ and $\beta$ refer to the income shares of the labor and intermediate inputs, and B is the Lerner index. Under perfect competition B = 0 and changes in factor prices should be matched by proportional changes in the price of output, where the factors of proportionality are again determined by income shares.

The similarity between (5) and (2) is obvious. Deducting (5) from (2) and adding an error term we obtain

[2] Norrbin (1993) and Basu (1995) argued that the use of value-added as a measure of production tends to underestimate the markup ratios and recommended using gross output instead.

$$\Delta(q_t+p_t)-\alpha_t\Delta(w_t+l_t)\ -\beta_t\Delta(p_{m,t}+m_t)-(1-\alpha_t-\beta_t)\Delta(r_t+k_t)$$
$$= B(\Delta(q_t+p_t)-\Delta(r_t+k_t))+\epsilon_t$$

or

$$SR_t\ -\ SRP_t\ =\ B((\Delta q_t+\Delta p_t)\ -\ (\Delta r_t+\Delta k_t))\ +\ \epsilon_t \tag{6}$$

Notice that in (6), the technology term has canceled out. Under perfect competition, the difference between the two Solow residuals should be white noise; under imperfect competition, it is negatively correlated with changes the income share of capital.

Equation (6) is the essence of Roeger's approach. Provided all relevant variables can be observed or proxied, it can be estimated directly – there is no need to resort to instrumental variables. Naturally, it is implicitly assumed that factors of production can be adjusted instantaneously.

## 2.2 General framework

There is an alternative way to derive Roeger's equation (6), one which may provide better insight to the properties of the method. Let us define the average markup ratio as

$$\mu\ =\ \frac{P\ Q}{WL\ +\ P_m\ M\ +\ RK} \tag{7}$$

Under perfect competition, $\mu$ equals one and P = MC (= AC). Note the direct relation between the markup ratio and the Lerner index B: $\mu = 1/(1 - B)$.

If all variables on the right hand side of (7) are known, the markup ratio can obviously be solved directly from the definition. In practice, however, we often have very poor information of the levels of many right-hand-side variables, particularly regarding the rental price of capital and capital stock. However, if there is reason to believe that the measurement error is fairly constant in size, then instead of levels of variables we can use differences, which should be more accurately measured. If measurement error is not constant, then differencing will generally only exacerbate the problems.

To derive Roeger's model, we assume constant markup and take the logarithmic total differential of (7) which, after some rearranging, yields

$$\begin{aligned} 0\ =\ \Delta(p\ +\ q)\ -\ \mu\frac{WL}{PQ}\Delta(w\ +\ l)\ -\ \mu\frac{P_mM}{PQ}\Delta(p_m\ +\ m) \\ -\ \mu\frac{RK}{PQ}\Delta(r\ +\ k) \end{aligned} \tag{8}$$

Using the adopted notation, this can be written as

$$\Delta(p + q) = \mu \, [\alpha\Delta(w + l) + \beta\Delta(p_m + m) + \gamma\Delta(r + k)] \tag{9}$$

Utilizing the facts that $\gamma = 1-\alpha-\beta-B$ and $\mu = 1/(1-B)$, this can be written equivalently as

$$\Delta(p + q) - \alpha\Delta(w + l) - \beta\Delta(p_m+m) - (1-\alpha-\beta)\Delta(r + k)$$
$$= B(\Delta(p + q) - \Delta(r + k))$$

which is identical to Roeger's equation (6).

Equations (6) and (9) are equivalent representations of the same economic relation. Both can be estimated and, if all assumptions are correct, they should yield identical markup estimates. A number of other equivalent forms could be derived, but for reasons explained later, we will concentrate on the two derived above. For lack of a better name, we shall refer to equation (9) as the "modified equation".

## 2.3 Rental price of capital and measurement errors

As explained above, equations (6) or (9) yield generally reliable estimates only if the measurement errors in levels of variables are sufficiently constant, ie they disappear in differences. This is probably the case with the measurement of capital stock, for which a measure can be constructed using data from gross fixed capital formation and a proxy of depreciation. Such a measure can be quite inaccurate as an approximation as the true level of capital stock, but its changes are likely to be well correlated with the true changes.

The situation is different with the measurement of rental price of capital. The rental price of capital is not directly observable and no obvious approximation exists. It is customary to measure the rental price of capital through its definition

$$R = ((i-\pi_e) + \delta)p_k \tag{10}$$

where $i$ is the appropriate nominal, after-tax interest rate, $\pi_e$ expected rate of change in the price of the capital good, $\delta$ is the depreciation rate, and $p_k$ is the price of capital goods. In practice, $i$ is usually proxied by a long-term interest rate, $\pi_e$ is calculated on the basis of the GDP deflator or the CPI, and $\delta$ is assumed to be a constant. Martins et al (1996) used this equation for the rental price of capital. It is also very close to formulations used by Roeger (1995) and Hall (1990).

Is this a good approximation of the true rental price? Very likely not. First, a long bond yield hardly gives an exhaustive picture of the nominal cost of capital: firms' sources of finance vary over time and from firm to firm, and agency costs create a wedge between nominal long rates and the true cost of capital. Second, changes in corporate taxation, investment deductions etc., which all have a crucial effect on the net nominal cost of capital, are almost impossible to capture in practice. Third, the correct deflator is not the immediate behavior of any aggregate price index, but instead the *expected* behavior of the price of the *particular capital good* over the *full life* of the investment. The expected average rate of capital price inflation for the next, say, 10 or 20 years is almost certainly considerably more stable than the annual change of GDP deflator. Finally, the rate of depreciation varies from one capital good to the next, and changes in the composition of investments over time affect the true rate of depreciation. We find it unlikely that these measurement errors are constant over time and would disappear in differences.

If one accepts that the proxy of rental price (or some other variable) is subject to significant measurement errors, what consequences will those errors carry to the estimated markup parameters? The answer depends on the exact nature of measurement error and the form of the equation estimated. If we assume that our measures are correct on average, but have stochastic error components with zero means, then the directions of the resulting biases are easy to solve for each form of equation. Table 1 presents this information (see the Appendix for details of the bias analysis).

Table 1. **Measurement errors and biases in estimation**

| Measurement error in | Eq. (6), Roeger bias in $\mu$ | bias in B | Eq. (9), modified bias in $\mu$ |
|---|---|---|---|
| $\Delta(p+q)$ | towards $\infty$ | towards 1 | unbiased |
| $\Delta(w+l)$ | unbiased | unbiased | towards 0 |
| $\Delta(p_m+m)$ | unbiased | unbiased | towards 0 |
| $\Delta(r+k)$ | towards $1/(\alpha+\beta)$ | towards $(1-\alpha-\beta)$ | towards 0 |

As seen from the table, Roeger's method is robust with respect to measurement errors in labor cost and the value of intermediate inputs. On the other hand, measurement errors in the rental price and stock of capital or in the value of output introduce a bias in the markup estimate. If the measurement error is in the rental price or stock of capital, then the estimate of B is biased towards $1-\alpha-\beta$, ie upwards (since $1-\alpha-\beta = B+\gamma > B$).[3] Similarly, if the value of output is incorrectly measured, the bias is always upwards, approaching infinity when measurement error variance grows without bound. Hence, in all cases, the bias in markup ratio estimates obtained using Roeger's method is upwards. Correspondingly, it can be shown that the markup estimates obtained with the modified method in equation (9) are robust with respect to measurement errors in the value of output, but biased downwards if any of the prices or quantities of the factors of production is mismeasured.

If our hypothesis is correct – ie measurement errors, particularly in the rental price of capital, play a significant role in the estimates of markups – then we should observe the following:

- Roeger's method will produce consistently higher markup estimates than the modified method.
- Where errors are particularly serious in the measurement of the rental price, then Roeger's method should yield estimates of B close to $1-\alpha-\beta$ and the correlation between the markup estimates obtained by the two methods should be small or negative.

[3] Roeger (1996, p. 322) discusses the role of measurement errors in his model. He argues that measurement errors in the rental price of capital are not likely to be a problem and, in any case, would not introduce a bias in the model. As demonstrated in the appendix, the latter statement is clearly false.

# 3 Empirical Results

## 3.1 Data and Method

Our data cover six EU countries: Germany, France, Italy, the UK, Sweden, and Finland. Most of our annual data is extracted from the OECD's ISDB- and STAN-databases and disaggregated at the 2-digit industry level.[4] Our data extends back to the '70s, but we concentrate mainly on the results obtained using data since 1980. The reason for discarding the earlier data is that the two oil shocks and effective credit rationing created circumstances which are not likely to yield informative estimates for the present situation. In particular, some countries experienced, by normal measures, periods of negative rental price of capital, which causes both the theoretical and empirical models to collapse. Further, since our model only includes one coefficient, the shorter time span still offers sufficient degrees of freedom.

Our proxy for the rental price of capital is constructed according to the method presented (and criticized) in section 2.3. Nominal interest rate is measured by the 10-year government bond yield. Expected inflation is proxied by an adaptive model of GDP deflator, which yields results slightly different from the Hodrick-Prescott filtering scheme used in the OECD study.

We will estimate the two versions of the markup model presented in equations (6) and (9). As demonstrated above, measurement error biases are upwards in Roeger's model and downwards in the modified model. Hence, estimation of both provides us with a range within which the true markup is likely to lie. In addition, we will also estimate both models under the assumption of a constant rental price capital, ie with the changes in rental price constrained to zero. To the extent that the true rental price of capital varies over time, ignoring this variation will obviously introduce a new source of measurement error in the model. However, as discussed above, since the true rental price of capital reflects the investor's expectations of the behavior of certain variables over a period stretching perhaps 10 or 20 years in the future, we do not think it can be very volatile. Hence, we believe that the error introduced by ignoring its variation is likely to be an order of magnitude smaller than that involved with using the normal, inadequate measure of the rental price.[5]

[4] The data for Finland was constructed on the basis of OECD data base. It is of somewhat suspect quality because capital stock data were taken from another source, which may be a reason why the result for Finland differs from those obtained for other countries. A broader study, utilizing more accurate data (and higher markups as a result), on Finnish industrial markups is forthcoming.

[5] Here we follow, for example, Shapiro (1987) who also dropped out the term $\Delta$ r when he estimated the price-based Solow residual (SRP). According to Shapiro, due to costs of adjustment and time lags involved in the installation of new capital, it is unrealistic to assume that capital is paid according its marginal product within the period.

Table 2. **Share of variance due to changes in rental price in Roeger's model**

| variance of | Germany | France | Italy | UK | Sweden | Finland |
|---|---|---|---|---|---|---|
| $\Delta x$ | 0.89 | 0.88 | 0.84 | 0.96 | 0.84 | 0.80 |
| $\Delta y$ | 0.80 | 0.84 | 0.83 | 0.74 | 0.57 | 0.50 |

To provide an idea of the role rental price plays in the results, we calculated for each country the share of variances of the regressor and the regressand (of Roeger's model) attributable to changes in the rental price. In other words, we compared actual variances of the model variables in Roeger's model with those that would be obtained if rental price of capital had been constant. From the difference between these two measures we calculated the contribution of rental price. The results are reported in Table 2. Only contributions for total manufacturing in each country are reported, but the results for individual industries are comparable. For the period starting from 1980, measured changes in rental price of capital are, on average, responsible for more than 80% of the variation *on each side of Roeger's equation.* The most extreme example is the UK, where the contribution is 96% for the regressor and 74% for the regressand. At the other end, Finland stands out with a contribution of only 80% for the regressor and 50% for the regressand.

Even without running a single regression, the knowledge that 80% of the variance in the two sides of the equation is due to the same variable makes it is easy to predict that fit in Roeger's model will be excellent and t-values high. It also demonstrates that if this variance is even partly due to measurement errors, the potential for bias in the results is significant. We find it unlikely that the true expected real capital cost or capital depreciation (over the life of an investment) are so volatile as to account for such high volatility of the rental price.

## 3.2 Markup ratios with variable rental price

Table 3 presents the summary table of the estimated sectoral markups. The table shows estimates from the period 1980–93 and they are presented without t-statistics. Full results for both different estimation periods together with t-statistics (testing the significance of the deviation from perfect competition) are given in the Appendix in Tables 4A–4B. We expect the estimates of markup ratios to be usually greater than unity (B > 0) but for a subsidized industry, a markup ratio below one is, in principle, possible.

As expected, the modified model (9) generates consistently and significantly lower markup estimates than Roeger's model (6). For the shorter estimation period, Roeger's method shows a statistically significant (positive) deviation from perfect competition in 72 cases of the total 74, whereas with the modified method the same is true only in three cases. With Roeger's method, the average markups ratios vary from 1.07 for the UK to 1.19 in Germany, while the modified method yields a range from Finland's 0.99 to Sweden's 1.06. In some cases, the latter markup estimates are below one, albeit never significantly so.

Despite a different industry division, the results we obtain with Roeger's method are in line with those presented in the OECD study by Martins et al (1996). Hence, we believe that our analysis of measurement errors is likely to apply to their work as well. One interesting feature shared by the two studies is that Roeger's method applied to the UK yields generally very low markup estimates. One might conjecture that the program of structural reform towards free market economy, implemented in the UK in 1980s, has resulted in a nearly perfect competition across a wide spectrum of industries. On the other hand, country differences might as well be due to measurement errors or different statistical procedures. With the estimates from the modified model, the UK does not stand out in any way. Overall, the coefficients obtained with the modified model are significantly smaller than those in the OECD study or any other study we are aware of.

Chart 2 presents the relationship between the estimates of B obtained by Roeger's method (horizontal axis), and the average values of $1 - \alpha_t - \beta_t$ over time for each industry (vertical axis). If our hypothesis of seriously mismeasured rental price is correct, we should observe a positive correlation between the two values across industries. This indeed is the case: an almost one-to-one correspondence is evident for Germany (with correlation coefficient 0.97), the UK (0.94), Italy (0.93), France (0.89), and Sweden (0.88). In Finland, where the correlation is less tight but still significant (0.51). The results are well in line with the relative contributions of rental price of capital to the model variables (presented above in Table 2): Finland, for which the proxy of rental price has been smoother than elsewhere, stands out here as well. Notice that the majority of observations in the chart lie to the right of the 45-degree line; ie capital's income share implied by Roeger's equation ($\gamma = 1 - \alpha - \beta - B$) is in most cases negative. This nonsensical outcome is, by itself, an indication of measurement problems.

Another implication of our measurement-error hypothesis was that the correlation over industries between the estimates obtained with the two models should be small or even negative. As Table 3 shows, this correlation is negative for three of the six countries, and highly negative for Germany and Sweden. Only in Italy, the correlation is significantly positive. Hence, so far all our evidence supports our hypothesis that measurement errors, particularly in the rental price of capital, have a significant effect on the results.

## 3.3 Markup ratios with constant rental price ($\Delta r = 0$)

Constraining the rental price of capital to be constant changes the estimates significantly (see Tables 3, 4C, and 4D). Markup estimates for the modified model rise in all of the 74 cases, and the number of significant deviations from perfect competition rises from 3 to 21. The estimates from Roeger's model are also generally affected, though in a less systematic fashion. Estimated markups increase 42 industries, decrease in 25, and stay unchanged in 5. Both outcomes are consistent with the role we hypothesized for measurement errors. In the modified model, mismeasured rental price introduces a bias downwards, so removing the bias should increase the estimates. In Roeger's model, on the other hand, the bias in B is towards $1-\alpha-\beta$. As the original estimates of B with variable rental price were clustered around $1-\alpha-\beta$, removing the bias should indeed have a variable effect on the markup estimates. One systematic outcome is, however, that without rental price variation, the strong correlation between $1-\alpha-\beta$ and the estimate of B in Roeger's model disappears: for four of the six countries, this correlation turns negative, and only for Italy does it remain significantly positive. Hence, the strong relation between the measures, evident in Chart 2, was completely due to the proxy of rental price.

In all countries except the UK, the correlation between the markup estimates obtained with the two models increases noticeably when rental price variation is taken out. For all countries, the correlation is now positive, and for Italy, Sweden, and France it is quite high (0.99, 0.88, and 0.80 respectively). Another encouraging outcome is that of the 21 cases for which the modified model found a significant deviation from prefect competition, in all but one the same was also true according to Roeger's model. Overall, the two methods produce much more consistent results when rental price variation is excluded.

We find this as an indication that the estimates in this case are likely to be more reliable than those obtained in the previous section.

The two markup estimates can be seen as providing information about the range in which the true markup lies. The evidence for imperfect competition is strongest for those 20 cases in which both the upper bound (given by Roeger's model) and the lower bound (from the modified model) imply a significant divergence from perfect competition. However, we find it disquieting that these 20 cases appear to be fairly randomly distributed across countries and, in particular, across industries. All in all, given the extent of the measurement problems, we recommend caution when interpreting the results.

# 4 Concluding remarks

In this paper we have built on the work of Hall (1988) and Roeger (1996) and analyzed different methods of estimating sectoral markups. We applied the methods in an empirical analysis on the industrial sectors of six OECD countries, and argued that measurement errors in the model variables, particularly in the rental price of capital, are likely to be a major problem in markup estimation. We showed that due to measurement errors, the approach developed by Roeger is likely to produce markup estimates that are upward biased. Results suffering from such a bias are particularly deceiving since the outcome tends to be artificially good fits, high t-values, and markup estimates which are "sensible" in magnitude.

We introduced another, "modified", model for markup estimation. This model should, if all assumptions are fulfilled and variables correctly measured, yield results identical to those obtained with Roeger's model. However, in contrast to Roeger's model, in the presence of measurement errors the markup estimates produced by this model are downward biased. Hence, comparison of the two sets of estimates enables us to assess the seriousness of the measurement problem. We found that the estimates produced by the two models differed in a systematic fashion which is symptomatic of measurement errors. All in all, our results provide strong support for our hypothesis that the markup estimates obtained with Roeger's method are likely to be artifacts created by measurement errors, mainly in the rental price of capital.

Since the estimates obtained with Roeger's model are biased upwards, they are best viewed as an upper bound for the true markups. Similarly, estimates from the modified model are downward biased and therefore provide a usable lower bound for the markups. Together, the two methods can be seen as providing a range in which the true markup is likely to lie. According to our results, the lower bound of markup ratio was generally close to unity and, in most cases, perfect competition could not be rejected.

Generally, our results are less than encouraging for industrial-level analysis of markups. Further work on the extent and effects of measurement errors, and better proxies for the rental price of capital, are obviously called for if such analysis is to yield reliable results.

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# Appendix

In the following we describe shortly how the directions of the biases were calculated. Suppose our measurement of $\Delta(r + k)$ is subject to a measurement error so that instead of $\Delta(r + k)$ we observe $\Delta(r + k)^*$ where

$$\Delta(r + k)^* = \Delta(r + k) + u,$$

Here $u$ is the measurement error with E(u) = 0, Var(u) = $\sigma_u^2$. In addition, we assume that $u$ is uncorrelated with all variables in the model. Let us write Roeger's equation as $y = Bx + \epsilon$ , where

$$y = \Delta(q_t+p_t) - \alpha\Delta(w_t+l_t) - \beta\Delta(m_t+p_{mt}) - (1-\alpha-\beta)\Delta(r+k)$$

and

$$x = \Delta(q_t+p_t) - \Delta(r_t+k_t)$$

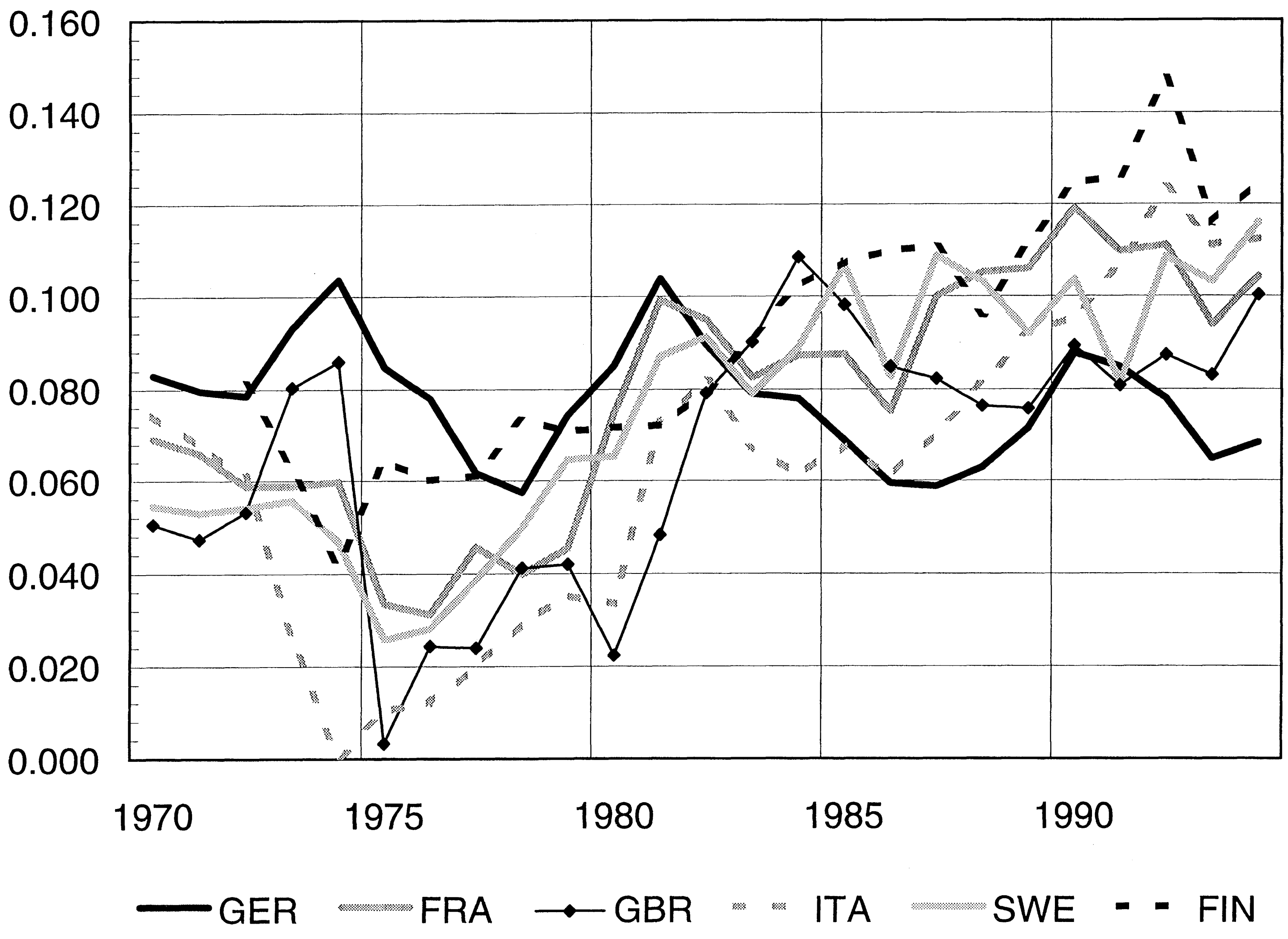
Due to the measurement errors in $\Delta(r + k)$, instead of $y$ and $x$, we observe $y_t^* = y_t - (1-\alpha-\beta)u_t$ and $x_t^* = x_t - u_t$. Running a least squares estimation on these variables yields an estimate of B

$$\hat{B} = \frac{\Sigma(y_i^* x_i^*)}{\Sigma(x_i^*)^2} = \frac{\Sigma y_i x_i - \Sigma y_i u_i - (1-\alpha-\beta)\Sigma u_i x_i + \Sigma(1-\alpha_i-\beta_i)u^2}{\Sigma x_i^2 - 2\Sigma x_i u_i + \Sigma u_i^2}$$

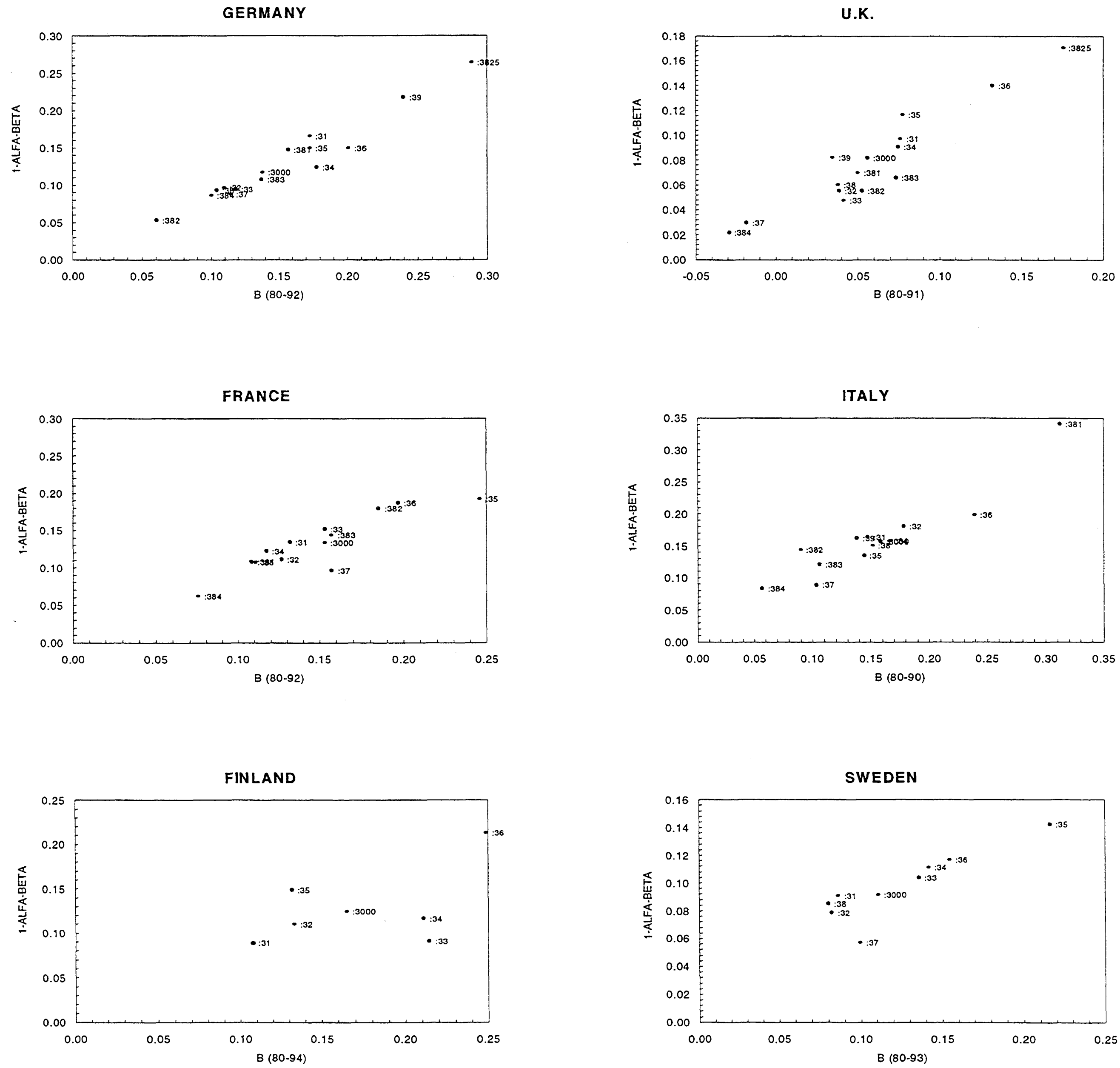
$$= \frac{\Sigma x_i y_i + (1-\alpha-\beta)\sigma_u^2}{\Sigma x_i^2 + \sigma_u^2}$$

When $\sigma_u^2$ grows without limit, $\hat{B}$ approaches $1 - \alpha - \beta$, and the corresponding estimate of $\mu$ goes to $1/(\alpha + \beta)$. A similar method yields the values for other cells of Table 1.

Chart 1. **RENTAL PRICE OF CAPITAL**



# Chart 2. CORRELATION: B AND 1 - ALFA - BETA *




* ISIC-code numbers are used in the figures to indicate industries.

Table 3. **Markup ratios in manufacturing industries**

(For each country, the first two columns present the results for a varying rental price, the last two for a constant rental price. R refers to Roeger's model and M to the modified model)

| Sector | GERMANY 1980–92 | | | | FRANCE 1980–92 | | | | ITALY 1980–90* | | | | U.K. 1980–91 | | | | SWEDEN 1980–93 | | | | FINLAND 1980–94 | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | dr = 0 | | | | dr = 0 | | | | dr = 0 | | | | dr = 0 | | | | dr = 0 | | | | dr = 0 | |
| Model | R | M | R | M | R | M | R | M | R | M | R | M | R | M | R | M | R | M | R | M | R | M | R | M |
| Total Manufacturing | 1.16 | 1.04 | 1.13 | 1.09 | 1.18 | 1.04 | 1.14 | 1.11 | 1.19 | 1.07 | 1.16 | 1.15 | 1.06 | 0.99 | 1.13 | 1.10 | 1.13 | 1.08 | 1.21 | 1.15 | 1.20 | 0.97 | 1.32 | 1.11 |
| Food, Beverages & Tobacco | 1.21 | 1.02 | 1.20 | 1.08 | 1.15 | 1.12 | 1.26 | 1.17 | 1.17 | 1.13 | 1.22 | 1.19 | 1.08 | 0.96 | 1.09 | 1.06 | 1.09 | 1.07 | 1.12 | 1.09 | 1.12 | 0.93 | 1.10 | 1.05 |
| Textiles, Apparel & Leather | 1.12 | 0.92 | 1.05 | 0.99 | 1.15 | 1.06 | 1.15 | 1.10 | 1.22 | 1.12 | 1.22 | 1.20 | 1.04 | 0.99 | 1.15 | 1.08 | 1.09 | 1.00 | 1.19 | 1.09 | 1.15 | 0.98 | 1.20 | 1.04 |
| Wood Products & Furniture | 1.13 | 1.15 | 1.23 | 1.20 | 1.18 | 0.99 | 1.22 | 1.12 | – | – | – | – | 1.04 | 1.05 | 1.15 | 1.10 | 1.16 | 1.24 | 1.34 | 1.25 | 1.27 | 1.22 | 1.58 | 1.27 |
| Paper, Products & Printing | 1.22 | 1.00 | 1.25 | 1.07 | 1.13 | 1.08 | 1.10 | 1.12 | 1.20 | 1.06 | 1.12 | 1.12 | 1.08 | 1.02 | 1.11 | 1.08 | 1.17 | 0.98 | 1.29 | 1.11 | 1.27 | 0.78 | 1.45 | 1.02 |
| Chemical Products | 1.21 | 0.94 | 1.06 | 0.98 | 1.33 | 0.92 | 1.03 | 1.00 | 1.17 | 1.04 | 1.14 | 1.13 | 1.08 | 1.02 | 1.03 | 1.03 | 1.28 | 0.91 | 1.07 | 0.98 | 1.15 | 1.09 | 1.14 | 1.20 |
| Non-Metallic Mineral Products | 1.25 | 1.04 | 1.37 | 1.18 | 1.25 | 0.95 | 1.32 | 1.16 | 1.32 | 1.00 | 1.12 | 1.11 | 1.15 | 1.03 | 1.29 | 1.19 | 1.18 | 1.08 | 1.29 | 1.20 | 1.33 | 0.97 | 1.33 | 1.13 |
| Basic Metal Industries | 1.13 | 1.06 | 1.13 | 1.11 | 1.19 | 1.11 | 1.39 | 1.25 | 1.12 | 1.02 | 1.12 | 1.09 | 0.98 | 0.94 | 1.17 | 1.09 | 1.11 | 1.11 | 1.23 | 1.17 | 1.22 | 1.13 | 1.35 | 1.21 |
| Fabricated Metal Products | 1.12 | 1.07 | 1.17 | 1.08 | 1.13 | 1.04 | 1.15 | 1.09 | 1.18 | 1.07 | 1.16 | 1.14 | 1.04 | 1.04 | 1.19 | 1.09 | 1.09 | 1.10 | 1.23 | 1.14 | – | – | – | – |
| Metal Products | 1.19 | 1.11 | 1.24 | 1.12 | 1.12 | 1.00 | 1.11 | 1.06 | 1.46 | 1.03 | 1.22 | 1.21 | 1.05 | 1.00 | 1.16 | 1.11 | – | – | – | – | – | – | – | – |
| Non-Electrical Machinery | 1.06 | 1.06 | 1.14 | 1.07 | 1.23 | 1.16 | 1.27 | 1.20 | 1.10 | 0.98 | 0.98 | 0.99 | 1.06 | 1.02 | 1.08 | 1.06 | – | – | – | – | – | – | – | – |
| Office & Computing Machinery | 1.41 | 0.84 | 1.13 | 0.92 | – | – | – | – | 0.90 | 0.71 | 0.72 | 0.71 | 1.21 | 1.04 | 1.11 | 1.07 | – | – | – | – | – | – | – | – |
| Electrical Machinery | 1.16 | 1.02 | 1.22 | 1.04 | 1.19 | 1.09 | 1.17 | 1.13 | 1.12 | 1.02 | 1.06 | 1.06 | 1.08 | 0.97 | 1.44 | 1.00 | – | – | – | – | – | – | – | – |
| Transport Equipment | 1.11 | 1.07 | 1.17 | 1.07 | 1.08 | 1.00 | 1.25 | 1.04 | 1.06 | 1.01 | 1.04 | 1.03 | 0.97 | 1.02 | 1.20 | 1.04 | – | – | – | – | 1.08 | 0.88 | 1.37 | 0.90 |
| Other Manufacturing | 1.32 | 0.98 | 1.73 | 0.99 | – | – | – | – | 1.16 | 0.92 | 1.12 | 1.08 | 1.04 | 1.12 | 1.18 | 1.16 | – | – | – | – | – | – | – | – |
| Average | 1.19 | 1.02 | 1.21 | 1.07 | 1.18 | 1.04 | 1.20 | 1.12 | 1.17 | 1.01 | 1.10 | 1.09 | 1.07 | 1.02 | 1.16 | 1.08 | 1.14 | 1.06 | 1.22 | 1.13 | 1.20 | 0.99 | 1.32 | 1.09 |
| Correlation R:M | –0.64 | | 0.06 | | –0.29 | | 0.80 | | 0.14 | | 0.99 | | 0.14 | | 0.02 | | –0.44 | | 0.88 | | 0.19 | | 0.35 | |

* Time period varies for some industries.

Table 4A. **Summary of results**

Varying rental price Model R

| | Germany | | France | | Italy | | UK | | Sweden | | Finland | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1970–92 | 1980–92 | 1970–92 | 1980–92 | 1970–90* | 1980–90* | 1970–91 | 1980–91 | 1970–93 | 1980–93 | 1972–94 | 1980–94 |
| Total Manufacturing | 1.17 | 1.16 | 1.16 | 1.18 | 1.17 | 1.19 | 1.05 | 1.06 | 1.11 | 1.13 | 1.17 | 1.20 |
| | *12.25* | *9.51* | *11.89* | *7.91* | *61.77* | *21.32* | *15.25* | *7.39* | *8.58* | *6.59* | *10.56* | *6.11* |
| Food, Beverages & Tobacco | 1.23 | 1.21 | 1.17 | 1.15 | 1.16 | 1.17 | 1.06 | 1.08 | 1.08 | 1.09 | 1.09 | 1.12 |
| | *12.80* | *7.94* | *14.61* | *5.85* | *119.33* | *11.48* | *15.70* | *9.54* | *5.55* | *4.12* | *7.86* | *8.20* |
| Textiles, Apparel & Leather | 1.14 | 1.12 | 1.12 | 1.15 | 1.11 | 1.22 | 1.05 | 1.04 | 1.07 | 1.09 | 1.14 | 1.15 |
| | *7.74* | *7.02* | *9.48* | *6.08* | *35.07* | *21.03* | *11.11* | *3.40* | *4.12* | *3.37* | *6.44* | *3.93* |
| Wood Products & Furniture | 1.14 | 1.13 | 1.17 | 1.18 | – | – | 1.07 | 1.04 | 1.14 | 1.16 | 1.26 | 1.27 |
| | *9.04* | *7.46* | *10.70* | *5.82* | – | – | *8.09* | *3.77* | *4.89* | *5.18* | *6.40* | *3.73* |
| Paper, Products & Printing | 1.19 | 1.22 | 1.14 | 1.13 | 1.18 | 1.20 | 1.07 | 1.08 | 1.18 | 1.17 | 1.24 | 1.27 |
| | *8.21* | *6.20* | *16.26* | *8.51* | *30.15* | *13.26* | *14.25* | *7.93* | *7.20* | *4.44* | *7.06* | *5.22* |
| Chemical Products | 1.18 | 1.21 | 1.21 | 1.33 | 1.16 | 1.17 | 1.09 | 1.08 | 1.16 | 1.28 | 1.17 | 1.15 |
| | *4.42* | *3.59* | *5.27* | *5.09* | *37.48* | *10.92* | *13.91* | *6.05* | *5.82* | *5.24* | *10.47* | *5.84* |
| Non–Metallic Mineral Products | 1.24 | 1.25 | 1.24 | 1.25 | 1.29 | 1.32 | 1.09 | 1.15 | 1.12 | 1.18 | 1.24 | 1.33 |
| | *11.42* | *9.22* | *13.31* | *6.91* | *52.83* | *10.15* | *11.93* | *9.29* | *4.93* | *5.76* | *7.00* | *4.88* |
| Basic Metal Industries | 1.11 | 1.13 | 1.11 | 1.19 | 1.22 | 1.12 | 0.98 | 0.98 | 1.06 | 1.11 | 1.19 | 1.22 |
| | *4.97* | *5.44* | *2.89* | *4.21* | *30.44* | *4.42* | *–2.63* | *–0.79* | *1.53* | *3.38* | *7.08* | *4.95* |
| Fabricated Metal Products | 1.15 | 1.12 | 1.14 | 1.13 | 1.19 | 1.18 | 1.03 | 1.04 | 1.11 | 1.09 | – | – |
| | *10.73* | *7.12* | *10.45* | *4.74* | *49.15* | *21.24* | *7.82* | *3.45* | *8.15* | *3.82* | – | – |
| Metal Products | 1.17 | 1.19 | 1.11 | 1.12 | 1.42 | 1.46 | 1.07 | 1.05 | – | – | – | – |
| | *4.94* | *4.99* | *7.83* | *4.07* | *32.45* | *10.64* | *18.29* | *5.76* | – | – | – | – |
| Non–Electrical Machinery | 1.10 | 1.06 | 1.25 | 1.23 | 1.21 | 1.10 | 1.06 | 1.06 | – | – | – | – |
| | *4.33* | *3.30* | *17.34* | *8.15* | *36.62* | *2.58* | *12.84* | *8.87* | – | – | – | – |
| Office & Computing Machinery | – | 1.41 | – | – | – | 0.90 | 1.27 | 1.21 | – | – | – | – |
| | – | *2.50* | – | – | – | *–0.77* | *16.71* | *6.04* | – | – | – | – |
| Electrical Machinery | 1.16 | 1.16 | 1.18 | 1.19 | 1.12 | 1.12 | 1.04 | 1.08 | – | – | – | – |
| | *8.67* | *5.77* | *12.06* | *8.23* | *27.50* | *5.81* | *5.04* | *2.76* | – | – | – | – |
| Transport Equipment | 1.17 | 1.11 | 1.10 | 1.08 | 1.11 | 1.06 | 0.97 | 0.97 | – | – | 1.12 | 1.08 |
| | *6.66* | *4.65* | *5.06* | *1.84* | *29.42* | *3.92* | *–6.10* | *–1.50* | – | – | *1.71* | *0.84* |
| Other Manufacturing | 1.36 | 1.32 | – | – | 1.16 | 1.16 | 1.05 | 1.04 | – | – | – | – |
| | *8.46* | *4.00* | – | – | *82.38* | *13.81* | *7.03* | *1.86* | – | – | – | – |

Table 4B. **Summary of results**

Varying rental price Model M

| | Germany | | France | | Italy | | UK | | Sweden | | Finland | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1970–92 | 1980–92 | 1970–92 | 1980–92 | 1970–90 | 1980–90 | 1970–91 | 1980–91 | 1970–93 | 1980–93 | 1972–94 | 1980–94 |
| Total Manufacturing | 1.02 | 1.04 | 1.04 | 1.04 | 1.14 | 1.07 | 0.97 | 0.99 | 1.08 | 1.08 | 1.07 | 0.97 |
| | *0.44* | *0.54* | *1.23* | *0.59* | *5.11* | *1.73* | *–1.00* | *–0.11* | *1.78* | *0.91* | *1.17* | *–0.27* |
| Food, Beverages & Tobacco | 1.04 | 1.02 | 1.11 | 1.12 | 1.14 | 1.13 | 1.01 | 0.96 | 1.02 | 1.07 | 0.99 | 0.93 |
| | *0.64* | *0.19* | *2.71* | *1.78* | *7.05* | *2.83* | *0.21* | *–0.65* | *0.54* | *1.17* | *–0.29* | *–0.89* |
| Textiles, Apparel & Leather | 0.84 | 0.92 | 1.05 | 1.06 | 1.15 | 1.12 | 0.94 | 0.99 | 1.03 | 1.00 | 1.05 | 0.98 |
| | *–2.50* | *–0.83* | *1.17* | *0.74* | *5.49* | *2.33* | *–1.50* | *–0.06* | *0.40* | *0.01* | *0.77* | *–0.19* |
| Wood Products & Furniture | 1.07 | 1.15 | 1.05 | 0.99 | – | – | 0.91 | 1.05 | 1.22 | 1.24 | 1.26 | 1.22 |
| | *1.52* | *2.01* | *1.18* | *–0.07* | – | – | *–1.75* | *0.73* | *3.26* | *2.23* | *2.60* | *1.39* |
| Paper, Products & Printing | 1.02 | 1.00 | 1.07 | 1.08 | 1.16 | 1.06 | 0.98 | 1.02 | 1.09 | 0.98 | 1.01 | 0.78 |
| | *0.30* | *–0.04* | *3.08* | *1.93* | *3.58* | *1.06* | *–0.42* | *0.24* | *1.23* | *–0.15* | *0.08* | *–1.41* |
| Chemical Products | 1.06 | 0.94 | 0.97 | 0.92 | 1.11 | 1.04 | 0.99 | 1.02 | 1.01 | 0.91 | 1.12 | 1.09 |
| | *1.23* | *–0.72* | *–0.63* | *–0.96* | *2.56* | *0.56* | *–0.23* | *0.54* | *0.25* | *–0.83* | *4.03* | *1.91* |
| Non–Metallic Mineral Products | 1.07 | 1.04 | 1.07 | 0.95 | 1.22 | 1.00 | 1.00 | 1.03 | 1.01 | 1.08 | 1.06 | 0.97 |
| | *1.01* | *0.28* | *1.27* | *–0.43* | *3.73* | *–0.02* | *0.00* | *0.23* | *0.19* | *0.64* | *0.81* | *–0.22* |
| Basic Metal Industries | 1.04 | 1.06 | 1.12 | 1.11 | 1.11 | 1.02 | 0.92 | 0.94 | 1.09 | 1.11 | 1.11 | 1.13 |
| | *1.09* | *0.82* | *1.41* | *0.66* | *1.98* | *0.25* | *–1.45* | *–0.43* | *1.13* | *0.93* | *1.81* | *1.24* |
| Fabricated Metal Products | 1.02 | 1.07 | 1.03 | 1.04 | 1.14 | 1.07 | 0.99 | 1.04 | 1.11 | 1.10 | – | – |
| | *0.58* | *1.42* | *0.87* | *0.57* | *4.75* | *1.89* | *–0.45* | *0.69* | *2.63* | *1.59* | – | – |
| Metal Products | 0.98 | 1.11 | 1.01 | 1.00 | 1.12 | 1.03 | 0.98 | 1.00 | – | – | – | – |
| | *–0.42* | *1.13* | *0.20* | *–0.01* | *1.36* | *0.44* | *–0.58* | *0.03* | – | – | – | – |
| Non–Electrical Machinery | 0.99 | 1.06 | 1.13 | 1.16 | 1.08 | 0.98 | 0.98 | 1.02 | – | – | – | – |
| | *–0.24* | *1.11* | *3.18* | *2.33* | *2.30* | *–1.16* | *–0.49* | *0.44* | – | – | – | – |
| Office & Computing Machinery | – | 0.84 | – | – | – | 0.71 | 0.98 | 1.04 | – | – | – | – |
| | – | *–1.14* | – | – | – | *–5.63* | *–0.21* | *0.76* | – | – | – | – |
| Electrical Machinery | 1.00 | 1.02 | 1.07 | 1.09 | 1.06 | 1.02 | 0.96 | 0.97 | – | – | – | – |
| | *–0.09* | *0.31* | *1.90* | *1.49* | *1.81* | *0.65* | *–0.87* | *–0.26* | – | – | – | – |
| Transport Equipment | 1.07 | 1.07 | 1.02 | 1.00 | 1.04 | 1.01 | 0.95 | 1.02 | – | – | 1.06 | 0.88 |
| | *1.09* | *1.35* | *0.33* | *0.03* | *1.90* | *0.20* | *–1.20* | *0.29* | – | – | *0.62* | *–0.90* |
| Other Manufacturing | 1.06 | 0.98 | – | – | 1.11 | 0.92 | 0.98 | 1.12 | – | – | – | – |
| | *0.50* | *–0.08* | – | – | *2.55* | *–1.10* | *–0.54* | *2.01* | – | – | – | – |

Table 4C. **Summary of results**

Constant rental price dr = 0Model R

| | Germany | | France | | Italy | | UK | | Sweden | | Finland | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1970–92 | 1980–92 | 1970–92 | 1980–92 | 1970–90* | 1980–90* | 1970–91 | 1980–91 | 1970–93 | 1980–93 | 1972–94 | 1980–94 |
| Total Manufacturing | 1.08 | 1.13 | 1.07 | 1.14 | 1.19 | 1.16 | 1.03 | 1.13 | 1.16 | 1.21 | 1.30 | 1.32 |
| | *2.35* | *2.33* | *2.02* | *2.21* | *10.34* | *7.07* | *1.28* | *3.13* | *4.89* | *4.52* | *5.06* | *4.41* |
| Food, Beverages & Tobacco | 1.12 | 1.20 | 1.17 | 1.26 | 1.17 | 1.22 | 1.06 | 1.09 | 1.06 | 1.12 | 1.17 | 1.10 |
| | *2.02* | *1.78* | *3.86* | *3.41* | *8.99* | *4.61* | *1.75* | *1.29* | *1.45* | *2.04* | *4.82* | *2.21* |
| Textiles, Apparel & Leather | 0.99 | 1.05 | 1.09 | 1.15 | 1.19 | 1.22 | 1.03 | 1.15 | 1.19 | 1.19 | 1.18 | 1.20 |
| | *–0.11* | *0.97* | *2.51* | *2.36* | *8.14* | *7.83* | *0.61* | *2.08* | *3.16* | *2.47* | *3.44* | *2.97* |
| Wood Products & Furniture | 1.14 | 1.23 | 1.10 | 1.22 | – | – | 1.00 | 1.15 | 1.36 | 1.34 | 1.91 | 1.58 |
| | *3.58* | *5.58* | *2.00* | *1.66* | – | – | *–0.08* | *3.39* | *6.70* | *5.28* | *7.89* | *5.49* |
| Paper, Products & Printing | 1.20 | 1.25 | 1.09 | 1.10 | 1.23 | 1.12 | 1.04 | 1.11 | 1.29 | 1.29 | 1.54 | 1.45 |
| | *3.48* | *2.09* | *4.23* | *2.78* | *6.04* | *2.62* | *0.99* | *1.84* | *4.75* | *2.81* | *5.49* | *4.45* |
| Chemical Products | 1.14 | 1.06 | 1.00 | 1.03 | 1.17 | 1.14 | 1.00 | 1.03 | 1.04 | 1.07 | 1.15 | 1.14 |
| | *2.80* | *0.68* | *–0.01* | *0.35* | *7.06* | *4.63* | *–0.07* | *0.79* | *1.19* | *0.69* | *4.64* | *3.38* |
| Non–Metallic Mineral Products | 1.25 | 1.37 | 1.18 | 1.32 | 1.34 | 1.12 | 1.17 | 1.29 | 1.19 | 1.29 | 1.41 | 1.33 |
| | *4.83* | *3.69* | *3.76* | *2.94* | *8.58* | *2.33* | *2.93* | *4.32* | *2.92* | *4.05* | *3.83* | *3.10* |
| Basic Metal Industries | 1.15 | 1.13 | 1.35 | 1.39 | 1.17 | 1.12 | 1.05 | 1.17 | 1.25 | 1.23 | 1.37 | 1.35 |
| | *5.16* | *3.32* | *4.94* | *3.85* | *4.10* | *2.43* | *1.37* | *2.40* | *3.97* | *3.73* | *7.27* | *5.74* |
| Fabricated Metal Products | 1.11 | 1.17 | 1.08 | 1.15 | 1.19 | 1.16 | 1.05 | 1.19 | 1.20 | 1.23 | – | – |
| | *2.07* | *3.02* | *1.88* | *1.99* | *8.43* | *7.48* | *1.37* | *2.95* | *5.65* | *4.91* | – | – |
| Metal Products | 0.99 | 1.24 | 1.07 | 1.11 | 1.31 | 1.22 | 1.06 | 1.16 | – | – | – | – |
| | *–0.24* | *2.25* | *1.52* | *1.27* | *3.43* | *3.56* | *1.74* | *3.45* | – | – | – | – |
| Non–Electrical Machinery | 1.08 | 1.14 | 1.18 | 1.27 | 1.10 | 0.98 | 1.04 | 1.08 | – | – | – | – |
| | *1.28* | *2.87* | *4.05* | *4.03* | *2.96* | *–0.81* | *1.09* | *2.72* | – | – | – | – |
| Office & Computing Machinery | – | 1.13 | – | – | – | 0.72 | 1.14 | 1.11 | – | – | – | – |
| | – | *0.81* | – | – | – | *–3.94* | *1.59* | *1.79* | – | – | – | – |
| Electrical Machinery | 1.03 | 1.22 | 1.07 | 1.17 | 1.08 | 1.06 | 1.07 | 1.44 | – | – | – | – |
| | *0.46* | *1.31* | *1.68* | *2.27* | *2.29* | *1.58* | *1.00* | *2.30* | – | – | – | – |
| Transport Equipment | 1.33 | 1.17 | 1.17 | 1.25 | 1.07 | 1.04 | 1.03 | 1.20 | – | – | 1.59 | 1.37 |
| | *4.30* | *2.45* | *2.22* | *1.85* | *2.84* | *1.16* | *0.48* | *1.91* | – | – | *3.66* | *1.66* |
| Other Manufacturing | 1.47 | 1.73 | – | – | 1.20 | 1.12 | 1.05 | 1.18 | – | – | – | – |
| | *3.06* | *2.31* | – | – | *8.94* | *2.39* | *1.19* | *3.57* | – | – | – | – |

Table 4D. **Summary of results**

Constant rental price dr = 0Model M

| | Germany | | France | | Italy | | UK | | Sweden | | Finland | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1970–92 | 1980–92 | 1970–92 | 1980–92 | 1970–90 | 1980–90 | 1970–91 | 1980–91 | 1970–93 | 1980–93 | 1972–94 | 1980–94 |
| Total Manufacturing | 1.06 | 1.09 | 1.07 | 1.11 | 1.17 | 1.15 | 1.02 | 1.10 | 1.11 | 1.15 | 1.08 | 1.11 |
| | *2.44* | *2.00* | *2.61* | *2.12* | *9.32* | *7.48* | *0.95* | *2.42* | *3.25* | *2.96* | *2.32* | *1.52* |
| Food, Beverages & Tobacco | 1.08 | 1.08 | 1.13 | 1.17 | 1.16 | 1.19 | 1.05 | 1.06 | 1.03 | 1.09 | 1.01 | 1.05 |
| | *1.67* | *0.83* | *3.91* | *2.78* | *9.60* | *4.78* | *1.50* | *1.12* | *0.97* | *1.62* | *0.48* | *1.37* |
| Textiles, Apparel & Leather | 0.90 | 0.99 | 1.07 | 1.10 | 1.17 | 1.20 | 0.99 | 1.08 | 1.08 | 1.09 | 1.07 | 1.04 |
| | *–1.89* | *–0.13* | *2.06* | *1.56* | *7.16* | *7.15* | *–0.27* | *1.14* | *1.23* | *1.04* | *1.37* | *0.46* |
| Wood Products & Furniture | 1.10 | 1.20 | 1.09 | 1.12 | – | – | 0.94 | 1.10 | 1.23 | 1.25 | 1.24 | 1.27 |
| | *3.07* | *4.32* | *2.60* | *1.38* | – | – | *–1.16* | *2.27* | *3.79* | *3.19* | *2.76* | *1.79* |
| Paper, Products & Printing | 1.09 | 1.07 | 1.10 | 1.12 | 1.18 | 1.12 | 1.03 | 1.08 | 1.15 | 1.11 | 1.06 | 1.02 |
| | *1.92* | *0.85* | *5.81* | *4.54* | *5.09* | *3.55* | *0.92* | *2.03* | *2.34* | *1.10* | *0.90* | *0.19* |
| Chemical Products | 1.09 | 0.98 | 1.00 | 1.00 | 1.15 | 1.13 | 1.00 | 1.03 | 1.03 | 0.98 | 1.11 | 1.10 |
| | *1.90* | *–0.20* | *–0.05* | *–0.03* | *5.70* | *3.95* | *–0.03* | *0.80* | *0.84* | *–0.24* | *4.06* | *2.13* |
| Non–Metallic Mineral Products | 1.15 | 1.18 | 1.13 | 1.16 | 1.28 | 1.11 | 1.09 | 1.19 | 1.08 | 1.20 | 1.10 | 1.13 |
| | *3.07* | *1.72* | *3.29* | *1.73* | *6.35* | *2.28* | *1.52* | *2.56* | *1.29* | *2.52* | *1.88* | *1.25* |
| Basic Metal Industries | 1.11 | 1.11 | 1.18 | 1.25 | 1.13 | 1.09 | 1.01 | 1.09 | 1.12 | 1.17 | 1.12 | 1.21 |
| | *2.97* | *2.17* | *2.25* | *2.06* | *2.97* | *1.72* | *0.18* | *1.03* | *1.61* | *2.16* | *2.15* | *2.52* |
| Fabricated Metal Products | 1.05 | 1.08 | 1.06 | 1.09 | 1.17 | 1.14 | 1.02 | 1.09 | 1.12 | 1.14 | – | – |
| | *1.56* | *2.39* | *1.88* | *1.60* | *7.58* | *7.28* | *0.61* | *1.47* | *3.57* | *2.78* | – | – |
| Metal Products | 0.99 | 1.12 | 1.04 | 1.06 | 1.16 | 1.21 | 1.03 | 1.11 | – | – | – | – |
| | *–0.30* | *1.35* | *1.31* | *1.01* | *1.80* | *2.99* | *1.00* | *2.22* | – | – | – | – |
| Non–Electrical Machinery | 1.01 | 1.07 | 1.15 | 1.20 | 1.09 | 0.99 | 1.01 | 1.06 | – | – | – | – |
| | *0.30* | *1.63* | *4.04* | *3.04* | *2.67* | *–0.64* | *0.44* | *2.05* | – | – | – | – |
| Office & Computing Machinery | – | 0.92 | – | – | – | 0.71 | 1.03 | 1.07 | – | – | – | – |
| | – | *–0.67* | – | – | – | *–5.16* | *0.37* | *1.21* | – | – | – | – |
| Electrical Machinery | 1.02 | 1.04 | 1.09 | 1.13 | 1.07 | 1.06 | 0.98 | 1.00 | – | – | – | – |
| | *0.71* | *0.65* | *2.95* | *2.95* | *2.23* | *1.65* | *–0.29* | *0.00* | – | – | – | – |
| Transport Equipment | 1.08 | 1.07 | 1.04 | 1.04 | 1.06 | 1.03 | 0.96 | 1.04 | – | – | 1.05 | 0.90 |
| | *1.49* | *1.84* | *0.75* | *0.53* | *2.65* | *1.23* | *–0.79* | *0.46* | – | – | *0.48* | *–0.67* |
| Other Manufacturing | 1.09 | 0.99 | – | – | 1.15 | 1.08 | 1.01 | 1.16 | – | – | – | – |
| | *0.84* | *–0.07* | – | – | *6.55* | *1.76* | *0.25* | *2.68* | – | – | – | – |

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