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THE SUPPLY SIDE IN THE ECONOMETRIC MODEL KOSMOS

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THE SUPPLY SIDE IN THE ECONOMETRIC MODEL KOSMOS

by

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INTRODUCTION[1]

This paper reports on the work with the supply side of the econometric model KOSMOS. The approach follows Kanis and Markowski [1990]. For each of the two private sectors, Industry and Other business, a production function is postulated. The demand for the two production factors, capital and labour, is then derived from this function. These relationships are assumed to hold only in the long run. The sectoral production function thus constitutes the implicit long run solution to both factor demand equations for the sector.

Following Kanis [1992], nested production functions are postulated. In each sector, the aggregate capital stock - which combines machinery and construction into one of the two production factors - is given by the inner function, which is either of the CES type or of the Leontieff type.

The estimated outer production functions are employed to assess the potential output in each sector.

Our approach to output determination is based on the assumption that supply decisions are taken separately from expenditure decisions. Industrial output is affected by demand and the relation between the actual and desired inventory stocks. In the short run, inventories constitute the buffer between demand and supply of industrial goods.

Inventory stocks are assumed to exist only in the industrial sector, 'Other business' being mainly a service sector. In the long run, inventory stock is determined by the desired stock/output ratio.

Output in 'Other business' is postulated to be equal to demand.

The paper is organised as follows. The remaining part of the introduction deals with some methodological questions. The results of the estimation of the inner production functions are reported in Chapter 1. The chapter starts with the theoretical model, followed by the empirical results. Factor demand equations are estimated in Chapter 2. In this chapter, Section 1 outlines the theoretical model. Estimation results for the factor demand equations in industry are shown in Section 2, the potential output and capacity utilisation are assessed in Section 3. Factor demand and potential output in 'Other

[1] We are indebted to Alfred Kanis and Lars-Erik Öller for comments on an earlier version of this paper.

business' are estimated in Sections 4 and 5, respectively. Chapter 3 defines the equation for output in industry and reports the estimation results for this equation.

Methodological considerations

The empirical results are affected by the bad quality of the data. As usual, data quality varies between variables, generally - however - consistent time series were available only beginning in 1980 (in some cases, such as fixed investment, beginning in 1985). The series were extended backwards to 1970, through splicing with older time series which differ in both definition and quality. In some cases, a striking change in the seasonal pattern can be noted. Further extension backwards was not possible on a semi-annual basis and - most probably - not meaningful, given the short-time character of the model.

The data were spliced at the lowest (most detailed) disaggregation level required by the model. More aggregated series were then obtained as sums of the spliced data. This approach includes an unavoidable element of arbitrariness, since different levels of disaggregation may lead to slightly different aggregated variables (such as the GDP).

The relatively small number of observations in the sample (at most 44) made statistical inference difficult and in the case of equations with many explanatory variables practically meaningless. The results of gradual reduction of general ADL (autoregressive, distributed lag) models, employed as the starting point in general-to-specific modelling (cf. Hendry [1993]), were often very much dependent on the order of reductions. We resorted then to direct testing of specific, theory-based and more sparsely parameterised models, thus testing a number of reductions at the same time. The final choice of equation was affected as much by considerations relating to the desired structure and simulation properties of the entire macroeconomic model as by the goodness of fit of the equation under scrutiny.

The relatively small sample size has also affected the choice of the estimation method. All equations were estimated using the method of ordinary least squares. OLS estimates of simultaneous equations are inconsistent but in really small samples - like ours - they proved to produce relatively reliable forecasting equations. On the other hand, instrumental variable methods - which in the case of a very large model are the only alternative to OLS - can result in poor forecasts due to low precision of the estimates when the instruments are only weakly correlated with the endogenous explanatory variable.

Furthermore, even a low correlation between those instruments and the error term in the equation can in this case result in large inconsistency of the instrumental variable estimates. Finally, in finite samples, instrumental variable estimates are biased in the same direction as the OLS estimates, with the bias increasing as the R^2 between the instruments and the endogenous explanatory variable approaches zero (cf. Bound, Jaeger and Baker [1993]).

It thus appears that it is crucial to identify instruments which are strongly correlated with the endogenous explanatory variable, in order to secure reliable small-sample estimates. However, when correlation between the instruments and the endogenous explanatory variable is high, the differences between OLS estimates and instrumental variable estimates tend to be very small.

CHAPTER 1. INNER PRODUCTION FUNCTIONS: AGGREGATION OF MACHINERY AND BUILDINGS

INTRODUCTORY REMARKS

The production functions in KOSMOS include the total capital stock, while the structure of the model requires a distribution of investment into machinery and buildings. Total capital stock is traditionally computed as a simple sum of real stocks of machinery and buildings. If these two types of capital are treated as factors of production, they can be aggregated using an inner production function which gives the total capital stock needed. The simple sum then corresponds to a linear production function with unit weights. Such a function implies an infinite elasticity of substitution (cf Evans [1969]), which in this case can be excluded in advance on theoretical grounds. However, even a fixed-proportion Leontief function, which implies zero elasticity of substitution, can be represented as a sum of the two factors, under the assumption that factor proportions are always optimal and that the relevant weights have suitable properties[2].

The inner function is here postulated, following Kanis [1992], to have a CES form. The fixed-proportion form can then be obtained as a special case, when the elasticity of substitution equals zero.

As can be seen in diagrams x.1 and x.3, the ratios of machinery stock to building stock in both industry and other business have been increasing over the past two decades in a trendwise manner. The rate of increase accelerated significantly in the 1980-ties. Since machinery and buildings to a large extent are complementary, only a relatively low degree of substitutability between them can be expected. Consequently, the steady increase in the stock ratios can hardly be explained by substitution due to the changes in the relations between machinery and building prices (cf diagrams x.2 and x.4). The trend in the stock ratios, which calls for a trend variable in the inner production function, should rather be attributed to technical development and - partly - to shifts in the composition of total production (in particular, new productive sectors).

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[2] In a Leontief function $K=\min(\alpha KM, \beta KB)$, where KM = machinery, KB = buildings and K = aggregate capital stock. Given the optimal proportion between KM and KB, $K=\alpha KM$ and $K=\beta KB$ and thus $KM=(\beta/\alpha)KB$. Consequently, $KM+KB=\{(\alpha+\beta)/(\alpha\beta)\}K$. $KM+KB=K$ if e.g. $\alpha=(KM+KB)/KM$ and $\beta=(KM+KB)/KB$.

Diagram x.1 Real capital stocks in industry

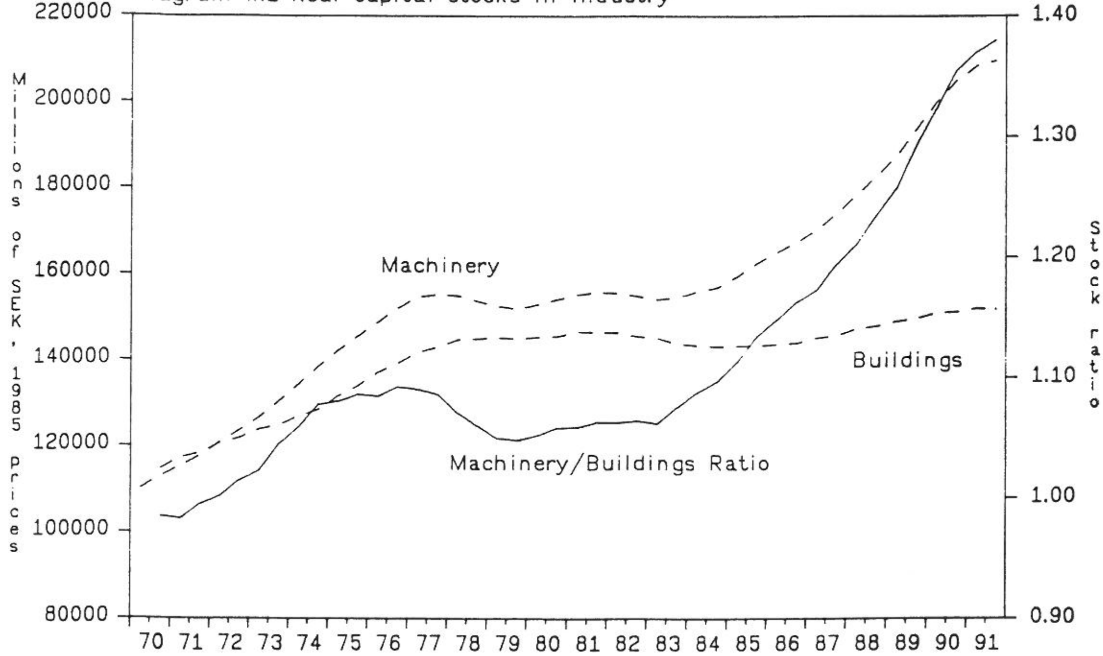


Diagram x.2 Rental cost of capital in industry

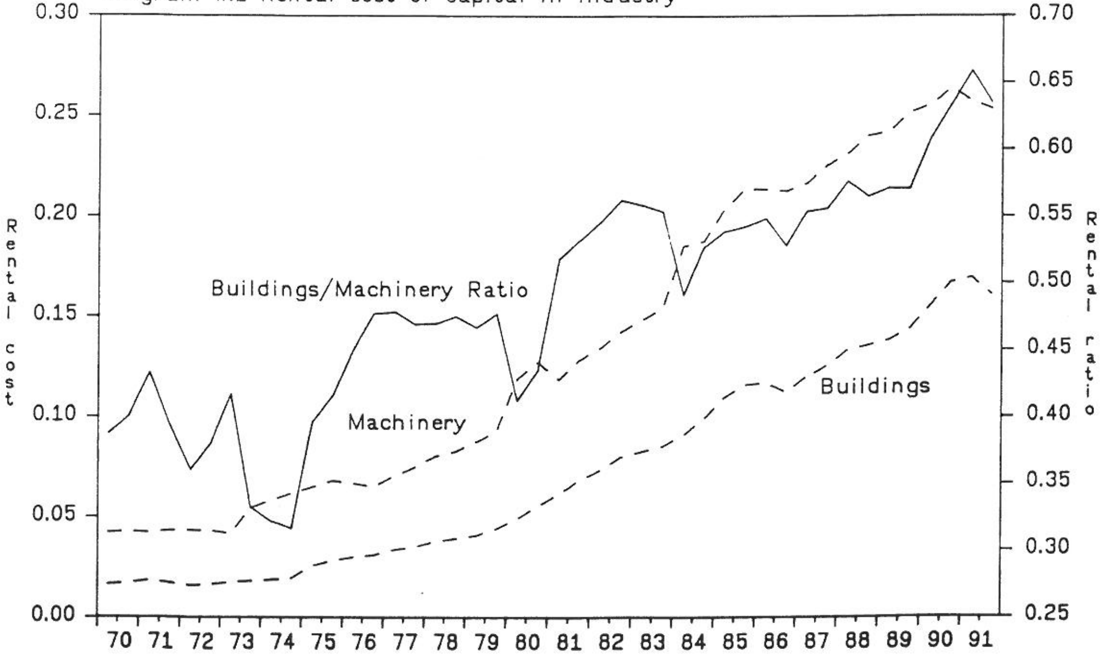


Diagram x.3 Real capital stocks in other business excl permanent housing

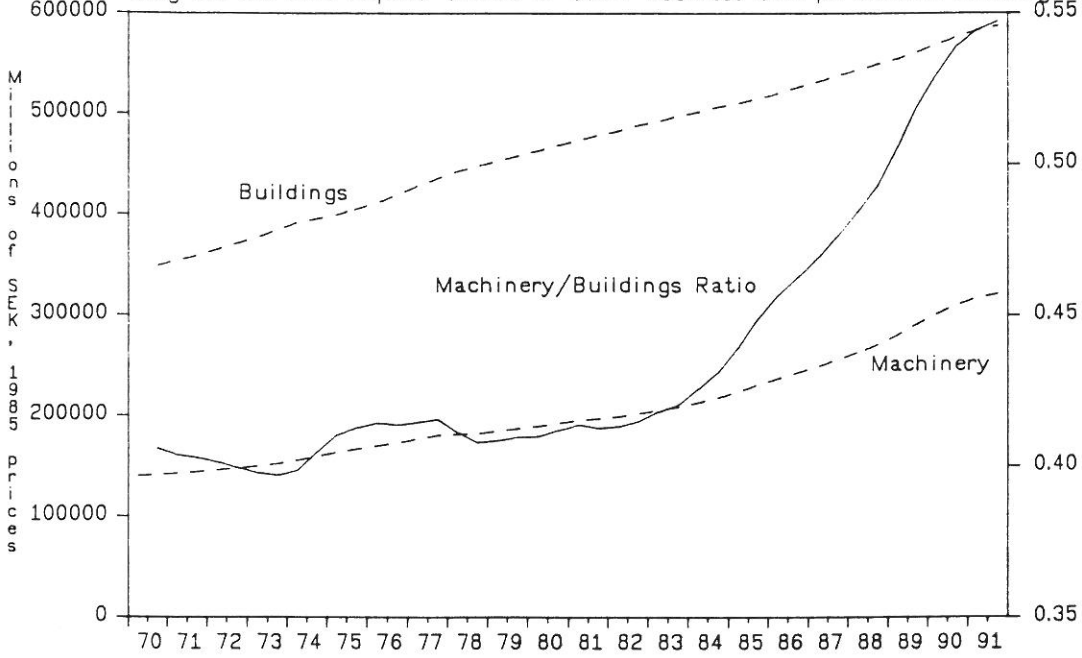
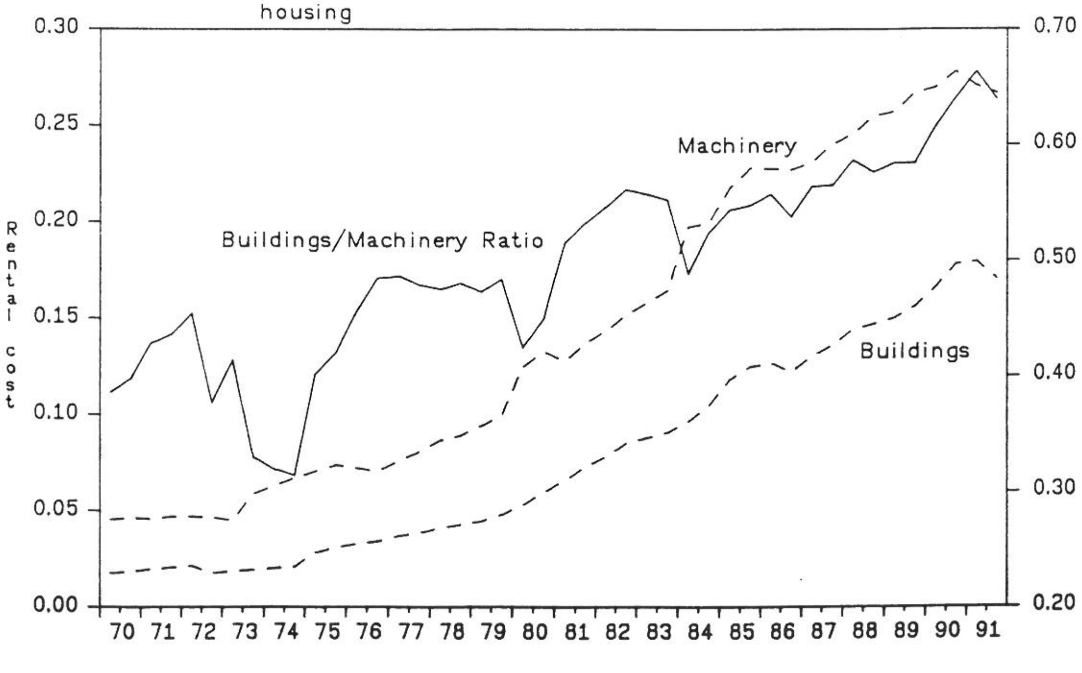


Diagram x.4 Rental cost of capital in other business excl permanent housing



The model

The inner production function, postulated here, combines machinery and buildings into the aggregate capital stock:

$$(K.1) \quad K = g^*\{\delta^*KM^{-r} + (1-\delta)^*(KB^*h)^{-r}\}^{-1/r},$$

where K - real productive capital, KM - real stock of machinery and equipment, KB - real stock of buildings and construction, h - efficiency index for buildings, g, δ, r - parameters, σ - elasticity of substitution ($\sigma = 1/(1+r)$) and * denotes multiplication.

Constant returns to scale are assumed. The efficiency index, h, reflects "buildings-augmenting" technical progress, i.e. technological development which results in an increased volume of machinery per unit of buildings capital. This could be due to less bulky machinery or to computerisation of the production process.

Given a desired value for K, the cost-minimizing ratio of machinery to buildings is obtained, following the standard procedure, as a ratio of two marginal conditions. In logarithmic form:

$$(K.2) \quad \ln(KM/KB) = \ln[\delta/(1-\delta)]^{\sigma} + \sigma^*\ln(PB/PM) + (1-\sigma)^*\ln(h),$$

where PB - rental cost of buildings capital, PM - rental cost of machinery capital.

Assuming $h=\exp(h_1T)$, where T is a time trend, the parameters σ, δ and h_1 can be estimated from the equation:

$$(K.3) \quad \ln(KM/KB) = z_0 + z_1^*\ln(PB/PM) + z_2^*T$$

The parameter σ, which is expected to be far below 1, is equal to z_1, while $h_1=z_2/(1-z_1)$ and $\delta=z/(1+z)$, where $z=\exp(z_0/z_1)$.

Finally, following Kanis [1992], the scale parameter g can be obtained from the arbitrary condition that the mean value of the CES aggregate should equal that of the simple sum of machinery and building stocks:

$$(K.4) \quad g = \text{Mean}(KB+KM)/\text{Mean}\{ [\delta^*KM^{-r} + (1-\delta)^*(KB^*h)^{-r}]^{-1/r} \}.$$

Since the inner and outer production functions are postulated to hold only in the long run, equation (K.3) is estimated as the long-run condition in the equation for the share of machinery investment in total investment[3]. The distribution of investment between machinery and buildings is assumed to be affected by the distance of the actual stock ratio from the optimal one:

$$\text{(K.5)} \qquad ma\text{-}ma^{+} = f[(ma\text{-}ma^{+})_{-i}, (km\text{-}kb)_{-i}, (pb\text{-}pm)_{-i}, T],$$

where MA - share of machinery in total investment, MA^{+} - mean value for MA and lower-case letters denote logarithms.

The dependent variable and the lagged dependent variable are expressed as deviations from their respective sample mean values in order to make it possible to interpret the intercept of the regression as part of the long-run solution. This is necessary for the calculation of the CES distribution parameter δ.

EMPIRICAL RESULTS.

The regression results and exact variable definitions are given in Table 1. The preferred equations for industry and other business, respectively, are given there as equation (1) and (2). In the latter case, the elasticity of substitution was not significantly different from zero and the distribution equation was thus reduced to a simple autoregressive scheme.

The actual and fitted values for the preferred equation for industry (equation (1)) are depicted in diagram x.5. The general fit of the equation is not very good, with the standard error of estimate round 0.023. The outside-sample forecasts for the last two years together with the actual and fitted values from the same equation estimated over a shorter period of time are shown in diagram x.6. As can be seen, the predictive accuracy is not too good. Still, the Chow test does not indicate the possibility of a structural break at the beginning of the forecast period.

Despite its somewhat poor fit, the equation appears to be an adequate tool for tracing the level of machinery investment. This can be seen in diagram x.7, where the actual values for machinery investment in industry are depicted together with those computed using the fitted machinery investment shares from equation (1). The calculated machinery investment is remarkably little affected by the errors of equation (1).

[3] See Kanis [1992] for an alternative approach.

Diagram x.5 Actual and fitted values for equation (1) in table x.1.

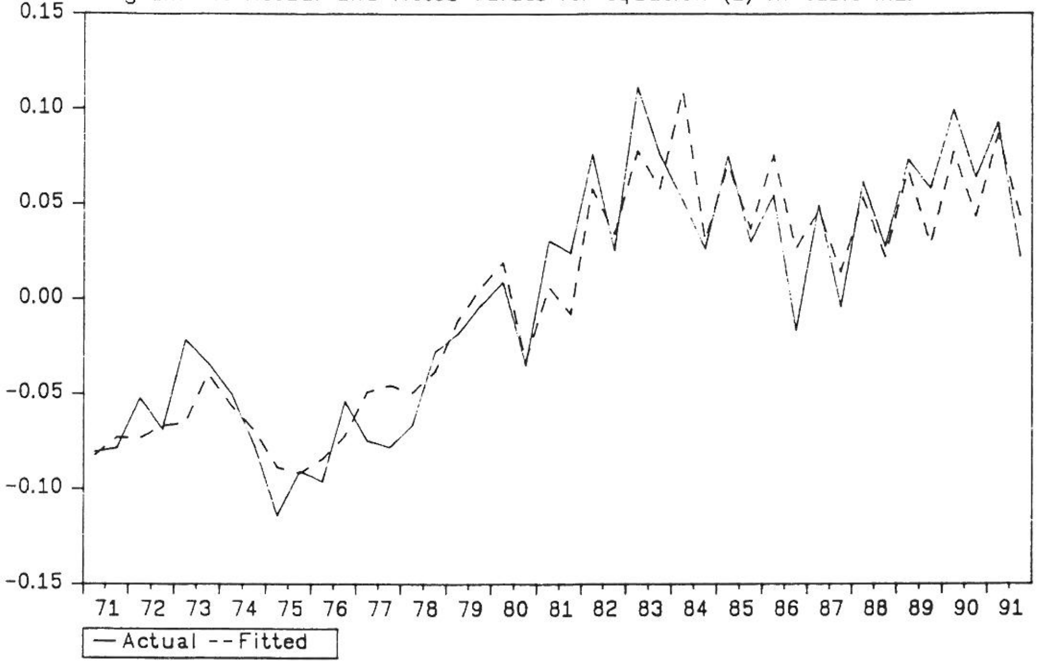
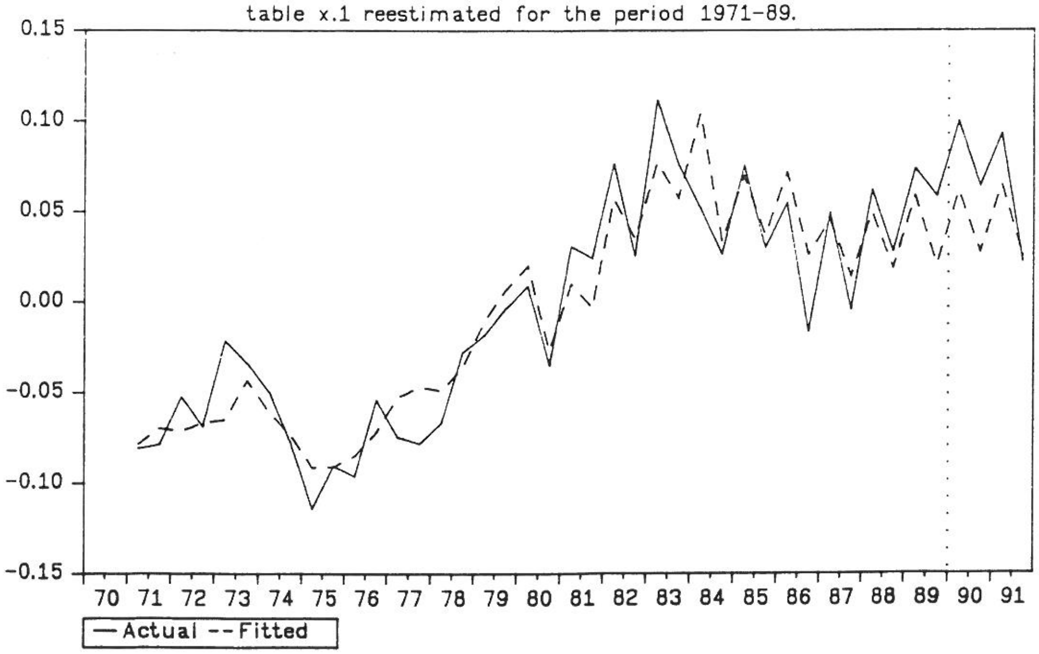


Diagram x.6 Outside-sample forecast for 1990-91 from equation (1) in table x.1 reestimated for the period 1971-89.



Equation (1) implies the following long-run (static) solution:

(6) kmi-kbi = 0.2796*(pbi-pmi) + 0.0099*T + 0.1244 - 0.1814*D80*S2,

where S2 is a seasonal dummy equal to 1 in the second half-year, 0 otherwise, and D80 is a dummy variable equal to 1 from 1980 onwards.

The parameters of the inner CES function for industry are:

$\sigma = .28, \ \delta = .53, \ h_1 = .0137, \ g = 1.73.$

The elasticity of substitution, σ, is relatively small, as expected. The time trend is fairly strong, approximately 2.7% *per annum*.

The aggregate capital stock in industry, computed using the CES function estimated above, is depicted in diagram x.8 together with the conventional sum of machinery and building stocks. The difference between the two aggregates stems mainly from the trend variable included in the CES function.

In other business, the elasticity of substitution between machinery and buildings was not significantly different from zero. In the equation reproduced in Table 1 (equation (3)), the price variable has the wrong sign and there is no significant relation between the stock ratio and the price ratio. The stock ratio becomes significant when the elasticity of substitution is set to zero (equation (4)).

This result implies that the elasticity of substitution between machinery and buildings in other business is even lower than that in industry. This appears to be intuitively acceptable, since buildings probably play a more prominent role in the production of services (in direct contact with customers) than in the production of industrial goods.

Given the zero elasticity of substitution, the CES function collapses to a Leontief function. The aggregate capital stock is here then computed as a simple sum of machinery and buildings (cf diagram x.12), under the assumptions mentioned above. Since one of those asumptions is that the proportions between machinery and buildings are always optimal, the error-correction term disappears in the equation for the share of machinery investment in total investment and the equation is reduced to an autoregressive scheme (cf equation (2) in Table 1). An alternative approach is to relax the optimality assumption for the short run and to include it as the long-run condition.

Diagram x.7 Actual and calculated gross fixed investment in machinery for industry, millions of SEK, 1985 prices.

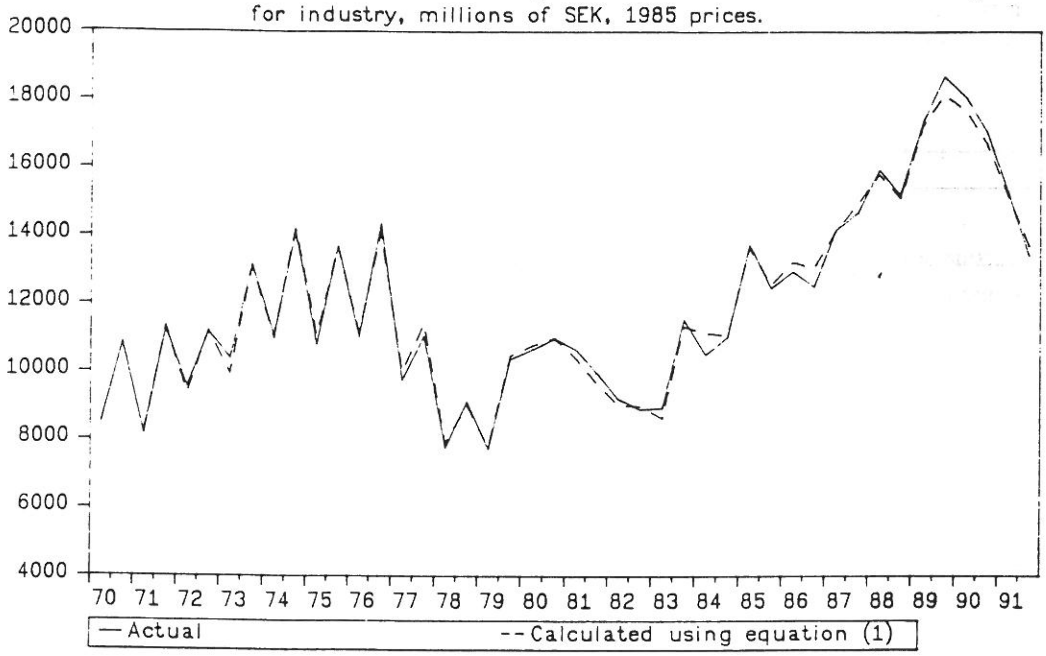
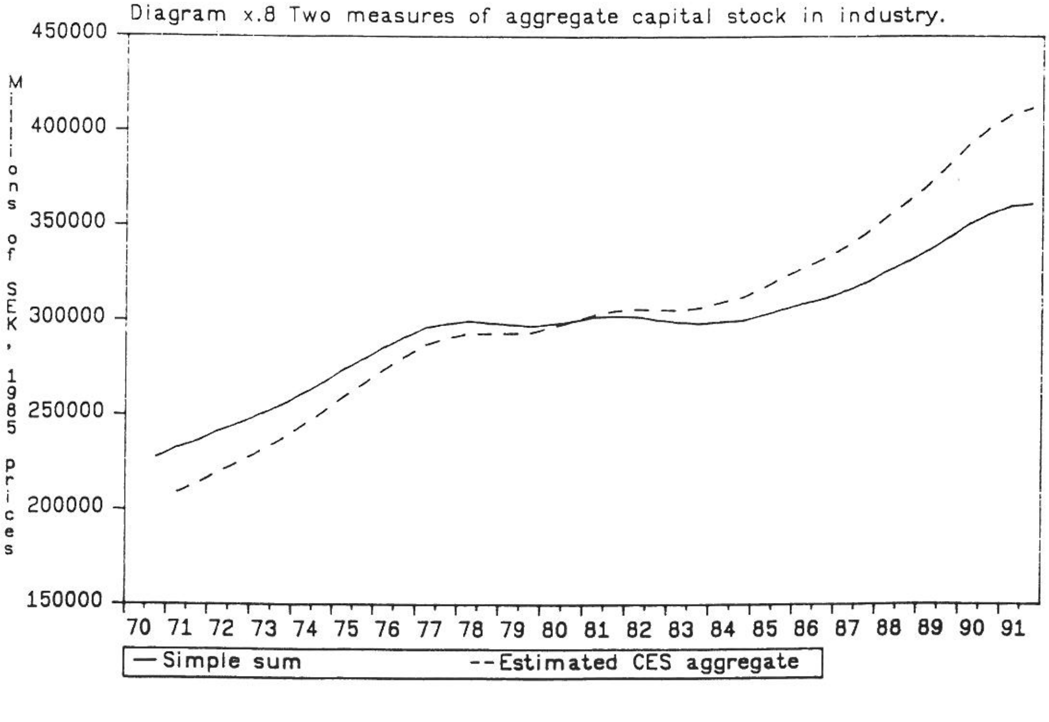


Diagram x.8 Two measures of aggregate capital stock in industry.



This is illustrated in equation (4) in Table 1, where the stock ratio in the long run is only affected by an exogenous trend. While a Leontief function is characterised by a constant stock ratio, the trend in it should be interpreted in the same way as its counterpart for industry.

The preferred equation, equation (2), was estimated over the last decade only, as it is not sophisticated enough to explain the apparent change in the pattern between the 1970-ties and the 1980-ties. The actual and fitted values are given in diagram x.9 and the outside-sample forecasts in diagram x.10. As in the case of industry, the fit of the equation does not appear to be very good (cf diagram x.9), but the machinery investments calculated using the fitted values from equation (2) seem to trace the actual investments adequately (cf diagram x.11).

Diagram x.9 Actual and fitted values for equation (2) in table x.1.

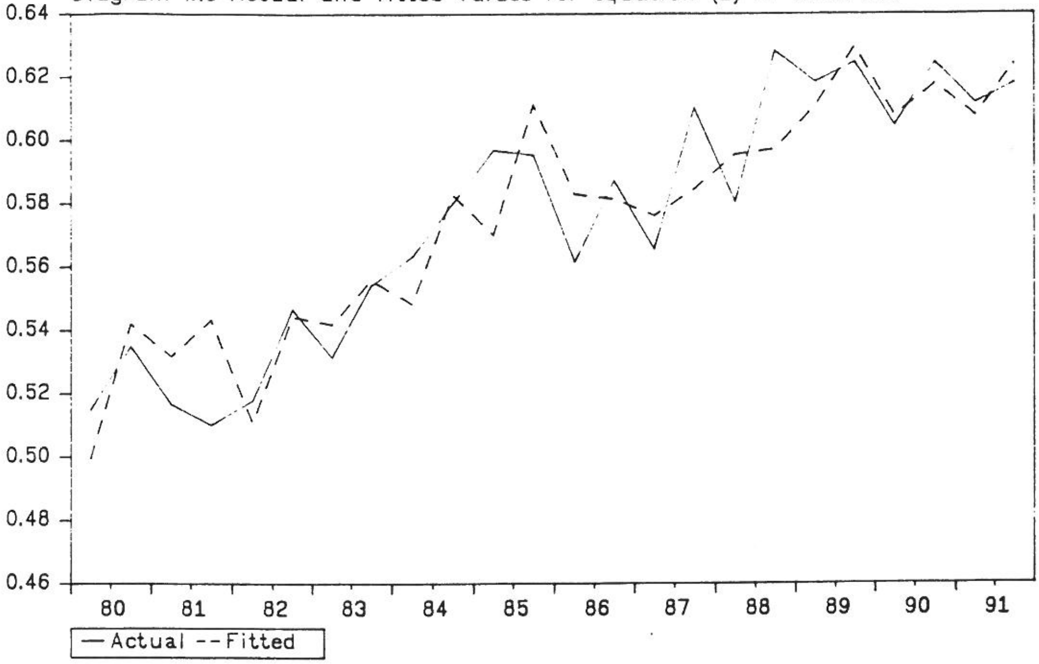


Diagram x.10 Outside-sample forecast for 1990-91 from equation (2) in table x.1 reestimated for the period 1980-89.

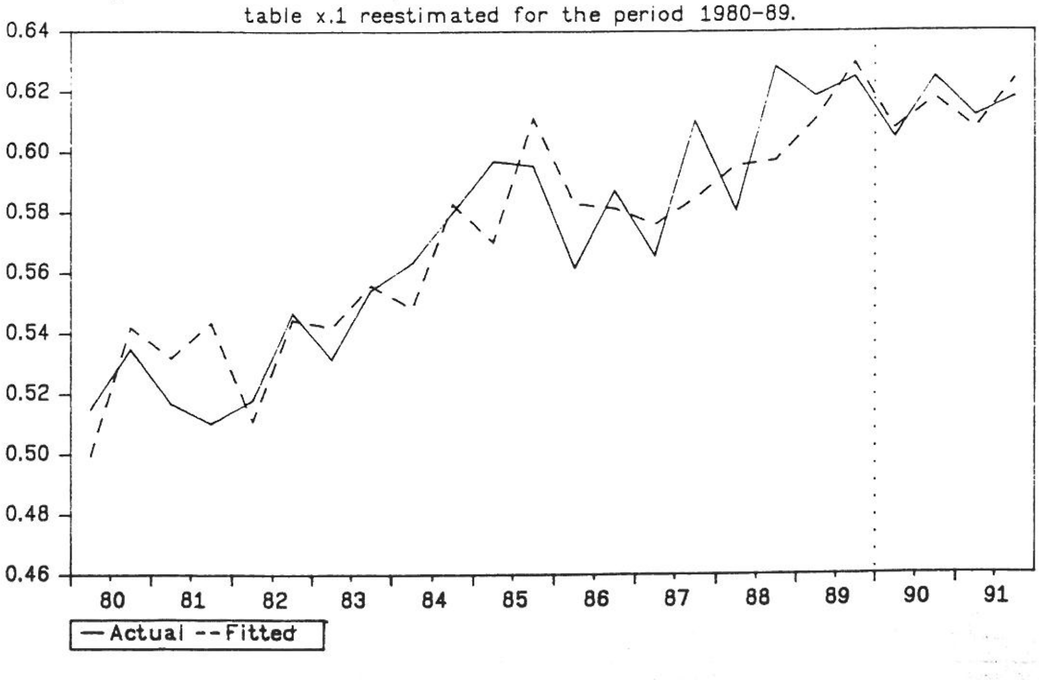


Diagram x.11 Actual and calculated gross fixed investment in machinery for other business, millions of SEK, 1985 prices.

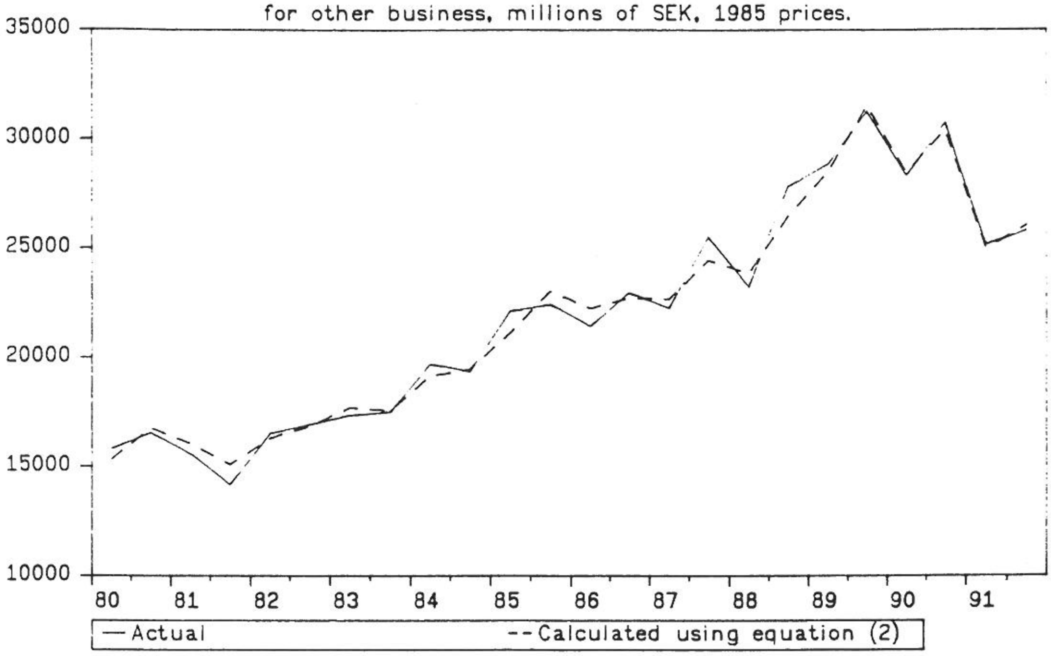


Diagram x.12 Aggregate capital stock in other business calculated as the sum of buildings and machinery stocks.

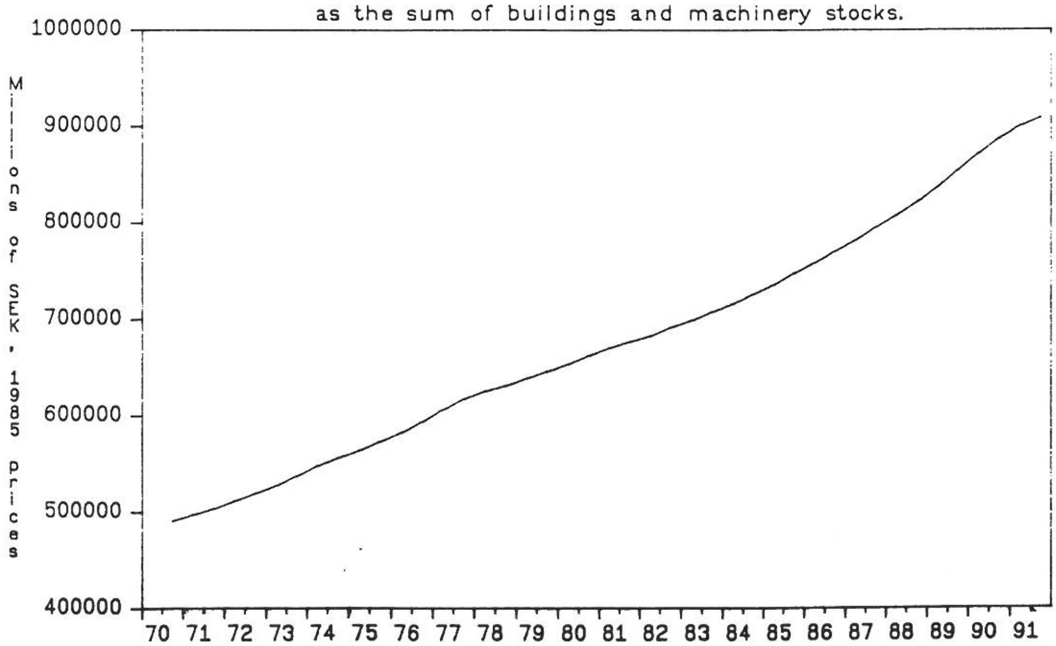


Table 1 Regression equations for the share of machinery investment in total investment[a,b,c]

Eq number	(1)	(2)	(3)	(4)
Dep var	mai-mai$^+$	MAO	mao-mao$^+$	mao-mao$^+$
Est per	71:1-91:2	80:1-91:2	71:2-91:2	80:1-91:2
Dep var$_{-1}$	0.453 (2.782)	0.847 (10.215)	0.220 (1.330)	0.251 (1.163)
Dep var$_{-2}$	0.217 (1.515)			
kmi$_{-1}$-kbi$_{-1}$	-0.280 (2.780)			
kmo$_{-1}$-kbo$_{-1}$			0.038 (0.271)	-0.371 (1.653)
pbi$_{-1}$-pmi$_{-1}$	0.078 (1.730)			
pbo$_{-1}$-pmo$_{-1}$			-0.228 (2.765)	
TREND	0.0028 (2.034)		0.0084 (4.180)	0.0113 (2.632)
D80*S2	-0.0508 (3.735)			
S2		0.0269 (4.012)	0.0187 (1.530)	0.0304 (2.655)
const	0.0348 (0.663)	0.0789 (1.649)	-0.3390 (2.227)	-0.6743 (2.211)
N	42	24	42	24
R^2	0.888	0.843	0.873	0.895
SE	0.0227	0.0163	0.0391	0.0247
DW	1.59	2.33	1.95	1.73
AR2	6.29	1.94	1.31	4.97
Chow	0.886 F(4, 32)	0.083 F(4, 17)	0.126 F(4, 32)	0.282 F(4, 15)

See next page for notes.

Notes to Table 1:

[a] The equations were estimated with the method of ordinary least squares. t-values are given in parenthesis.
[b] Variable names in lower case denote logarithms.
[c] All the variables are expressed in millions of kronor, 1985 prices, unless otherwise stated.

MAI - IMIND/(IMIND+IBIND),
MAI^+ - mean of MAI,
IMIND - gross fixed investment in machinery, industry,
IBIND - gross fixed investment in buildings, industry,
MAO - IMOVR/(IMOVR+IBOVR),
MAO^+ - mean of MAO,
IMOVR - gross fixed investment in machinery, other business,
IBOVR - gross fixed investment in buildings, other business,
KMI - stock of machinery capital in industry,
KBI - stock of buildings capital in industry,
KMO - stock of machinery capital in other business,
KBO - stock of buildings capital in other business,
PMI - rental cost of machinery capital in industry,
PBI - rental cost of building capital in industry,
PMO - rental cost of machinery capital in other business,
PBO - rental cost of building capital in other business,
TREND - time trend, equal to 1 in 1970:1,
S2 - seasonal dummy equal to 1 in the second half-year, 0 otherwise,
D80 - dummy equal to 1 from 1980 onwards, otherwise zero,
CONST - the equation's intercept,
N - number of observations in the regression,
R^2 - coefficient of determination,
SE - equation standard error,
AR2 - Lagrange multiplier test for residual autocorrelation of first and second order,
Chow - F-test for stability of the regression, degrees of freedom are given in parenthesis,
Z_{-i} - variable Z lagged by i periods.

CHAPTER 2. FACTOR DEMAND AND POTENTIAL OUTPUT IN INDUSTRY AND OTHER BUSINESS

THE MODEL[4]

The approach employed here follows Kanis and Markowski [1990]. A sectoral production function is postulated. This function is of nested CES type and includes two factors of production: capital, K, and labour, L. The inner production function aggregates machinery and buildings into the total capital stock, K, (cf. the previous chapter). The outer function has the well-known form:

(X.1) $Q = g[\delta K^{-r} + (1-\delta)L^{-r}]^{-n/r}$,

where Q is real output; n is the degree of homogeneity (n=1 means constant returns to scale); g is a scale parameter that can be used to describe neutral technical change; δ describes to what extent the production process is capital intensive and r is the substitution parameter such that the elasticity of substitution between capital and labour, σ, equals

(X.2) $\sigma = 1/(1+r)$.

The scale parameter, g, is assumed to incorporate neutral technical progress:

(X.3) $g = g_0 e^{g_1 t}$,

where t is time trend.

An alternative approach is to define technical change as purely labor-augmenting (Harrod-neutral) and to express the labour input in efficiency units as:

(X.4) $L = g_2 e^{g_3 t} E$,

where E is employment (hours).

The production function (X.1) can be estimated directly, upon multiplication of the factor inputs by some capacity utilization measures, or from the marginal conditions, which is the approach chosen below.

[4] This section draws partly on Kanis and Markowski [1990], Section 4.

The producers are assumed to perceive factor prices and the price of output as given. Prices are determined in the respective market and producers cannot affect them through their decisions. Assuming profit maximisation, we obtain the marginal productivity conditions[5]:

$$(X.5)\quad Q_K = n\delta\, g^{-r/n}\, Q^{1+r/n}\, K^{-(1+r)} = c/p\,,$$

$$Q_L = n(1-\delta)\, g^{-r/n}\, Q^{1+r/n}\, L^{-(1+r)} = w/p\,,$$

where p is output price, c is the price of capital services, w is the price of labour and Q_K, Q_L are the partial derivatives of Q with respect to K and L, respectively.

Solving for K and L, respectively, and allowing for technical progress we get in the case of neutral technical change[6] (cf equation (X.3)):

$$(X.6)\quad K = (c/p)^{-\sigma}\, Q^{\sigma(1+r/n)}\, e^{[(\sigma-1)/n]g_1 t}\, [n\delta\, g_0^{-r/n}]^{\sigma}\,,$$

$$L = (w/p)^{-\sigma}\, Q^{\sigma(1+r/n)}\, e^{[(\sigma-1)/n]g_1 t}\, [n(1-\delta)\, g_0^{-r/n}]^{\sigma}\,,$$

and in the case of labor-augmenting technical change (cf equation (X.4)):

$$(X.7)\quad K = (c/p)^{-\sigma}\, Q^{\sigma(1+r/n)}\, (n\delta\, g^{-r/n})^{\sigma}\,,$$

$$L = (w/p)^{-\sigma}\, Q^{\sigma(1+r/n)}\, e^{(\sigma-1)g_3 t}\, [n(1-\delta)\, g_2^{-r}\, g^{-r/n}]^{\sigma}\,.$$

Equations (X.6) (or (X.7)) define the profit-maximising real demand for the factors of production. They are thus postulated to constitute the long-run solutions to our factor demand equations. In the short run, factor inputs can differ from the optimal ones, due to adjustment costs.

The volume of output, Q, is in this context an endogenous variable, controlled by the producers. In equations (X.6) and (X.7) it is subject to the technological constraint, i.e. it is equal to the output from the production function with inputs K and L as defined by (X.6) or (X.7), respectively.

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5 Cf. Wallis [1973].

6 Note the printing error in Kanis and Markowski [1990], equation (10).

In the short run, demand for capital is affected by the variation in output, real cost of capital services (c/p) and relative yield (RYIELD). The latter variable reflects the profitability of real production in relation to the profitability of alternative uses of capital, e.g. financial investment.

Demand for labour is in the short run affected by the variation in output and in real labour cost (w/p).

The equations to be estimated have the error-correction form:

$$\text{(X.8)} \quad DlnK = -a_4[lnK_{-1} - a_0 - a_1 ln(c/p)_{-1} - a_2 lnQ_{-1} - a_3 t] + \Sigma a_{5,i} Dln(c/p)_{-i} + \Sigma a_{6,i} DlnQ_{-i} + \Sigma a_{7,i} DlnK_{-i} + \Sigma a_{8,i} ln(RYIELD_{-i}),$$

$$\text{(X.9)} \quad DlnL = -b_1[lnL_{-1} - b_0 - a_1 ln(w/p)_{-1} - a_2 lnQ_{-1} - a_3 t] + \Sigma b_{2,i} Dln(w/p)_{-i} + \Sigma b_{3,i} DlnQ_{-i} + b_{4,i} DlnL_{-i},$$

where a_i, $a_{j,i}$, b_i, $b_{j,i}$ denote coefficients, $lnX = log(X)$ and $DlnX = log(X) - log(X_{-1})$.

Equations (X.8)-(X.9) correspond to model (X.6) above. When model (X.7) is estimated, equation (X.8) has no trend term.

The coefficients a_0, a_1, a_2, a_3 and b_0, a_1, a_2, a_3 give the long-run solutions[7] to equations (X.8) and (X.9), respectively. It should be noted that the coefficients a_1, a_2 and (in the case of model (X.6)) a_3 are common to both equations. They define the parameters of the production function in accordance with (X.6) or (X.7):

$$\text{(X.10)} \quad \sigma = -a_1,$$

$$n = (1 - \sigma)/(a_2 - \sigma),$$

$$g_1 = -n\, a_3/(1 - \sigma) \quad \text{for model (X.6)},$$

$$g_3 = -a_3/(1 - \sigma) \quad \text{for model (X.7)}.$$

[7] The long-run solutions are shown explicitly (with a negative sign) in equations (X.8) and (X.9). The estimated form is obtained upon multiplying $-a_4$ and $-b_1$ by the terms in the respective square bracket.

The coefficient a_2 equals 1 in the case of constant returns to scale.

Neither g and g_2 (g_0), nor δ need actually to be known in order to compute the potential output, O, given by the production function derived from the long-run solutions to equations (X.8) and (X.9). From (X.1) and (X.4) :

$$\text{(X.11)} \quad O^{-r/n} = g^{-r/n}\,\delta\,K^{-r} + g_2^{-r}\,g^{-r/n}\,(1-\delta)\,(e^{g_3 t}\,E)^{-r}$$

$$= v_1\,K^{-r} + v_2\,(e^{g_3 t}\,E)^{-r}\,.$$

Since a_0 and b_0 are equal to the logs of the respective intercepts of the two equations in (X.7):

$$\text{(X.12)} \quad a_0 = \log[\,(n\delta\,g^{-r/n})^{\sigma}\,]\,,$$

$$b_0 = \log\{\,[n(1-\delta)\,g_2^{-r}\,g^{-r/n}]^{\sigma}\,\}\,,$$

it can be easily seen that:

$$\text{(X.13)} \quad v_1 = g^{-r/n}\,\delta = [\exp(a_0/\sigma)]/n \qquad \text{and}$$

$$v_2 = g_2^{-r}\,g^{-r/n}\,(1-\delta) = [\exp(b_0/\sigma)]/n.$$

Because the intercepts in equations (X.8) and (X.9) are not invariant with respect to the units of measurement, it is important that the units of measurement of the variables involved are conform with the original profit identity.

FACTOR DEMAND IN INDUSTRY

The factor demand equations were estimated under the assumption of labor-augmenting technical change (model (X.7)), since in all the preliminary attempts to estimate the investment equation alone, the trend variable had the wrong sign ($a_3 > 0$).

The output was represented by real value added and the output price by the value added implicit deflator. The cost of labour was defined as the wage rate plus employers' contributions. The wage rate was obtained as the ratio of the wage cost bill (*kostnadslönesumma*) to employment in hours (cf the appendix).

The capital stock was obtained from the inner production function as a CES-aggregate of buildings and machinery (cf Chapter 1). The capital stocks for machinery and buildings were computed as mid-period stocks under the assumption that the average lag between an investment outlay and the moment this investment becomes productive is six months for constructions and three months for machinery[8].

The simple sum of buildings and machinery (together with the corresponding rental cost) was tested in the investment function as an alternative to the CES aggregate. The latter proved to have a higher explanatory power in the equation.

In order to ensure comparability with the annual stock/flow ratios, in estimation of the investment function, which is semi-annual, the capital stock was divided by 2.

The cost of capital services was obtained from the capital rental rates computed in Markowski and Persson [1993]. Capital rentals for machinery and buildings were aggregated using the inner production function mentioned above. These capital rental rates, based on Jorgenson's neoclassical approach (cf Jorgenson [1965]), correspond to the wage rate in that they reflect the cost of the services of one unit of capital over one unit of time.

Relative yield was defined as the ratio of the yield on fixed assets to the interest rate on five-year government bonds (cf the appendix). A profitability measure, defined as the ratio of "extraordinary" profits after tax to value added (cf the appendix), was introduced in addition to the former variable, but it did not improve the explanatory power of the equation, probably due to high collinearity with the relative yield.

The dependent variable in equation (X.8) is

$$(X.14) \quad DlnK = \log(K) - \log(K_{-1}) \approx (K - K_{-1})/K_{-1},$$

i.e. approximately the ratio of net investment to the previous period's capital stock. The dependent variable in the estimated investment equation was defined as the corresponding ratio for gross investment:

---

8 $KBINDM = IBIND_{-1} + (1 - DBINDM)*KBINDM_{-1}$,
$KMINDM = 0.5*IMIND + 0.5*IMIND_{-1} + (1 - DMINDM)*KMINDM_{-1}$,
where KBINDM, KMINDM are the mid-period capital stocks for industrial buildings and machinery, respectively, and IBIND, IMIND and DBINDM, DMINDM are the corresponding pairs of investment flows and depreciation coefficients. The depreciation coefficients were derived from the capital stocks in Hansson [1991] using the perpetual inventory formula and the benchmark values for 1969:2 and 1986:2. Cf Sterte [1990].

(X.15) $\mathrm{DlnKci} = \log(1 + \mathrm{INVG}/K_{-1}) \approx (K-K_{-1} + d^{*}K_{-1})/K_{-1}$

$\approx \mathrm{DlnK} + d,$

where INVG denotes real gross fixed investment and d the depreciation rate. Thus, the intercept in the estimated investment equation includes the depreciation rate, which has to be subtracted before the intercept estimate is employed for computation of the production function parameters.

The main problem with estimation of equations (X.8)-(X.9) was the imposition of the common long-run coefficients. When estimated separately, the investment equation (without the trend term) implied a relatively high elasticity of substitution and a low degree of homogeneity in the production function ($\sigma=0.5$, $n=0.3$). The results were radically reversed in the employment equation, where we obtained $\sigma=0.01$ and $n=1$. The estimate of the returns-to-scale coefficient in the employment equation ($n=1$) was stable and highly significant. The elasticity of substitution was more difficult to estimate in this equation, since the relative price variable (w/p) was collinear with the trend. The long-run trend estimate was 1.24% per half-year.

Simultaneous estimation of the two equations with cross-equation constraints - using the non-linear least squares method in PC TSP, Version 4.2[9] - gave similar results as free estimation of the employment equation: $\sigma=0.035$ and $n=1$. The same results were obtained when the full information maximum likelihood algorithm from the same package was employed.

While the result concerning constant returns to scale appeared to be firmly established, the elasticity of substitution, which was practically zero, was difficult to reconcile with our view of the industry's response to the high labour costs of the early 1980-ies. The latter coefficient was, furthermore, not significant.

We ended up by imposing on both equations $\sigma=0.33$ and $n=1$. The value of the elasticity of substitution was chosen through casual scanning, starting from a mixture of our prejudice and the value obtained from the investment equation. Estimating each equation with ordinary least squares gave then the following results:

---

[9] Cf Hall [1991].

(X.16)

dlnkci

$$= 0.26049 * \text{dlnkci}_{-2}$$
(3.92127)

$$- 0.06185 * [\log(\text{kci}_{-1}) - \log\text{Qima}_{-1} + .33*\log(\text{cci}_{-1}/\text{pi}_{-1})]$$
(5.17795)

$$+ 0.05862 * \text{dlog}(\text{qi}_{-1}) + 0.20944 * \log(\text{rci}_{-2})$$
(2.49066) (7.93213)

$$- 0.00900 * \text{D1}*(1-\text{D80}) + 0.07115$$
(2.36262) (10.6006)

Sum Sq 0.0011 Std Err 0.0059 LHS Mean 0.1004
R Sq 0.9341 R Bar Sq 0.9241 F 5, 33 93.5316
D.W.(1) 1.4568 D.W.(2) 1.9031 Est.per. 72:2-91:2

(X.17)

dlog(li)

$$= - 0.70359 * \text{dlog}(\text{li}_{-1})$$
(15.7950)

$$- 0.39592 * [\log(\text{li}_{-1})-\log(\text{qi}_{-1})+.33*\log(\text{wci}_{-1}/\text{pi}_{-1})]$$
(7.95596)

$$- 0.00356 * T + 0.33663 * \text{dlog}(\text{qi}) - 1.21881$$
(7.08828) (6.59089) (8.07936)

Sum Sq 0.0045 Std Err 0.0115 LHS Mean -0.0086
R Sq 0.9715 R Bar Sq 0.9682 F 4, 34 289.846
D.W.(1) 1.6098 D.W.(2) 1.0905 Est.per.72:2-91:2
H 0.7738

where :

- cci - capital rental cost rate,
- D1 - seasonal dummy variable equal to 1 in the first half-year, 0 otherwise
- D80 - dummy variable equal to 1 beginning 1980:1, 0 before,
- dlnkci = log(1 + INVGi/Kci)
- INVGi - gross fixed investment in industry, SEK million, 1985 prices,
- kci - fixed capital stock in industry in the middle of the period, SEK million, 1985 prices
- li - employment in industry, million of hours,
- logQima = $[\log(Qi) + \log(Qi_{-1})]/2$
- pi - implicit deflator for industrial value added, index 1985 = 1,
- qi - value added in industry, SEK million, 1985 prices,
- rci - ratio of the yield on fixed capital to the yield on five-year government bonds (cf the appendix),
- T - time trend, equal to 1 in 1970:1.
- wci - average hourly wage cost to the employer, including employers' contributions

Simultaneous estimation with $\sigma = 0.33$ as the only cross-equation constraint gave very much similar results as above, with $n = 1.08$ ($a_2 = 0.95$).

Statistical testing of the posited values of the production function parameters gave no clear-cut results, as usual when the number of observations is limited to 40 or less. Cointegration tests using the Johansen procedure (cf Johansen and Juselius [1990]) indicated the existence of one cointegrating vector in the case of both equation (X.8) and (X.9). The long-run parameter estimates were of the same order of magnitude as in free estimation of each equation separately ($\sigma = 0.4$, $n = 0.3$ for the variables included in the investment equation and $\sigma = 0.05$, $n = 1.08$ for those included in the employment equation). A cointegrating vector with $\sigma = 0.33$ and $n = 1$ was in both cases not rejected at the significance level of between 2 and 3 per cent (it was, however, rejected at the 5% level).

The long-run trend coefficient obtained from the employment equation (corresponding to g_3 in (X.7)) is 0.0134, which - given that the equation is semi-annual - implies 2.7% per year. The lagged dependent variable in this equation accounts for the strong seasonal pattern. We can also note the fairly high speed of adjustment towards long-term equilibrium, the adjustment coefficient being close to 0.4.[10]

---

10 An alternative dynamic specification with a lower adjustment coefficient, but the same long-run trend and the same forecasting power, is:

$$\underset{}{\mathrm{dlog}(li)} = \underset{(4.35041)}{-0.51721} * \mathrm{dlog}(li_{-1}) + \underset{(2.36484)}{0.31771} * \mathrm{dlog}(li_{-2}) - \underset{(2.57127)}{0.21037} * [\log(li_{-1}) - \log(qi_{-1}) + .33 * \log(wi_{-1}/pi_{-1})]$$

In the investment equation, the dependent variable exhibits a peculiar change in the seasonal pattern, which practically disappears beginning in 1980 (cf Chart X.13). This is in all probability a reflection of the deficiencies of the statistical time series employed. We have dealt with this problem by introducing a special seasonal dummy for the period preceding 1980. The output variable in the error-correction term (logQima) was seasonally adjusted, using a two-term moving average, in order to eliminate short-term variation in the form of a very strong seasonal pattern.

The short-term accelerator effect in the investment equation (represented by the lagged dlog(qi) term) is rather substantial, if we recall that the dependent variable is the ratio of gross fixed investment to the capital stock, its mean value for the period under study being 0.10. By the same token, the coefficient of adjustment towards long-term equilibrium (0.06) implies a much higher adjustment elasticity in terms of the level of investment.

We can note the significant effect of the relative yield variable on investment. Short-term variation in relative factor prices did not prove important in any of the equations.

The overall fit of the two equations is illustrated in Charts X.13 and X.15. Since the strong seasonal pattern of the relative change in employment blurs the picture, the employment level is shown instead in the charts for the employment equation.

As in many equations estimated through 1991, the fit is much worse at the end of the estimation period. The investment equation substantially underestimates the period 1988:2-90:1. The employment equation overestimates the last two years. Outside-sample forecasts four periods ahead are shown in Charts X.14 and X.16. In the case of the investment equation, outside-sample forecast errors are similar to the residuals of the equation estimated over the whole period. However, when the estimation period is shortened by one year and outside-sample forecasts are computed six periods ahead, the forecast errors increase significantly.

$$- 0.00190 * T + 0.34475 * \mathrm{dlog}(qi) + 0.15701 * \mathrm{dlog}(qi_{-1}) - 0.65174$$
(2.50094) (6.70236) (2.11541) (2.60864)

Sum Sq 0.0036 Std Err 0.0107 LHS Mean -0.0086 D.W.(1) 2.1840 D.W.(2) 1.4664
R Sq 0.9771 R Bar Sq 0.9728 F 6, 32 227.721 Est.per.72:2-91:2

Chart X.13 Investment equation
Actual values (solid line) and fitted values (dashed line)

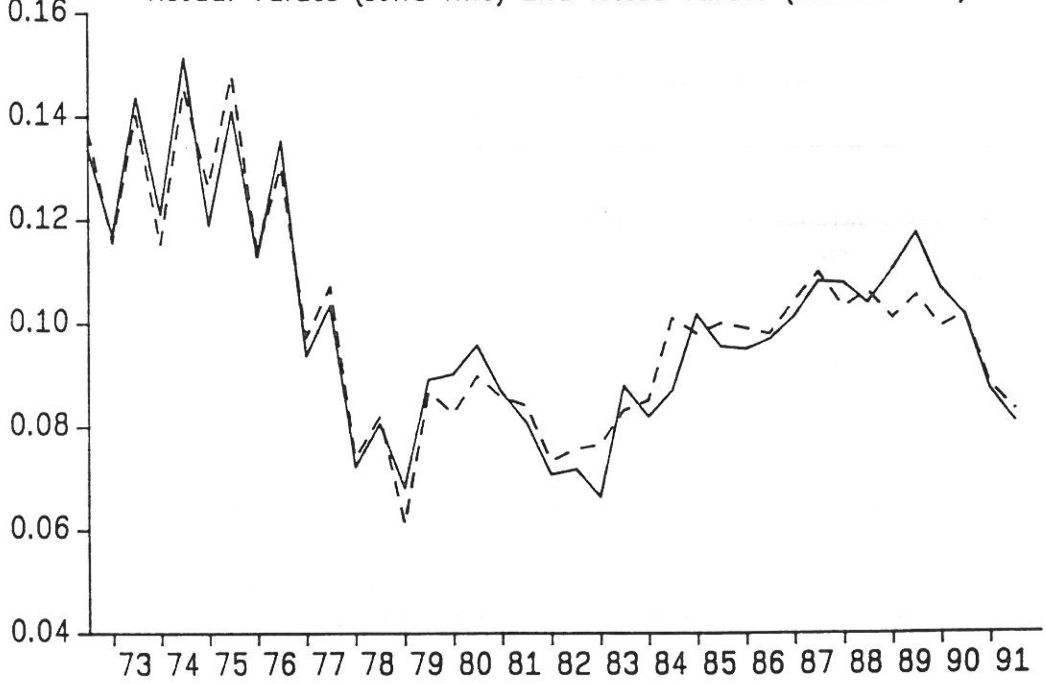
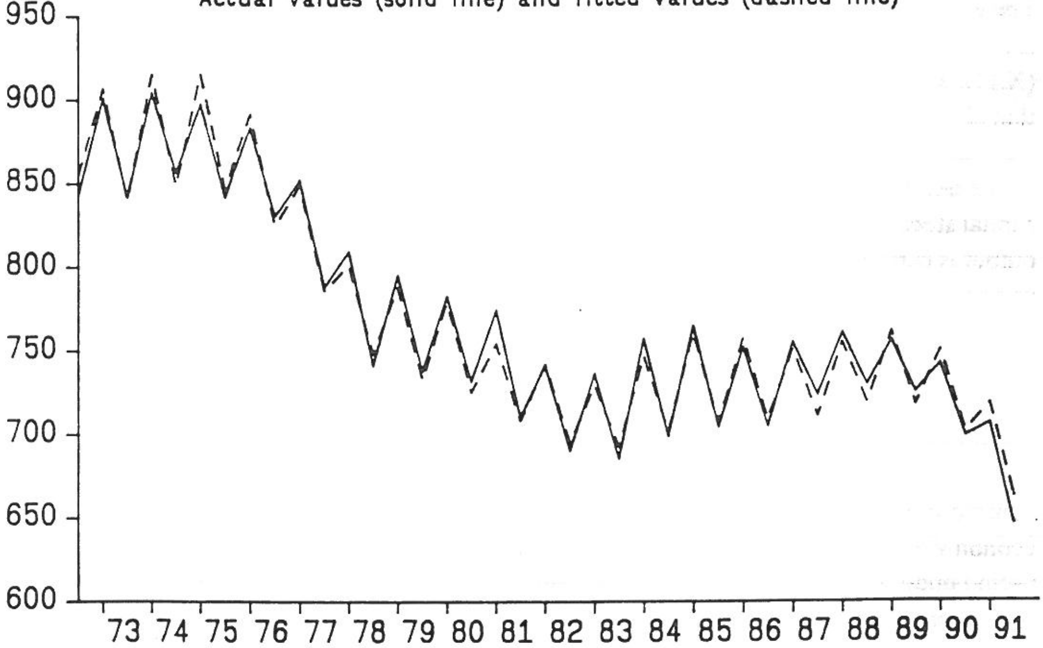


Chart X.14 Investment equation estimated for 1972:2-89:2
Actual values (solid line) and fitted values (dashed line)*

*The dashed line shows outside-sample forecasts for the last two years.

Chart X.15 Employment equation - transformed into levels*

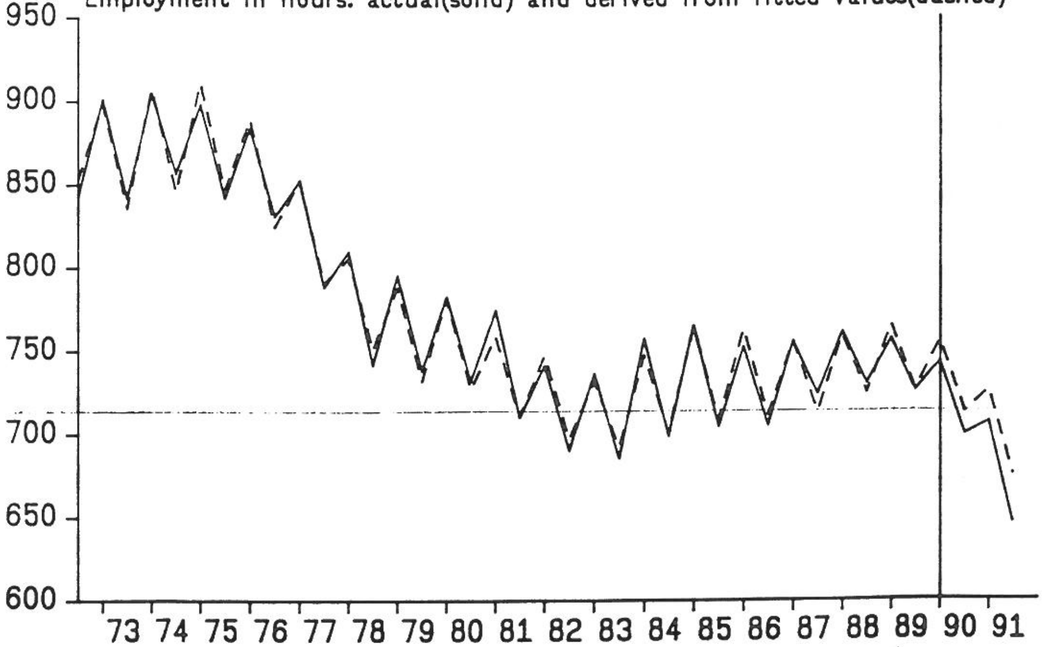
Actual values (solid line) and fitted values (dashed line)



*Employment in hours: actual and derived from equation fitted values.

Chart X.16 Employment equation estimated for 72:2-89:2

Employment in hours: actual(solid) and derived from fitted values(dashed)



Dashed curve shows outside-sample forecasts for the last two years.

The estimates of the production function parameters, derived from equations (X.16) and (X.17), were employed to compute the potential output in accordance with equation (X.11). The intercepts in the long-run solutions were computed under the assumption that all the short-term factors assume in the long run their sample mean values.

Three definitions of the potential output were considered. They all included the actual capital stock and differed with respect to the definition of the labour input. If potential output is construed as capacity output, the labour input should include those unemployed, leaving us with the task of distributing unemployment between the sectors of the economy. The simplest solution here is to assume that the sectoral structures of unemployment and employment are identical and to increase employment in each sector by the overall unemployment rate. (This correction does not add up to total unemployment, making potential employment somewhat smaller than the labour force.)

A more sophisticated approach should account for the changing structure of the economy and allot to industry, which has been shedding labour during most of the period under study, a share of those unemployed that would increasingly exceed the sector's share of employment. This was achieved by allocating to industry 35% of those unemployed, roughly, the sector's share of employment in the early 1970-ies.

Alternatively, potential output can be interpreted as Helliwell's "normal output" (cf Helliwell et al. [1986]), where actual employment is substituted into the production function. Normal output is defined as the one that would be obtained with the actual factor inputs used with "normal" intensity. Jarrett and Torres [1987] report that the intensity of factor utilisation rate computed using normal output is insensitive to short-run shocks and they recommend the capacity utilisation rate instead.

As can be seen in Chart X.17, the three definitions of potential output give very much the same results, with normal output being for obvious reasons somewhat lower than the other two. Although the second definition above (the dotted line in Chart X.17) is the most appropriate one, in view of the very small differences let us choose the first one, which is much simpler to implement in simulations, since it does not require any distribution of unemployment by sector.

A capacity utilisation index, defined as the ratio of the actual output to our measure of the potential output, is depicted in Chart X.18. In order to provide a frame of reference,

Chart X.17 Potential output with different potential employment definitions

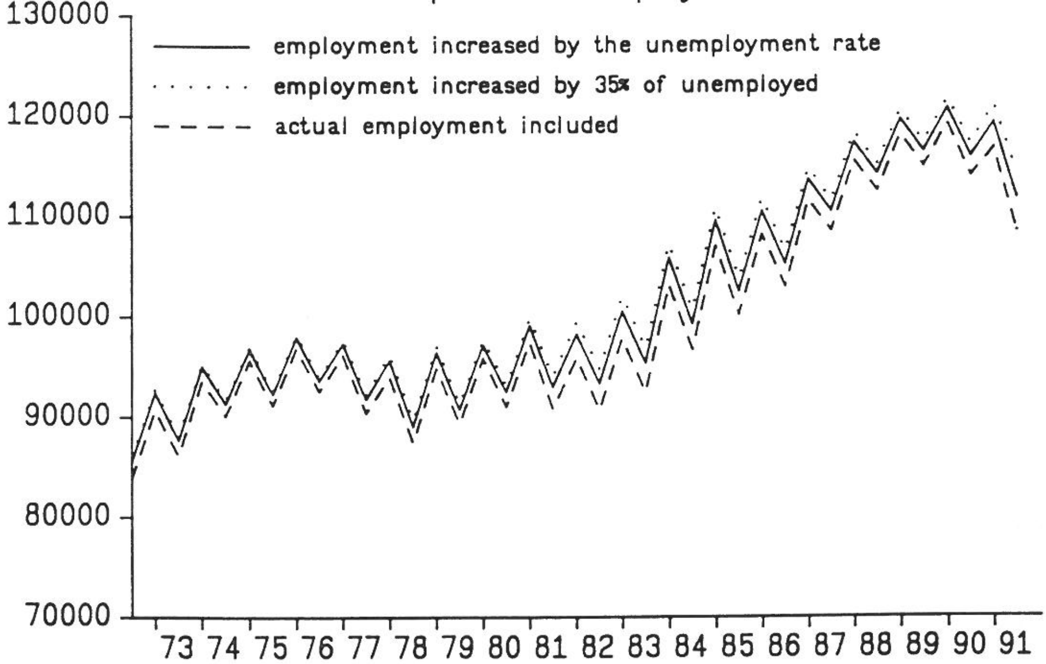


Chart X.18 Capacity utilisation index according to two definitions

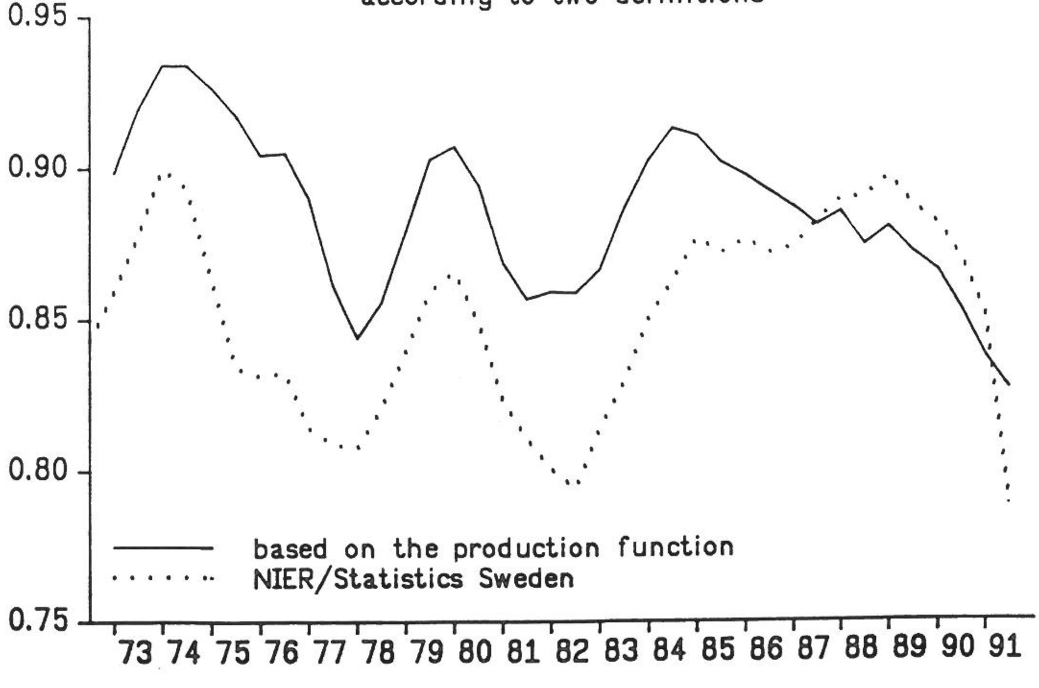
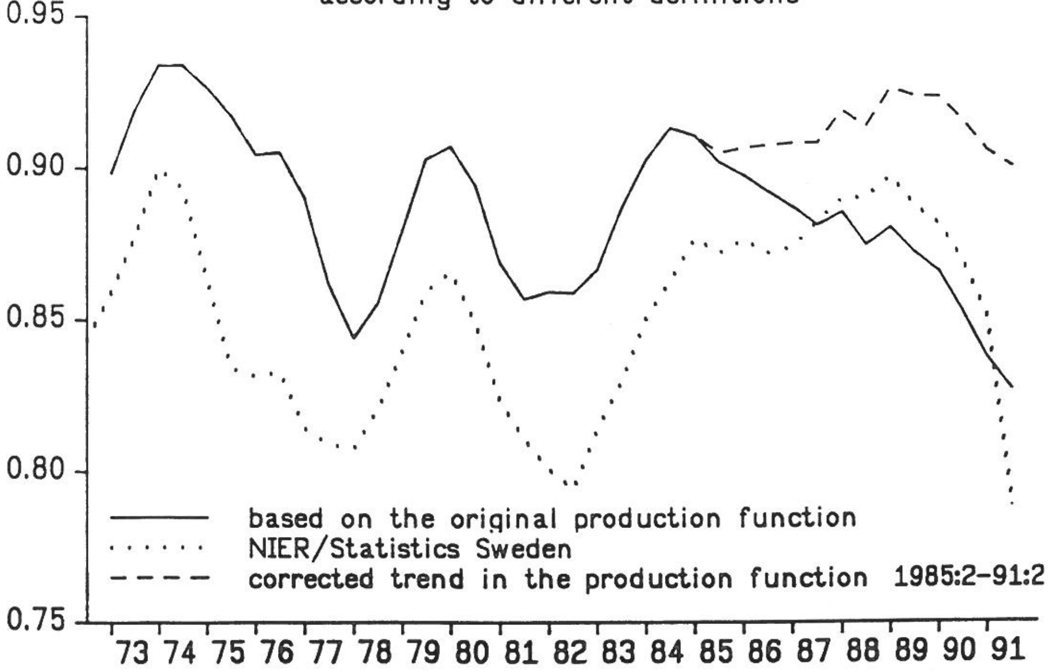


Chart X.19 Labor productivity

Percentage changes between corresponding half-years

Chart X.20 Capacity utilisation index

according to different definitions



the chart also includes "Actual capacity utilisation in industry" from Statistics Sweden extended backwards using the "Utilisation of resources" from the Business Tendency Survey[11].

As can be seen in the chart, the capacity utilisation index derived from our production function gives the same picture as the reference series with the exception of the 1989 peak[12]. According to our definition, capacity utilisation decreases steadily between 1985:2 and 1987:2 and the upturns in 1988:1 and 1989:1 do not create a real peak.

This difference depends on the definition of productive capacity. In particular, the trend term in the production function implies ceteris paribus a steady productivity increase of 2.7% per annum (1.34% per half-year[13]). As can be seen in Chart X.19, productivity changes - which otherwise are extremely volatile - were consistently below 2.7% during the whole period 1985:1 - 1991:2 (with two minor exceptions). If the trend in the potential output equation is lowered in 1985:2-91:2 to 0.64% (which is close to the average productivity growth for the period), the capacity utilisation index has a peak in 1989. This is illustrated in Chart X.20. We can note that the corrected capacity utilisation does not show the steep decline at the end of the period.

FACTOR DEMAND IN OTHER BUSINESS

Other business, which includes agriculture and fisheries, construction and the whole range of private services from transportation to telecommunication, is a much more heterogeneous sector than industry. A glance at Chart Y.1 will show that the structure of the sector has undergone a far-reaching change during the period under study. While real value added was steadily increasing up to 1989, employment in hours decreased in absolute terms throughout the 1970-ies and then surged up in the 1980-ies[14].

Changes in the industrial structure are further illustrated in Chart Y.2, which shows the share of Construction, Wholesale and retail trade, Restaurants and hotels and Other

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11 Since the industrial capacity utilisation index from Statistics Sweden is available only beginning 1982, a qualitative index of utilisation of resources from the Business Tendency Survey of the National Institute of Economic Research was employed for the preceding years. The index, which combines the shares of firms reporting full utilisation of resources and lack of manpower, was transformed to have the same mean and the same variance as the former series. Since both component series are quarterly, the result was transformed into half-years by averaging.

12 When the index is computed using the second potential output series, which attributes more of unemployment to industry, capacity utilisation in the 1980-ies is increasingly lower - and somewhat more similar to the reference series - but there is still no pronounced peak in 1989.

13 If $Dlog(Qi/Li)=0$ and according to equation X.4 $Li=g_2*exp(0.0134*t)*E$ then $Dlog(Q/E)=0.0134$.

14 Note, however, that the two curves are depicted in different scales.

Chart Y.1 Real value added and employment in hours in other business excluding permanent housing

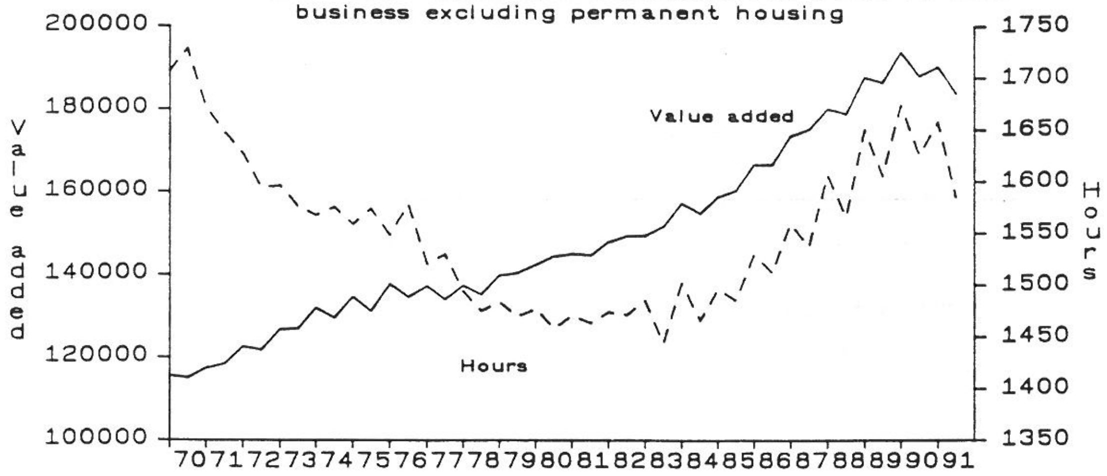
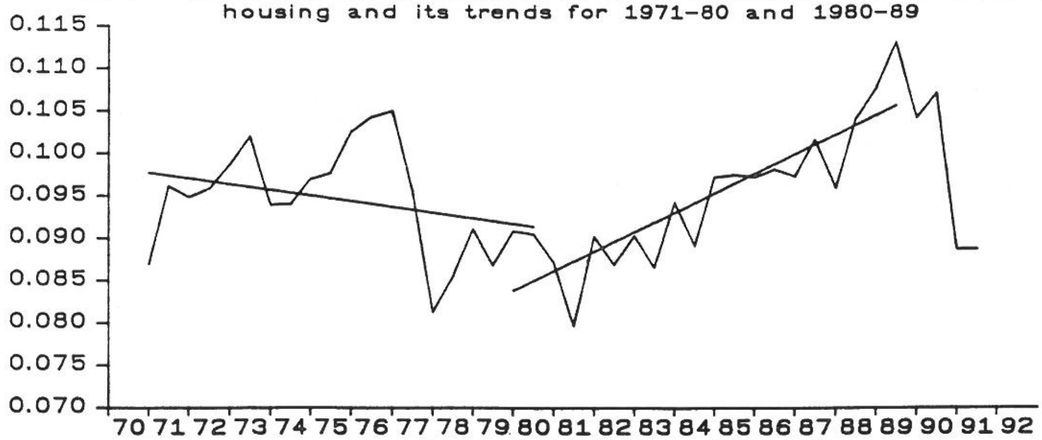


Chart Y.2 Share of selected subsectors* in the real value added of other business excluding permanent housing

* SNR 5000, 6100, 6300, 9000.

Chart Y.3 Real gross investment in other business* excl. permanent housing and its trends for 1971-80 and 1980-89



* Expressed as a share of the capital stock.

private services in the sector's total real value added. As can be seen in the chart, the share of those four subsectors decreased steadily during the two decades under study. The subsectors that gained in importance during the period were Telecommunication and Financial institutions.

Changes in the composition of the sector offer a reasonable explanation of the behaviour of the gross real investment in other business, which otherwise does not seem to be compatible with the development of neither output nor real price of capital services. As shown in Chart Y.3, real gross investment expressed as a share of capital stock exhibits an underlying downward trend during the 1970-ies and a strong upward trend in the 1980-ies. Meanwhile, both value added and the real rental cost of capital increased in a trendwise manner throughout most of the period.

In order to allow for the acceleration of investment due to the expansion of new subsectors in the 1980-ies (and accompanied by a reversal of the employment trend, cf Chart Y.1), a trend variable was introduced into the investment equation beginning in 1980. Since this trend is supposed to have been temporary, the trend variable introduced is curved and approaches asymptotically the value 1.

The model estimated for Other business was otherwise exactly the same as that for Industry. It involved thus equations (X.8) and (X.9), with the trend term in equation (X.8) replaced by (T-18)/T in order to obtain the curvature mentioned above. The number 18, subtracted in the denominator of the trend expression, was chosen by casual scanning. It should be reiterated that the trend term in the investment function was introduced solely to allow for the change in the sector's composition; the technical change in the production function was still assumed to be purely labor-augmenting.

The variables in the factor demand equations for Other business were defined analogously to those for Industry. The sector excludes permanent housing, thus output was defined as real value added in other business excluding housing, and output price as the corresponding implicit deflator.

The dependent variable in the estimated investment equation was defined as the ratio of *gross* investment to the previous period's capital stock. The latter was computed as the sum of building and machinery stocks, as no inner CES function could be estimated for this sector (cf Chapter 1). The corresponding capital rental cost was computed as a weighted average of the rentals for buildings and machinery, using their respective shares in total capital as weights. As in the case of Industry - and for the same reason - the capital stock in the investment function was divided by 2.

Similarly to the case of Industry, the common parameters, relating to the production function, created problems in the estimation of the employment and the investment equations. The employment equation, when estimated separately, gave $\sigma=0.3$ and $n=0.5$. The long-run trend estimate was 1.96% per half-year.

Separate estimation of the investment equation over the whole period 1972-1991 gave a very poor fit. The estimates implied zero elasticity of substitution and a degree of homogeneity of the production function well below unity ($\sigma=0$, $n=0.6$). Since the development of employment (cf Chart Y.1) and of investment (cf Chart Y.3) indicate a structural change in the sector (as explained above) round 1977/78, the equation was reestimated for the period 1977-1991. The fit of the equation improved radically and the estimated elasticity of substitution was no longer zero ($\sigma=0.15$ and $n=0.9$).

Simultaneous estimation of the two equations with cross-equation constraints proved to be very sensitive to the choice of starting values. When the starting values for the production function parameters were taken from free estimation of one of the equations, simultaneous estimation largely replicated this equation.

After an analysis of the results of unconstrained estimation, we imposed on both equations the values $\sigma=0.2$ and $n=1$. The value of the elasticity of substitution is close to the average of the results from free estimation of both equations. It appears also reasonable that this elasticity here is lower than in Industry, where the opportunities for substitution should be bigger.

Constant returns to scale (i.e. $n=1$) were indicated by the investment equation. Theoretical considerations were also important here. Less weight was given to the results from the employment equation, which appeared to have been seriously affected by the structural change, mentioned above. In fact, the estimate of the parameter n was much closer to 1 when the employment equation was estimated only over the 1980-ies.

Estimation of each equation with two parameters imposed, using ordinary least squares, gave the following results:

(X.18)

dlnko

$$= - 0.22455*[\log(ko_{-1}) - \log Qoma_{-1} + 0.2*\log(co_{-1}/po_{-1})]$$
(3.98548)

$$+ 0.31883*d\log Qoma + 0.07953*\log(ro_{-3})$$
(3.52399) (1.04975)

$$+ 0.08316*((T-18)/T)*D80 - 0.01092*D80 + 0.17177$$
(6.68960) (3.11258) (9.14557)

Sum Sq 0.0004 Std Err 0.0042 LHS Mean 0.0943
R Sq 0.7797 R Bar Sq 0.7338 F 5, 24 16.9873
D.W.(1) 1.8036 D.W.(2) 2.2061 Est.per. 77:1-91:2

(X.19)

dlog(lo)

$$= - 0.67254*d\log(lo_{-1})$$
(6.92556)

$$- 0.35349*[\log(lo_{-1}) - \log(qo_{-1}) + 0.2*\log(wo_{-1}/po_{-1})]$$
(4.66712)

$$- 0.00242*T + 0.28781*d\log(qo)$$
(3.48660) (3.54323)

$$- 0.07852*d\log(wo/po) - 1.26052$$
(1.16860) (4.74287)

Sum Sq 0.0033 Std Err 0.0099 LHS Mean -0.0007
R Sq 0.8416 R Bar Sq 0.8176 F 5, 33 35.0589
D.W.(1) 1.4158 D.W.(2) 1.1239 Est.per. 72:2-91:2
H 2.1817

where:

co - capital rental cost rate,
D80 - dummy variable equal to 1 beginning 1980:1, 0 before,
dlnko - log(1+invgo/ko),
invgo - gross fixed investment in Other business excluding permanent housing, SEK millions, 1985 prices,
ko - fixed capital stock in Other business excluding permanent housing in the middle of the period, SEK million, 1985 prices,
lo - employment in Other business excluding permanent housing, million of hours,
logQoma = [log(qo) + log(qo.1)]/2,
po - implicit deflator for value added in Other business excluding permanent housing, index, 1985 = 100,
qo - value added in Other business, SEK million, 1985 prices,
ro - ratio of the yield on fixed capital to the yield on five-year government bonds (cf the appendix),
T - time trend, equal to 1 in 1970:1,
wo - average hourly wage cost to the employer, including employers' contributions.

Probably due to the changes in the structure of the sector, the overall fit of the equations is worse than in the case of industry. Also, the underlying production function is less pronounced. Thus, cointegration tests using the Johansen procedure rejected a cointegrating vector with $\sigma = 0.2$ and $n = 1$, postulated in our equations. This was mainly due to the relative factor cost variables, which in Johansen estimation were insignificant but had a positive sign.

The employment equation implies relatively large variation in productivity, as labour input in the short run rises by less than one third of the relative increase in output. The short run effect of changes in the real wage cost is extremely limited. Adjustment towards long-run equilibrium is fairly fast, with a coefficient of 0.35. The long-run trend coefficient is 0.0086, implying a 1.7% productivity increase per year. The lagged dependent variable in the equation accounts for the strong seasonal pattern.

The investment equation was estimated over a shorter time period in an attempt to reduce the impact on our estimates of changes in the industrial composition of the sector (cf the discussion of the unconstrained estimation above). This, together with the introduction of the curved trend, allowed us to eliminate the apparent positive correlation between investment and the relative cost of capital services, as well as between investment and the error-correction term.

Chart Z.1 Other business: Investment equation
Actual values (solid line) and fitted values (dashed line)

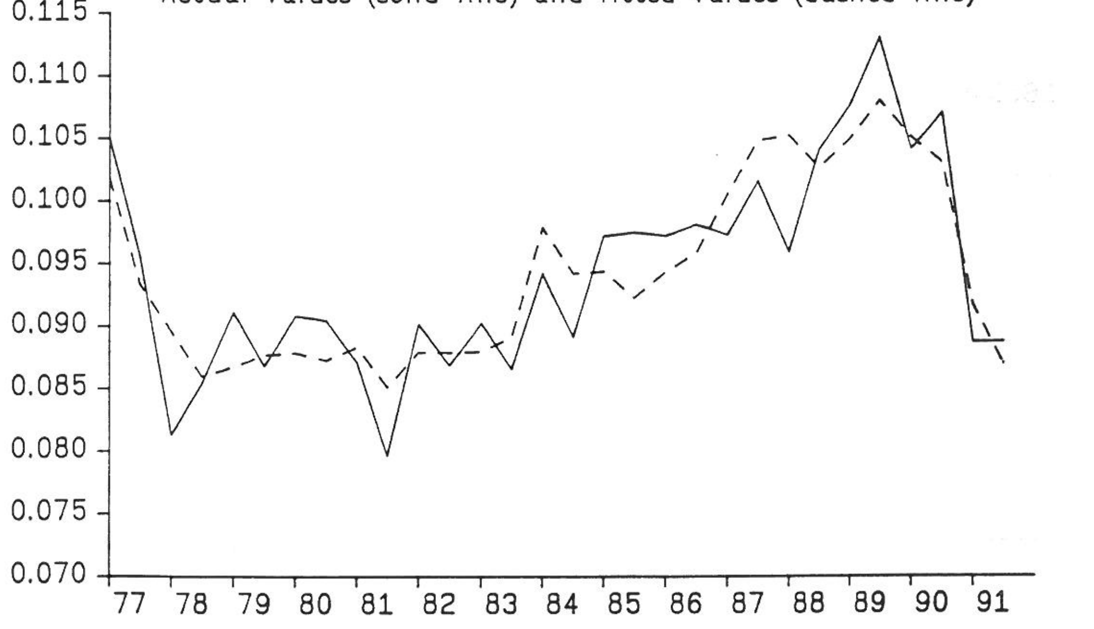
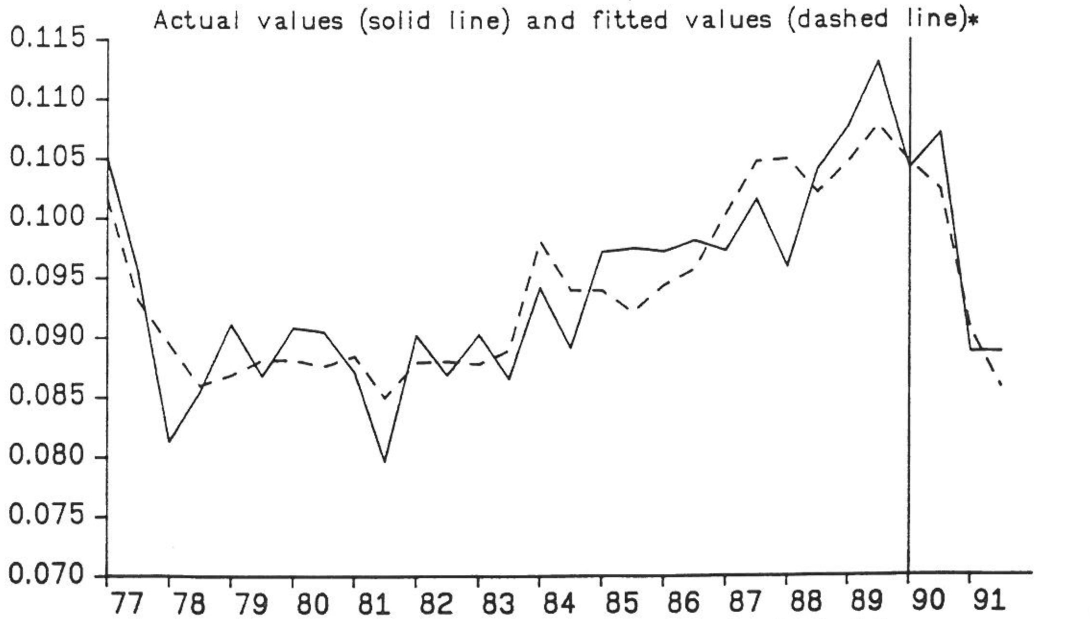


Chart Z.2 Other business: Investment equation estimated for 72:2-89:2
Actual values (solid line) and fitted values (dashed line)*



*The dashed line shows outside-sample forecasts for the last two years.

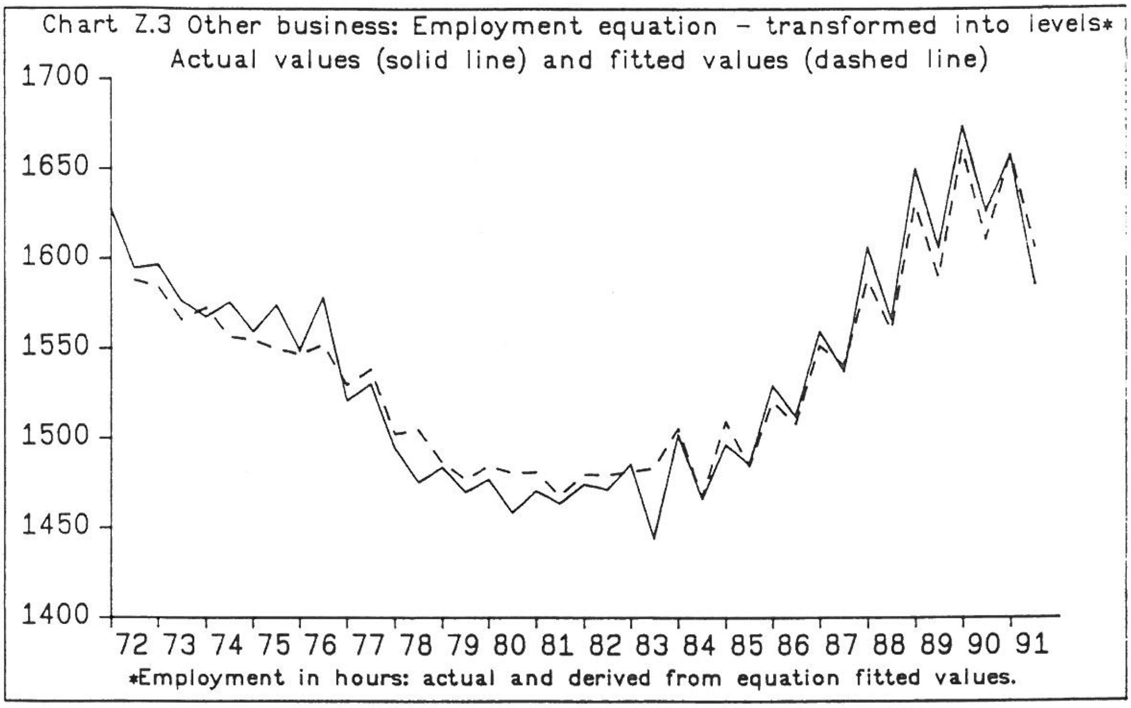


Chart Z.3 Other business: Employment equation - transformed into levels*
Actual values (solid line) and fitted values (dashed line)
1700
1650
1600
1550
1500
1450
1400
72 73 74 75 76 77 78 79 80 81 82 83 84 85 86 87 88 89 90 91
*Employment in hours: actual and derived from equation fitted values.

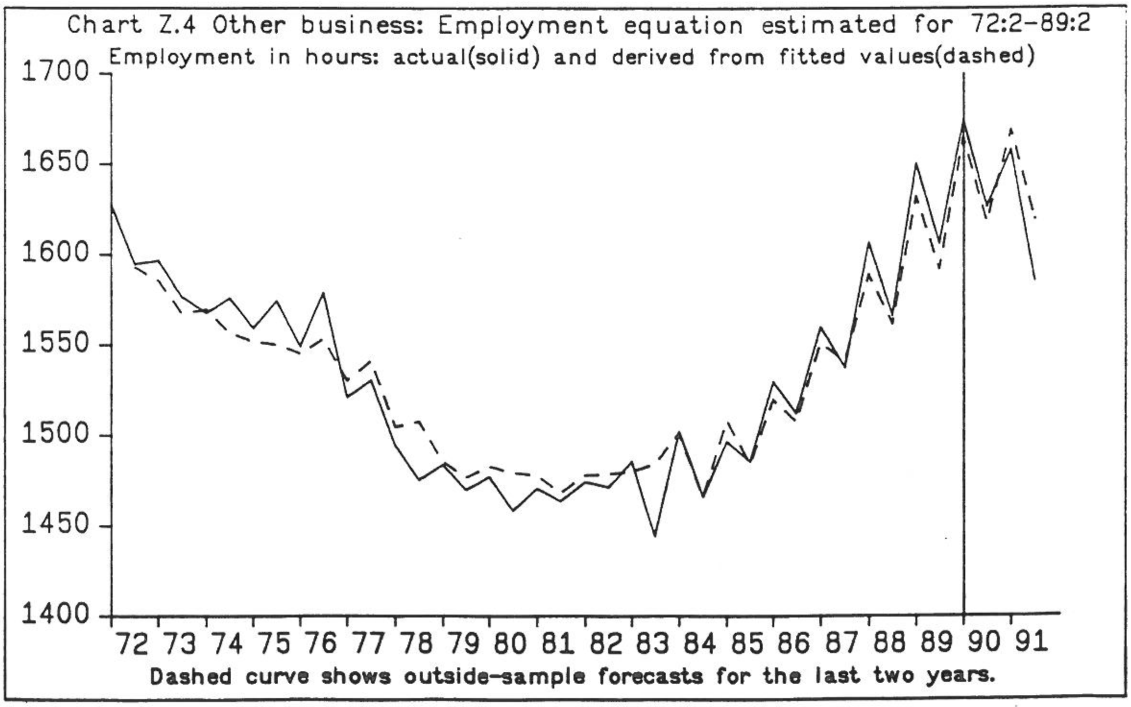


Chart Z.4 Other business: Employment equation estimated for 72:2-89:2
Employment in hours: actual(solid) and derived from fitted values(dashed)
1700
1650
1600
1550
1500
1450
1400
72 73 74 75 76 77 78 79 80 81 82 83 84 85 86 87 88 89 90 91
Dashed curve shows outside-sample forecasts for the last two years.

The output variable in the investment equation was seasonally adjusted using a two-term moving average. The short-term accelerator effect is rather strong and the coefficient of adjustment towards equilibrium high, especially when compared to the corresponding estimates for Industry. The relative yield variable, which transmits the short-term interest-rate effects, is less important in Other business than in Industry.

The overall fit of the equations is illustrated in Charts z.1 and z.2. Due to the strong seasonal pattern, the employment level rather than its growth rate is shown in the charts for the employment equation. Outside-sample forecasts four periods ahead are depicted in Charts z.2 and z.4. As can be seen there, the pattern of the outside-sample forecast errors is very similar to the pattern of the corresponding residuals in full-sample estimation.

POTENTIAL OUTPUT AND CAPACITY UTILISATION IN OTHER BUSINESS

The estimates of the production function parameters, derived from the investment and employment equations for Other business excluding permanent housing, were employed to compute the potential output in accordance with equation (X.11). Similarly to the case of industry, the intercepts in the long-run solutions were computed under the assumption that all the short-term factors assume in the long run their sample mean values.

Potential output computed according to the three definitions, discussed in the section on potential output for industry above, is depicted in Chart z.5. A capacity utilisation index, defined as the ratio of the actual output to our measure of the potential output is shown in Chart z.6. The potential output employed in the capacity utilisation index in the chart involves employment increased by the overall unemployment rate.

As can be seen in the chart, the capacity utilisation index based on our estimates is during most of the period under study higher than 1. This upward shift in the curve is most probably attributable to the errors in estimation of the long-run intercepts in the investment and employment equations. The discussion in the previous section indicated significant data problems, which could be expected to affect the precision of coefficient estimates.

No data on the capacity utilisation in Other business are to our knowledge available, it is therefore difficult to assess whether the profile of our index is plausible. In general, we would however expect the two sectors to show similar patterns of capacity utilisation. In

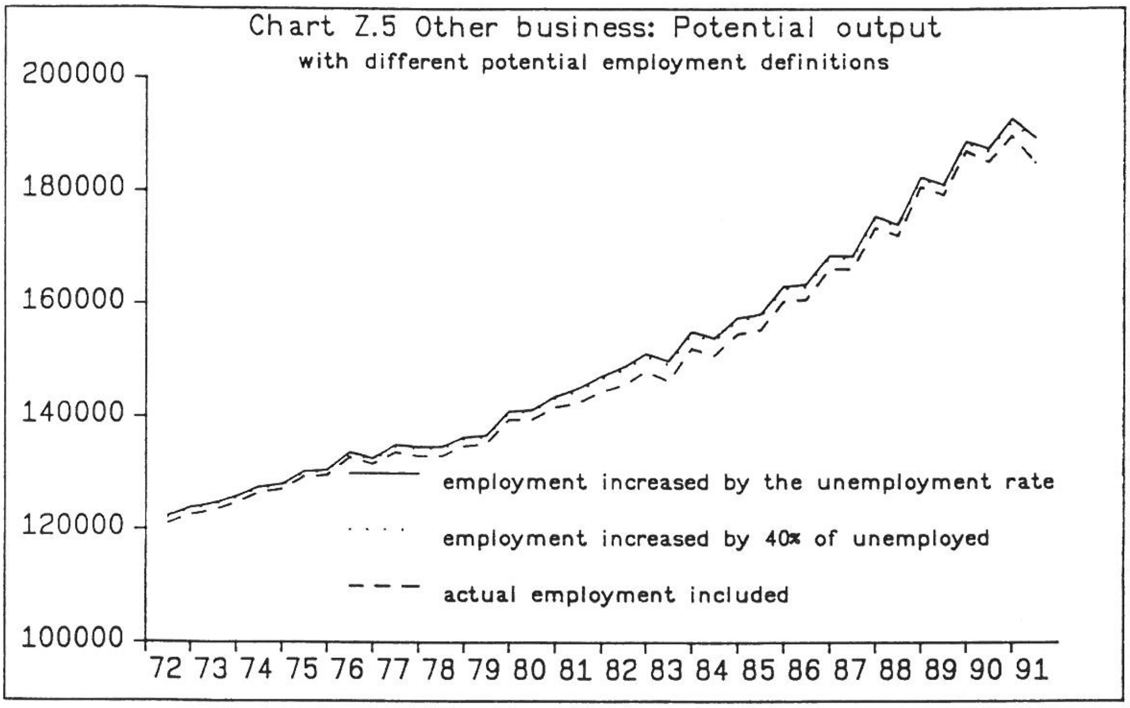


Chart Z.5 Other business: Potential output
with different potential employment definitions
200000
180000
160000
140000
120000
100000
employment increased by the unemployment rate
employment increased by 40% of unemployed
actual employment included
72 73 74 75 76 77 78 79 80 81 82 83 84 85 86 87 88 89 90 91

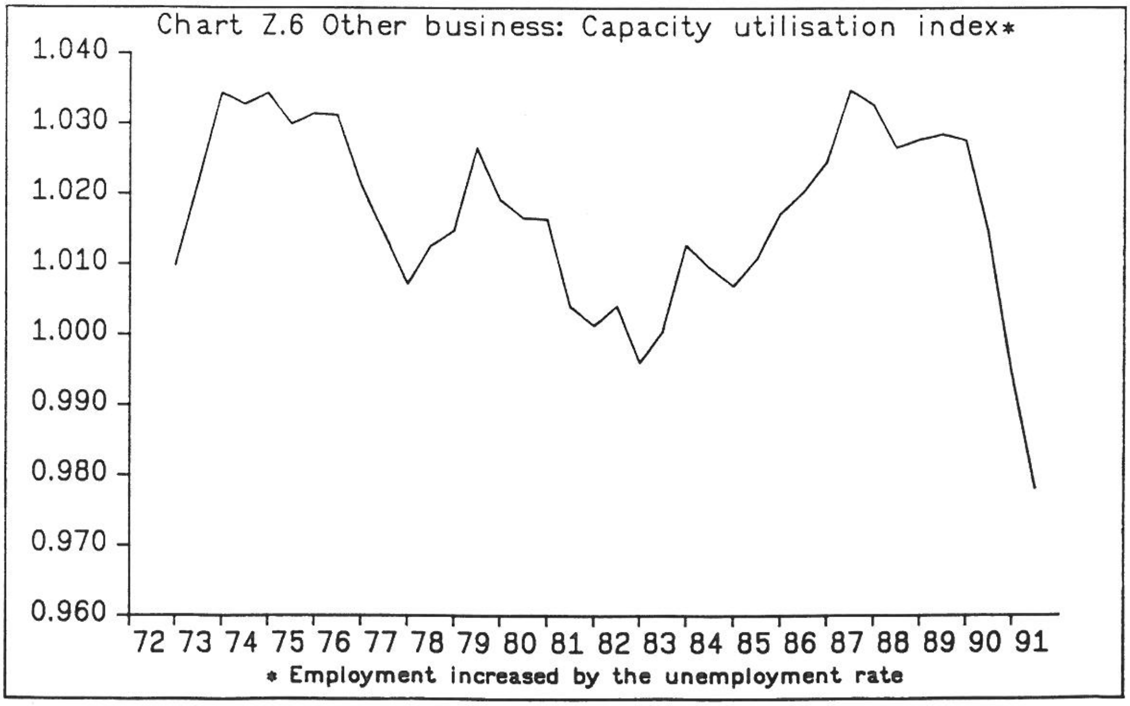


Chart Z.6 Other business: Capacity utilisation index*
1.040
1.030
1.020
1.010
1.000
0.990
0.980
0.970
0.960
72 73 74 75 76 77 78 79 80 81 82 83 84 85 86 87 88 89 90 91
* Employment increased by the unemployment rate

fact, we can note far reaching similarity in the estimated capacity utilisation indices for Industry and Other business up to the beginning of the 1980-ies. Thereafter, the index for Other business appears to be closer to the reference series from Statistics Sweden.

CHAPTER 3. OUTPUT DETERMINATION

This chapter deals with determination of industrial output. Output in 'Other business', which mainly is a service sector, is postulated to be equal to demand. The identity for the latter output involves, besides the final demand terms, demand from industry and the public sector (i.e. intermediate production) and a discrepancy term which in the case of industry was omitted (see below). Intermediate production in 'Other business' was treated analogously to that in industry (see below).

The starting point of our approach is the view that supply decisions are taken separately from expenditure decisions. This is different from the traditional econometric models of the Keynesian type, where output is determined by demand. According to our view of the economy, supply decisions need not match exactly the expenditure decisions taken by the consumers and entrepreneurs.

When a mismatch between supply and demand occurs, several adjustment processes are initiated. Prices, output, inventories, imports and demand for factors of production are simultaneously adjusted.

It is postulated, that output adjusts only partially to a sudden change in demand. The role of the buffer, which accounts for the remaining discrepancy between supply and demand, is played by inventories. The supply decision of the producers is in the short run affected by sales, the deviation of the actual inventory stock from the desired one and by the profitability of production. In the long run, output is determined by demand.

Inventories are here considered to be held by the producers. This is consistent with our data definitions, where - in the input-output framework - inventories are defined in terms of the producing sector rather than holding sector. Thus, inventories of industrial products held by wholesale and retail trade are attributed to industry rather than to 'Other business'.

Helliwell (Helliwell et al. [1986]) describes the output decision in terms of intensity of factor utilisation, i.e. the ratio of actual output to normal output. In any moment, an output change involves a change in the intensity of factor utilisation. Below, we employ the capacity utilisation rate as the dependent variable. The difference between the two depends on the denominator, which in Helliwell's case is defined as "normal" rather than "potential" output, the former being computed using actual employment and the latter using the potential one.

Industrial sales in our model are defined to include final domestic demand (excluding inventory change) and intermediate production for the use of other sectors, all at producers' prices. Intermediate production was approximated by constant proportions of public consumption and final demand in 'Other business'. The proportionality constants were based on the actual inter-industry flows obtained from the semi-annual input-output tables, which - however - are available only for the period 1988-91.

The discrepancy in GDP computation, which constitutes the difference between sales (demand) and output, was available by sector from the same source and for the same period. As the available data for total discrepancy exhibit high volatility and are rather shaky, we decided to neglect it altogether rather than venture any attempt to distribute it on a sectoral basis for the whole sample period.

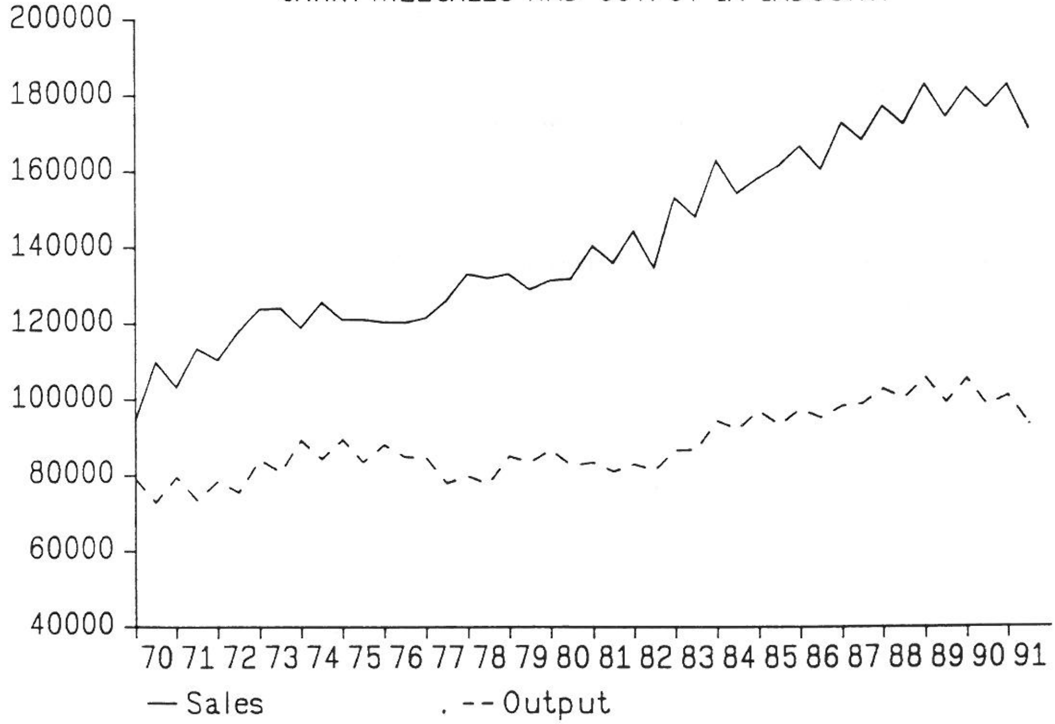
The real inventory stock was computed by cumulation of real inventory investment in the National Accounts, given a nominal benchmark value for 1985 (the base year for the fixed-price data). As inventories in 'Other business' are very small, the total inventory stock was attributed to industry.

The desired inventory stock is usually defined in terms of a constant stock/output ratio. However, the ratio of inventory stock to output for the period under investigation, 1970-91, had the "inverted v" shape and could hardly be assumed to be a result of adjustment to a constant desired value. The data exhibited an upward trend in 1970-77 and a strong downward trend thereafter. The high values of mid-seventies can be partially due to the stockbuilding incentives (support for stocks) introduced by the government in 1975 and 1976. The subsequent downward tendency is consistent with the well-known fact that inventory stocks have been steadily decreasing in the past 15 years, due to a more rational and cost-efficient organisation of businesses.

The desired stock/output ratio was modelled using a linear trend up to 1977 and a quadratic trend in 1978-91. Attempts to include the interest rate as an additional determinant of the desired ratio were unsuccessful.

The behaviour of inventories explains the disparity between the paths of sales and industrial output, illustrated in Chart X.21. As can be seen in the chart, sales have been increasing much faster than output, making estimation of a supply function all the more difficult.

CHART X.21 SALES AND OUTPUT IN INDUSTRY



Potential output was defined and estimated above, in the section on potential output and capacity utilisation in industry.

The estimated function has the following general form:

$\log(Oi/POi) = f(\log(Si/POi), \log(IS/DIS)_{-1}, Prof)$,

where

- Oi - real value added in industry,
- POi - potential output (value added) in industry,
- Si - gross sales in industry at producers' price,
- IS - real inventory stock,
- DIS - desired real inventory stock,
- Prof - measure of profitability of industrial production.

Assuming

$$DIS = DRAT*Oi,$$
$$DRAT = a*\exp(b*T + c*T^2),$$

where DRAT is the desired ratio of inventory stock to output, T is the time trend and a, b, c are constant coefficients, we obtain:

$\log(Oi/POi) = f(\log(Si/POi), \log(IS/Oi)_{-1}, T, T^2, Prof)$.

The results of OLS estimation were as follows:

(X.20)

$$\log(Oi/POi)$$

$$= \underset{(2.01120)}{0.21362} * \log(Si_{-1}/POi_{-1})$$

$$- \underset{(6.90485)}{0.33269} * \log(IS_{-1}/Oi_{-1}) + \underset{(1.20046)}{0.00234} * (1-D7891)*T$$

$$+ \underset{(2.52405)}{0.00546} * D7891*T - \underset{(5.01751)}{0.00024} * D7891*T^2 + \underset{(2.32609)}{0.17525}$$

$$- \underset{(1.46528)}{0.00977} * S2$$

Sum Sq	0.0090	Std Err	0.0170	LHS Mean	-0.0220
R Sq	0.8669	R Bar Sq	0.8412	F 6, 31	33.6616
D.W.(1)	2.3631	D.W.(2)	1.5379	Est. per.	1973:1-91:2

where

D7891 - dummy variable equal 1 beginning in 1978, otherwise 0,

S2 - seasonal dummy for the second half-year.

The actual and fitted values for the equation are depicted in Chart X.22. Outside-sample forecasts from the equation estimated through 1988:2 are shown in Chart X.23. Generally, the fit of the equation is very good and outside sample forecasts do not indicate any greater changes in the estimated relation at the end of the sample period.

As can be seen, the estimated elasticity of output with respect to sales (0.2) is rather low. Furthermore, this elasticity pertains to sales lagged by one period, the effect of contemporaneous sales changes being zero. This result implies that changes in demand in the first year are to a large extent made up by the off-setting changes in inventories. The resultant effect on inventory stocks, causes gradual adjustment of the output level. It is difficult to say to what extent this result is due to the specific development of the inventory stock during the estimation period, alluded to above. Certainly, data problems should not be underestimated in this case.

According to our results, the desired inventory stock is crucial in the relation, since it - at any given actual stock level - determines the adjustment of output. In such a situation, it obviously is very uncomfortable to have the desired inventory stock determined by a quadratic trend, which quickly reaches very high (or, in this case, very low) values. It is, therefore, important to remember that the trend was employed in estimation as a convenient proxy for developments which could not be modelled directly and that its role in forecasting is subject to further analysis.

The values of the implicit desired inventory stock level can be computed from the long-run solution to the estimated equation, under the assumption that the capacity utilisation ratio and the sales to potential output ratio take on their sample mean values. The long-run solution actually gives the desired inventory stock to output ratio (DIS/Oi), desired stock can then be obtained upon multiplication by output. The desired inventory stock levels, thus computed, are depicted in Chart X.24. We can note the fast decrease of the desired stock level at the end of the estimation period.

The estimated equation does not include any profitability variable. The profitability measure tested, the "extraordinary profit" ratio is described in detail in the appendix. This variable is highly correlated with the capacity utilisation rate and it made some other variables (including sales) superfluous. It was discarded, since we believe that

CHART X.22 ACTUAL AND FITTED VALUES FOR THE CAPACITY UTILISATION EQUATION

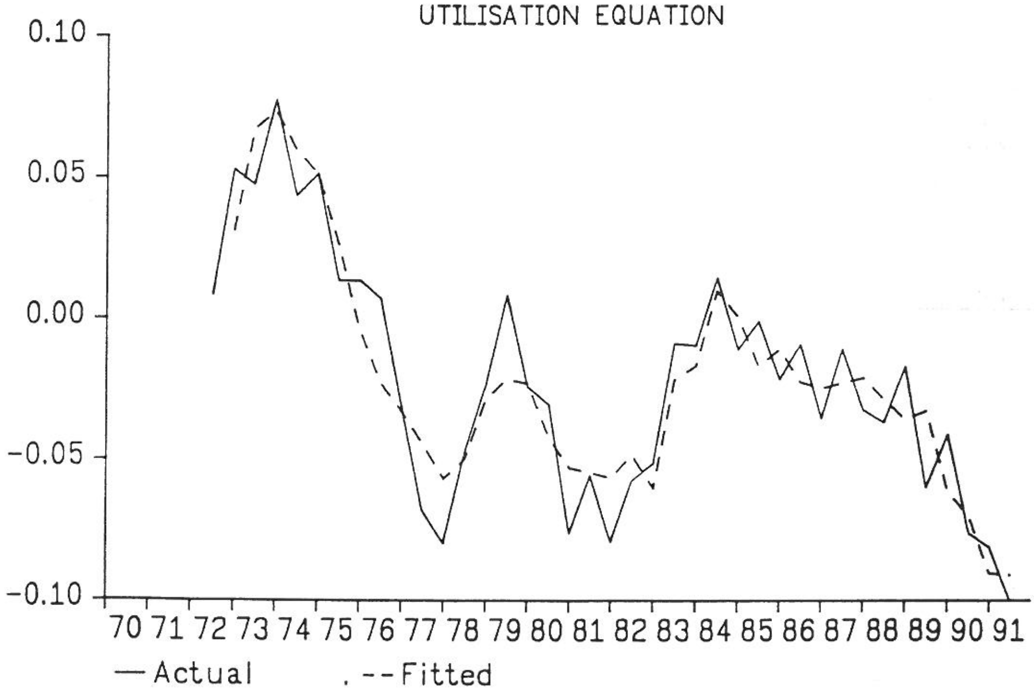


CHART X.23 ACTUAL AND FITED* VALUES FOR THE CAPACITY UTILISATION EQUATION ESTIMATED FOR 1973:1-88:2

* The last six values are outside sample forecasts

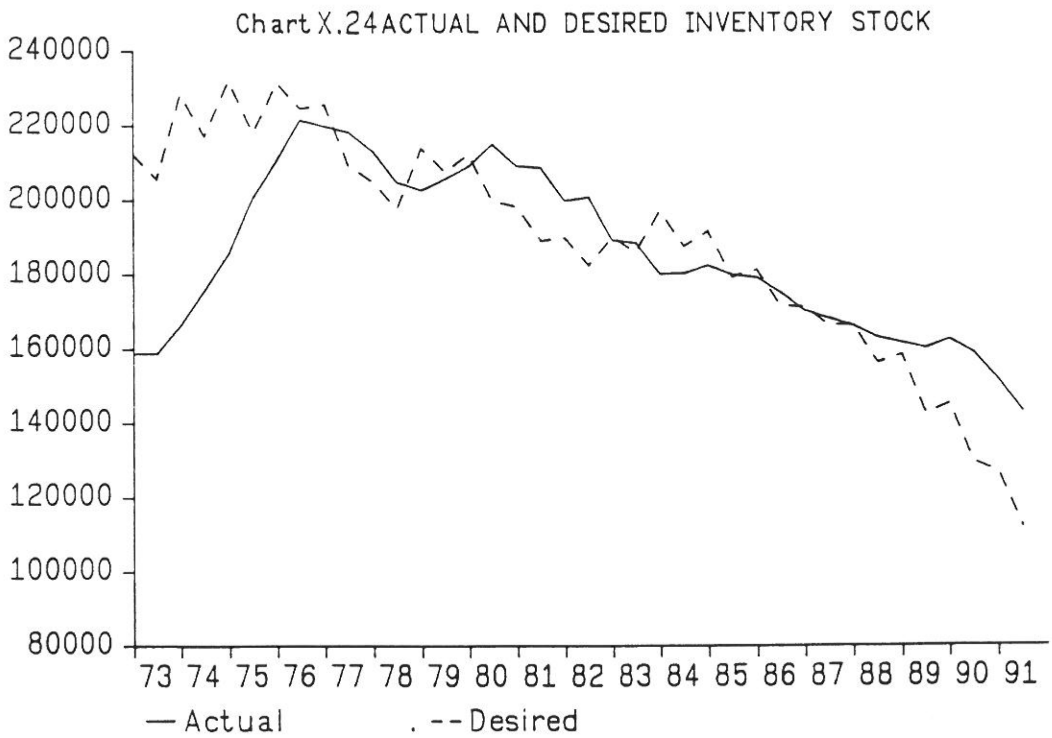


Chart X.24 ACTUAL AND DESIRED INVENTORY STOCK
240000
220000
200000
180000
160000
140000
120000
100000
80000
73 74 75 76 77 78 79 80 81 82 83 84 85 86 87 88 89 90 91
— Actual
. -- Desired

variation in this measure of profitability is a result rather than a cause of output changes. This is so, because changes in output involve corresponding short-run changes in labour productivity, due to slow adjustment of the labour input. The profitability measure needed, but rather difficult to compile, should reflect the average relation between costs and revenue, excluding the effects of short-run productivity variation.

The supply equation above, with all the data problems involved, does not carry any clear signs of lack of parameter constancy. Outside-sample forecasts indicate parameter constancy in regard of the last years of the period under study (cf Chart X.22 and X.23). This hypothesis is neither rejected by formal tests. Graphs of parameter values obtained from recursive least squares (i.e. repeated regressions with moving end period) show reasonable (though by no means complete) constancy.

On the other hand, one could suspect that the strong downward trend in the desired inventory stock/output ratio may gradually have changed the role of inventories in the supply relation. As inventory stock decreases, the sheer fact of its smaller size may limit its role as a buffer stock. In such a case, direct effects on output of variation in domestic demand would gain in importance. This conjecture means that the coefficients of the relevant variables in the supply equation could gradually change with time.

In fact, when the equation was repeatedly reestimated with the starting period of the regression being moved forwards, the coefficient of the contemporaneous sales variable was increasing and became significant, while that of the lagged stock/output ratio was decreasing. The equation estimated for 1982-91, with the 1978-91 dummy excluded for obvious reasons, gave the following results:

(X.21)

$$\log(Oi/POi)$$

$$= \underset{(2.23578)}{0.34597} * \log(Si/POi)$$

$$- \underset{(2.03976)}{0.26358} * \log(IS_{-1}/Oi_{-1}) + \underset{(1.02158)}{0.01680} * T$$

$$- \underset{(1.93537)}{0.00038} * T^2 - \underset{(0.41279)}{0.16348} - \underset{(0.62883)}{0.00511} * S2$$

Sum Sq 0.0024 Std Err 0.0132 LHS Mean -0.0359
R Sq 0.8706 R Bar Sq 0.8243 F 5, 14 18.8304
D.W.(1) 3.1916 D.W.(2) 0.9234 Est. per. 1982:1-91:2

The results of estimation for only the second part of the sample appear to confirm the hypothesis of time-varying coefficients. This, however, need not really be the case. Our attempts to introduce a trendwise change in the coefficients in question or to make them a function of the smoothed stock/output ratio were completely unsuccessful. These coefficients do not seem to have changed in a gradual manner neither during the whole period 1970-91 nor during 1978-91.

Furthermore, the equation estimated for the shorter time period is, despite obvious differences, basically the same equation as the one estimated for the whole sample period. The coefficient for the sales/capacity ratio is now larger than the one for the stock/output ratio, but their order of magnitude has not changed (both coefficients are still greater than 0.2 and smaller than 0.4). The sales/output ratio is no longer lagged, but it obviously represents the same development as the lagged variable, although with differently dated turning points.

The equation estimated for the shorter period conforms better with our theoretical expectations of a significant *direct* linkage between demand and output. It appears that the prolonged liquidation of inventory stock has so severely distorted the relation between sales and output that it affected our estimates of the supply function for the whole estimation period. The relation could apparently be better estimated for the last ten years of the sample, though the precision of the estimates is affected by the small sample size.

The dynamic ex-post forecast for output in industry 1978-91, obtained from the latter equation, is depicted together with the actual output in Chart X.25. The desired inventory stock level 1978-91 implied by the equation is shown in Chart X.26.

CHART X.25 DYNAMIC FORECAST FOR VALUE ADDED IN INDUSTRY 1978-91
OBTAINED USING THE EQUATION ESTIMATED FOR 1982-91

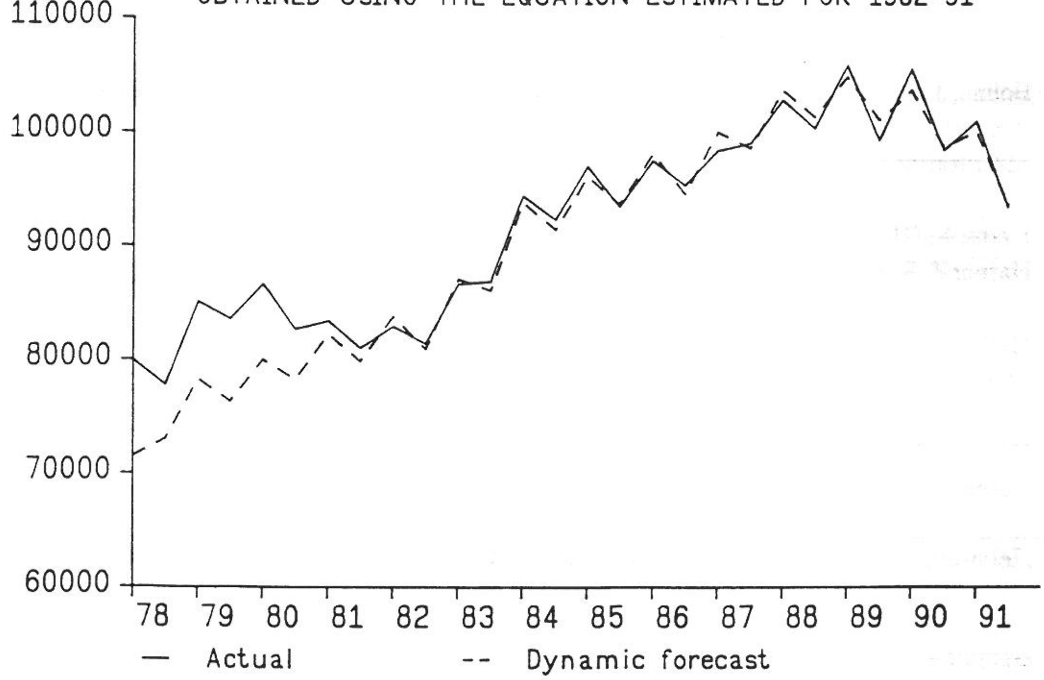
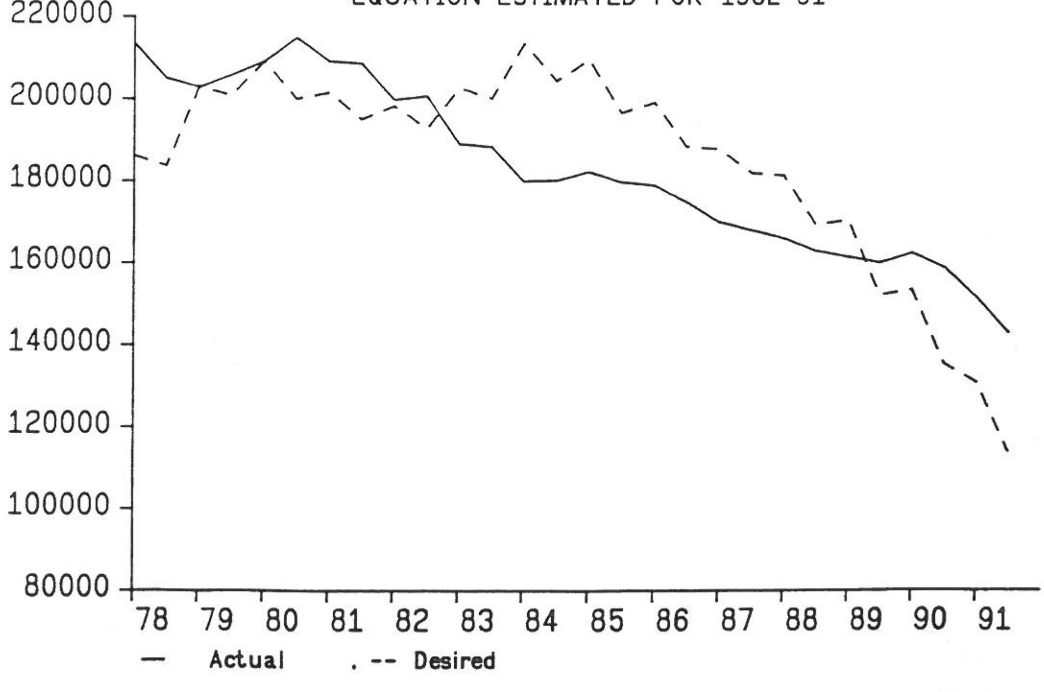


CHART X.26 DESIRED INVENTORY STOCK 1978-91 DERIVED FROM THE
EQUATION ESTIMATED FOR 1982-91



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Appendix. Definition of production profitability and relative yield

Production profitability is here measured as the ratio of "extraordinary" profits after tax to value added. "Extraordinary" profits are defined as gross trading surplus minus the imputed rental cost of the existing fixed capital stock. Thus, our profitability measure reflects profits net of long-run capital costs.

Gross trading surplus is computed using the "wage cost bill" (*kostnadslönesumma*), which is the wage bill adjusted for retroactive payments. The wage cost bill is, thus, the "long-run" wage bill at the current wage rate and with the current employment.

The production profitability formula has the following general form:

profitability = (1-tax rate)(value added-wage cost bill-rental cost of capital)/value added.

The tax rate employed is the effective corporate tax rate, rather than the statutory one. The effective tax rate allows for the fact that part of the profits are occasionally tax exempt. In practice, only the tax effects of the investment fund system have been accounted for.

Value added in KOSMOS is defined on a producer-price basis. This means that it includes indirect non-commodity taxes net of non-commodity subsidies[15]. The profitability measure involves value added defined on a factor-cost basis, i.e. excluding non-commodity taxes and subsidies.

In the National Accounts, the major[16] part of indirect non-commodity taxes is connected with wages and can therefore be considered as employers' contributions (*arbetsgivaravgifter*). The latter have traditionally been included in the wage bill and, thus, in the value added at factor cost. Since the share of taxes not connected with wages appears to be small in indirect non-commodity taxes, the whole variable is here treated as employers' contributions. In this way we hope to better reflect the employers' view of their wage costs. Consequently, value added at factor cost is obtained by addition of non-commodity subsidies only, indirect non-commodity taxes being assumed to be part of the wage bill.

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15 Icke varuanknutna indirekta skatter minus icke varuanknutna subventioner. Cf T. Nordström, "Definition av förädlingsvärde samt vinst- och löneandelar i KOSMOS", mimeo., Stockholm: National Institute of Economic Research, 1988-03-14.

16 Ibid.

The rental cost of capital is computed as the product the real capital stock and half of the rental rate. The capital rental cost rate is halved, since it is originally computed on an annual basis and the model is semi-annual.

Relative yield is here defined as the ratio of the yield on fixed assets to the yield on financial assets. The yield on fixed assets is measured as the ratio of net trading surplus (computed using the wage cost bill) to the value of fixed capital stock. The yield on financial assets is represented by the interest rate on five-year government bonds.

Since the interest rate is defined on an annual basis and the model is semi-annual, the annual yield on fixed capital is approximated by relating (the semi-annual) net trading surplus to *half* of the value of fixed capital stock.

The relative yield formula has the following general form:

relative yield=[1 + (value added-wage cost bill-depreciation of fixed capital)/(capital stock/2)]/(1 + interest rate).

SVENSK SAMMANFATTNING

Utbudssidan i Konjunkturinstitutets ekonometriska modell KOSMOS har konstruerats i enlighet med ansatsen i Kanis och Markowski [1990]. För var och en av de två privata sektorerna, Industri och Övrigt näringsliv, postuleras en CES produktionsfunktion. Efterfrågan på de två produktionsfaktorerna, kapital och arbete, härleds sedan ur denna funktion. Dessa efterfråge-samband utgör långsiktslösningar till de skattade ekvationerna för efterfrågan på kapital och arbete. Den totala kapital-stocken erhålls inom varje sektor genom aggregering av maskiner och byggnader med hjälp av en inre funktion av CES eller Leontief typ (jfr Kanis [1992]).

Den implicita långsiktiga produktionsfunktionen - vars numeriska form härleds ur de skattade efterfrågesambanden - används för att uppskatta kapacitetsutnyttjandegraden i varje sektor.

Produktionsbestämningen inom industrin antas vara till en viss grad skild från efterfrågebestämningen. Utbudet inom industrin påverkas av efterfrågan och relationen mellan den faktiska och den önskade lagerstocken. Lagerstocken har på kort sikt buffertrollen, d.v.s. lagerförändringen är lika med differensen mellan utbud och efterfrågan. På lång sikt bestäms lagerstocken av den önskade kvoten mellan lagerstocken och produktionen. Utbudet inom Övrigt näringsliv antas vara lika med efterfrågan.

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