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# CONSUMPTION AND INVESTMENT IN THE BOF4 QUARTERLY MODEL OF THE FINNISH ECONOMY

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ABSTRACT

This report describes the determination of private consumption and investment in the BOF4 model.

The consumption function of the model is largely based on the permanent income hypothesis. Relative prices and the level of aggregate consumption determine the shares of the three consumption subgroups included in the aggregate. The non-residential investment equations are derived from the capital owners' intertemporal profit maximization problem in accordance with the neoclassical investment theory. Modelling of residential investment is based on Tobin's q approach and that of inventories on the buffer stock-accelerator approach. The properties of the equations are illustrated by means of tables of dynamic elasticities throughout the paper.

CONTENTS

# 1 INTRODUCTION

The BOF4 model of the Finnish economy is a quarterly econometric model developed at the Bank of Finland for forecasting and policy analysis.[1] The present paper is part of a series intended to cover all sectors of the present version of BOF4.

This report continues the description of the determination of aggregate demand in the BOF4 model. Foreign trade was discussed in volume 3/88, and a report on public sector incomes and spending is forthcoming. We now focus on the determination of private consumption and investment in the model. The technology assumptions employed in deriving the investment equations have been reported in detail in volume 14/88.

First, the breakdown of aggregate demand and the relative size of the different components is described. Second, the aggregate private consumption function is derived and the disaggregation of private consumption into subgroups using a simple expenditure system is described.

Equations for non-residential private fixed investment, housing investment and inventory investment are derived in the third part of the paper. The properties of the estimated equations listed in the appendix are described by means of partial elasticities throughout the paper.

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[1]A preliminary list of the equations of BOF4 has been circulated in the Bank of Finland's research papers series TU 6/87. The earlier version of the model, BOF3, is documented in Tarkka and Willman (1985).

## 2 THE STRUCTURE OF AGGREGATE DEMAND

The relative significance of the private demand components dealt with in the present paper is set forth in the following table.

Table 1. The structure of aggregate demand less imports in 1985 according to the classification used in BOF4.

- 73.3 % total consumption
  - 72.7 % private consumption
    - 11.0 % durables
    - 35.4 % services
    - 53.6 % non-durables
  - 27.3 % public consumption
    - 33.6 % central govt.
    - 66.4 % local govt.
- 1.3 % inventory investment
- 23.3 % total fixed investment
  - 86.8 % private fixed investment
    - 70.0 % non-residential investment
      - 9.7 % agriculture
      - 3.2 % forestry
      - 27.6 % manufacturing
      - 59.5 % private services etc.
    - 30.0 % residential construction
  - 13.2 % public fixed investment
    - 36.0 % central govt. investment
    - 64.0 % local govt. investment
- 28.8 % exports
  - 84.0 % exports of goods
    - 75.8 % multilateral (west)
    - 24.2 % bilateral (east)
  - 16.0 % exports of services
- -27.8 % imports
  - 85.1 % imports of goods
    - 47.5 % raw materials excl. crude oil
    - 21.9 % crude oil, fuels & lubricants
    - 16.1 % consumption goods
    - 14.5 % investment goods
  - 14.9 % imports of services

In the first column of percentages, the relative sizes of the different components are given as per cent of GDP in purchasers' values (incl. the statistical discrepancy). In the other columns, the percentages indicate relative shares in the next higher aggregate.

Altogether, there are 16 categories of aggregate demand and 5 categories of imports. Of these, only three are exogenous, namely central government consumption and both categories of public fixed investment (central and local government). All other items have their own behavioural equations in the model.

## 3 PRIVATE CONSUMPTION

Three categories of private consumption are distinguished in BOF4: durable goods, services and a residual category consisting of nondurable and semidurable goods. This disaggregation is useful mainly because different consumption categories have different import propensities and different treatment in indirect taxation. Furthermore, the structure of consumption has, of course, an effect on how aggregate demand is allocated among the different production sectors of the economy.

The model has an aggregate consumption function determining private consumption as a whole. Its disaggregation into the three subgroups is achieved by three equations forming a highly simplified "expenditure system".

### 3.1 The Consumption Function

The consumption function is shown as equation C.1 (page 31) in the equation list. The specification is close to that included in the previous BOF3 version of the model (see Tarkka & Willman (1985)). According to the equation, consumption is a loglinear function of real disposable income, liquid assets, inflation, the interest rate on tax-free bonds and past consumption. The specification is perhaps best understood in the light of the permanent income hypothesis originally developed by Friedman (1957). In the following we briefly review the theoretical foundations of the equation. For a more thorough survey of the subject, see e.g. King (1985) and the literature cited therein.

The permanent income hypothesis is based on the notion that if consumers have access to a well-functioning capital market, the timing of their lifetime earnings is irrelevant to their consumption decisions. Only the discounted present value of consumers' present and future income matters for optimal consumption decisions.

The concept of permanent income is a way of summarizing households' expectations concerning their future disposable income as a single number. Permanent income may be defined as the constant income level which has the same discounted present value as the expected future incomes of currently living households. According to the permanent income theory of consumption, private consumption is determined by permanent income:

(1) $$\log C = \log k + \log Y^{p}$$

where C is (real) consumption and $Y^{p}$ is (real) permanent income and k is a factor of proportionality which depends at least on the real rate of interest and the subjective rate of time preference (impatience). If the rate of time preference is independent of the level of consumption, k is independent of $Y^{p}$. Otherwise, unit elasticity of consumption with respect to permanent income as implied by (1) does not hold.

To make the permanent income model operational, assumptions must be made on how expectations concerning future incomes and real interest rates are formed. In BOF4 we make the following assumptions:

1. Income expectations are adaptive:

(2) $$\log Y^{p} = a \cdot \log Y + (1-a) \cdot \log Y^{p}_{-1} + b$$

See, e.g., Muth (1960). The constant term adjusts permanent income for a possible trend in actual income. Without a constant term and with growing actual income, the adaptive scheme (2) would lead to permanent income being systematically lower than actual income.

2. Expectations concerning the long-run average level of the real rate of interest are adaptive with the same adaptation parameter a as in (2):

$$r^e = a \cdot (i - inf^e) + (1 - a) \cdot r^e_{-1}, \tag{3}$$

where i is the after-tax bond rate, $r^e$ is the expected real interest rate, and $inf^e$ is the expected 12-month rise in consumer prices.

To obtain a proxy for expected inflation, we estimated a loglinear function of actual inflation and the divergence of prices in manufacturing from competitors' prices on foreign markets. The estimated equation is presented as equation C.15 in the appendix. In the private consumption equation, expected inflation is measured by a moving average of the model's inflation expectations proxy.

Still assuming that the effect of the expected real interest rate on k in equation (1) can be linearized, the above assumptions allow us to write the following "permanent income-adaptive expectations" model:

$$\log C = c_1 \cdot \log Y - c_2 \cdot (i - inf^e) + c_3 \cdot \log C_{-1} + c_4 \tag{4}$$

This served as a basis for the consumption equation of the BOF4 model. However, the actual equation contains some (three) additional elements which are found to be empirically important and which seem to take into account effects neglected by the basic permanent income theory.

These added terms are the following:

- A liquidity variable (the ratio of currency and deposits to disposable income) may capture liquidity effects which are assumed away by the assumption of perfect capital markets in the simplest permanent income theory.

- A variable measuring unexpected inflation, which was originally proposed by Deaton (1977). This affects consumption negatively. Deaton attributed this empirically rather robust effect to the informational difficulty of separating inflation from relative price changes. It is also possible that what is observed is in fact the real balance effect of unexpected inflation on the real value of household assets denominated in nominal terms.

- In the adaptive income expectations mechanism, the observed actual income was operationalized by including both lagged and current income in the equation, as if real income were in fact observed with a mean lag of half a quarter.

The properties of the consumption function of the BOF4 model can be characterized by the dynamic elasticities of consumption with respect to changes in real income, the rate of interest, liquidity and the general level of prices (incl. nominal incomes and money balances). These elasticities are summarized in table 2.

Table 2. Dynamic Elasticities of Private Consumption According to Equation C.1.

| Variable | Immediate Elasticity | One-year Elasticity | Long-run Elasticity |
|---|---|---|---|
| 1. Real income | 0.27 | 0.60 | 0.81 |
| 2. Real liquid assets | 0.00 | 0.08 | 0.14 |
| 3. Both above | 0.27 | 0.68 | 0.94 |
| 4. Real interest rate | 0.00 | -0.05 | -0.09 |
| 5. Inflation surprise | -0.31 | -0.12 | 0.00 |

Line 3 shows an income elasticity computed on the assumption that the ratio of liquid assets to income is constant. The one-year elasticities in the table are average effects during the first year.

The elasticity with respect to the interest rate is a "semi-elasticity": the percentage effect on consumption of a one percentage point change in the relevant rate.

As regards the results presented in the table, the following observations should be made. First, the long-run income elasticity is somewhat less than one, which points to non-homotheticity of households' preferences, so that the rate of time preference - or "impatience" - would be greater at lower levels of consumption. Second, the effect of the real rate of interest on consumption is weak. (In the estimated equation it is also statistically insignificant.) Third, inflation has negative short-run effects on consumption, which disappear only slowly over a period of two years or so. The equation has, however, been constructed so that in the long run pure inflation has no effects on consumption (or saving).

## 3.2 Division of Consumption into Subgroups

The starting point for the specification of the demand functions for the three consumption subgroups are static, constant-elasticity demand functions of the form

$$\text{(5)} \qquad \log C^i = a + b \cdot \log C - \log (P^i/PCP)$$

where $C^i$ is consumption of goods in category i, C is total private consumption, $P^i$ is the price index for goods in category i and PCP is the price index for total private consumption.

A well-known problem with demand systems consisting of equations like (5) is that they do not satisfy "the adding-up criterion", according to which the sum of $C^i$'s must be equal to C. To remedy this problem one has to resort either to the so-called Rotterdam approximation or to compute one of the categories as a residual, thus forgoing the constant-elasticity assumption for that category. The latter approach was followed in BOF4. Thus, the largest of the consumption categories, semi-durables and non-durables, is residually determined by subtracting from total private consumption the consumption of durables and services.

In the model the division of consumption into subgroups is achieved by equations C.2, C.3 and C.4. The income and price elasticities of the simple "expenditure system" of the BOF4 model are presented in table 3. "Income elasticities" refer to elasticities of demand for different consumption categories with respect to changes in total private consumption. There are two different concepts of own-price elasticity of demand: compensated price elasticity measures the effect of a change in the price of a good on the demand for it when real income (or real total consumption) is held constant; uncompensated elasticity, which is the other concept of price elasticity, measures the effect on demand when nominal income (nominal total consumption) is held constant. Both compensated and uncompensated elasticities are reported in the table.

Table 3. Demand Elasticities of Consumption Subgroups

| Category of goods | Income elasticity | Compensated price el. | Uncompensated price el. |
|---|---|---|---|
| Services | 1.25 | -0.36 | -0.80 |
| Durables | 1.40 | -1.19 | -1.31 |
| Other goods | 0.75 | -0.26 | -0.66 |

For a comprehensive discussion on expenditure systems and elasticities of demand, see, e.g., Deaton and Muellbauer (1980).

# 4 FIXED INVESTMENT

There are five categories of private fixed investment in BOF4. Non-residential investment is modelled separately for each of the four privately-operated production sectors and residential construction constitutes the fifth category.

## 4.1 Non-residential Private Fixed Investment

The productive, or non-residential, investment functions are reported as equations I.1, I.3, I.5 and I.7 for agriculture, private services, forestry and manufacturing, respectively. The theoretical foundation of these equations is the neoclassical investment theory as developed by Jorgenson (1963), Lucas (1967), Gould (1968) and Abel (1980).

Investment is viewed as a result of demand for fixed capital in production. The crucial parts of the analysis of the demand for capital are: (1) the prevailing production technology; (2) the form of adjustment costs arising from changing the stock of capital; (3) the price elasticity of the demand curve faced by firms in the market where they sell their output; (4) the corporate tax system.

The investment equations of BOF4 are derived from the capital owners' intertemporal profit maximization problem. Firms are assumed to maximize the discounted present value of their profits. The maximization problem may be written as follows:

(6) $$\max \sum_{t=0}^{\infty} (1+i-\Delta \log P^k)^{-t} \cdot PROFIT_t$$

$$PROFIT = (P^y/P^k) \cdot Y - (W/P^k) \cdot L - UC \cdot K - A(K, K_{-1})$$

$$Y = CES(K, L, TIME) \qquad \text{(production function)}$$

$$Y = D(P^y, P^c, Z) \qquad \text{(firm-level demand for output)}$$

where $A(K, K_{-1})$ is the real adjustment cost function and $D(P^y, P^c, Z)$ is the firm-level demand for output, which is a function of the selling price, the average price in the market and other factors, respectively. A first-order condition for the profit-maximizing capital accumulation program is now given by the following Euler equation:

$$(7) \qquad \partial A/\partial K = (P^y/P^k)\cdot(1+1/E)\cdot MPK - UC - (1+i-\Delta \log P^k_{+1})\cdot \partial A_{+1}/\partial K$$

Here E is the price elasticity of the firm-level demand for output, which is infinite in the case of perfect competition. MPK is the marginal product of capital function through which the production technology affects the investment program. UC is the real user cost of capital, which includes the effects of the expected real rate of interest and the corporate tax system. $\partial A/\partial K$ and $\partial A_{+1}/\partial K$ are the marginal adjustment costs incurred in the current and next period, respectively, of increasing the stock of capital in this period. We now discuss each of these terms of the Euler equation in turn.

The technology assumptions employed in BOF4 are specified by the production functions reported in volume 14/88 of this series. The CES "putty-putty" production functions of the four private sectors of production imply real marginal product of capital functions of the type

$$(8) \qquad MPK^i = C\cdot(GDP^i/KF^i_{-1})^r\cdot \exp(0.01\cdot g\cdot TIME)$$

where $MPK^i$ is the marginal product of capital in sector i, $GDP^i$ is the real value added produced in sector i and $KF^i$ is the stock of fixed capital in sector i (lagged one quarter in the MPK function). The parameter values of this function applicable to the different sectors are indicated in the following table. The marginal and average products of capital in 1985 are also presented in the table (in annualized rates).

Table 4. The Parameters of the Marginal Product of Capital Function in the Different Production Sectors and Estimated Real Marginal and Average Products in 1985.

| Sector | C | r | g | MPK | APK |
|---|---|---|---|---|---|
| Agriculture | 0.68 | 1.03 | 0.00 | 0.17 | 0.26 |
| Forestry | 0.33 | 0.67 | 0.10 | 0.24 | 0.62 |
| Manufacturing | 0.49 | 1.14 | -0.44 | 0.28 | 0.59 |
| Private services etc. | 0.85 | 1.61 | -1.94 | 0.32 | 0.54 |

The fixed capital stock concept used in BOF4 corresponds fairly closely to the "net fixed capital stock" of the Finnish Central Statistical Office. Further, it should be noted that the linear time trend variable TIME, which captures the effect of technical progress, increases by 0.25 units per quarter and thus by one unit yearly. In calculating the marginal product of capital for the private services sector, the stock of residential capital is excluded from the capital stock and the value added originating from the ownership of dwellings is also excluded from the GDP concept.

The real user cost of fixed capital is defined by equations I.2, I.4, I.6 and I.8 for the different sectors. User costs are calculated using the standard "Jorgensonian" formula (for a review of the concept and estimation of the user cost of capital, see Koskenkylä (1985)).

$$(9) \qquad UC = (i - inf^e + d)\cdot(1 - tc\cdot td/(i+td))/(1-tc)$$

where i is the nominal rate of interest (market yield on tax-free bonds), $inf^e$ is expected inflation, d is the rate of depreciation of capital, tc is the corporate income tax rate and td is the tax depreciation coefficient, which is infinite in the case of free tax depreciation. For the agricultural sector, in which the owners of fixed capital are typically private households, the marginal personal tax rate was used in the user cost formula instead of the corporate tax rate. BOF4 includes two tax depreciation allowance parameters (td in the formula): one for manufacturing and another for the other sectors.

"Adjustment costs" are a broad category of costs arising from planning, installment and gestation of new structures and equipment. In the neoclassical capital theory adjustment costs are needed to ensure that the flow of new investment is finite even when the marginal product of capital differs from the marginal cost of capital. The form of the adjustment cost function is one of the main determinants of the form of the investment function. Particularly elegant results are obtained in the case of translog adjustment costs:

$$A = (a/2) \cdot \Delta K \cdot \Delta \log K \tag{10}$$

This specification, which is also used in BOF4, yields the following partial derivatives $\partial A/\partial K$ and $\partial A_{+1}/\partial K$ for the Euler equation:

$$\partial A/\partial K = (a/2) \cdot (\Delta \log K + (K-K_{-1})/K) \approx a \cdot \Delta \log K \tag{11}$$

$$\partial A_{+1}/\partial K = -(a/2) \cdot (\Delta \log K + (K-K_{-1})/K_{-1}) \approx -a \cdot \Delta \log K \tag{12}$$

So the Euler equation may be written as:

$$a \cdot \Delta \log K = a \cdot (1/(1+r^e)) \cdot \Delta \log K_{+1} + (P^y/P^k) \cdot (1+1/E) \cdot MPK - UC \tag{13}$$

Here the optimal current increase in the capital stock is given as a function of the present difference of the marginal product and user cost of capital, as well as the optimal increase in capital in the next period. By successive substitutions, the Euler equation (13) may be solved to yield

$$\Delta \log K = 1/a \cdot \sum_{t=0}^{\infty} (1+r^e)^{-t} \cdot ((P^y/P^k) \cdot (1+1/E) \cdot MPK - UC) \tag{14}$$

Of course, (14) is not yet a complete solution since the marginal product of capital variable MPK is still a function of K. The right-hand side of the equation is the present value of the expected marginal quasi-rent on fixed capital. Denoting this by $QR^e$, the Euler equation may be written as

(15) $\Delta \log K = 1/a \cdot (QR^e)$

With adaptive expectations of the quasi-rent, as in the presentation of the permanent income model, this gives

(16) $\Delta \log K = g/a \cdot ((P^y/P^k) \cdot (1+1/E) \cdot MPK - UC) + g \cdot \Delta \log K_{-1}$

This is the basis of the investment equations of the model (see appendix). The dependent variable of the equations is $I/K_{-1}+d = \Delta \log K$. In developing the actual functional forms of the estimated equations, perfect competition was assumed to prevail in manufacturing and forestry, implying $(1+1/E)=1$. In services and agriculture, a finite firm-level price elasticity of demand was allowed. This means that the coefficients of $(P^y/P^k) \cdot MPK$ and $-UC$ can not be restricted to be equal and have to be estimated separately.

The dynamics of the equations in the model are a little more general than in (16). In particular, it turned out that in the services sector the data favoured the inclusion of a yearly difference in UC as an additional explanatory variable. This makes the impact of capital costs on investment emerge somewhat slower than in the basic specification (16). In manufacturing, the inclusion of a two-quarter lag of investment and an accelerator term (log change of output) in the equation was found to improve the stochastic properties of the equation significantly. These additions do not alter the long-run properties of the equations.

The dynamic properties of the investment equations can be analyzed with the help of price and output elasticities. The elasticities of demand can be computed for the flow of gross investment and for the stock of fixed capital; of these, the former has perhaps more practical interest from the demand management angle whereas the latter is probably more meaningful from the analytical point of view. The elasticities for the flows are reported in the following tables, while the elasticitics for the stocks are reported in Appendix 1. It should be borne in mind that these elasticities are strictly partial in the sense that prices and output volumes are kept exogenous. The only feedback which is taken into account is that due to the capital accumulation equations $\Delta K = I - d \cdot K_{-1}$ (these are equations I.24 to I.31 in the list).

Table 5. Dynamic Output Elasticities of Gross Fixed Investment

| | Time span of the elasticity (years) | | | |
|---|---|---|---|---|
| Sector | 0 | 1 | 5 | 10 |
| Agriculture | 0.11 | 0.17 | 0.25 | 0.29 |
| Forestry | 0.07 | 0.15 | 0.58 | 0.69 |
| Manufacturing | 1.10 | 1.03 | 1.60 | 1.28 |
| Private services etc. | 0.42 | 0.73 | 1.28 | 1.16 |
| Total | 0.60 | 0.75 | 1.21 | 1.08 |

To summarize table 5, the average long-run output elasticity of private gross fixed investment is about one. As can be expected, the lowest elasticity is in agriculture and the highest in manufacturing.

The cost of capital has two components, the user cost of financial capital and the price of capital goods. These have different effects on investment in the model, as shown in the following tables.

Table 6. Dynamic Price Elasticities of Gross Fixed Investment With Respect to the Real User Cost of Financial Capital

| | Time span of the elasticity (years) | | | |
|---|---|---|---|---|
| Sector | 0 | 1 | 5 | 10 |
| Agriculture | 0.00 | -0.00 | -0.23 | -0.22 |
| Forestry | 0.01 | -0.01 | -0.49 | -0.46 |
| Manufacturing | -0.02 | -0.08 | -1.20 | -0.90 |
| Private services etc. | 0.00 | 0.00 | -0.38 | -0.21 |
| Total | -0.01 | -0.02 | -0.57 | -0.38 |

Table 7. Dynamic Price Elasticities of Gross Fixed Investment With Respect to the Real Price of Capital Goods

| | Time span of the elasticity (years) | | | |
|---|---|---|---|---|
| Sector | 0 | 1 | 5 | 10 |
| Agriculture | -0.11 | -0.16 | -0.22 | -0.28 |
| Forestry | -0.11 | -0.22 | -0.75 | -1.01 |
| Manufacturing | -0.08 | -0.16 | -0.76 | -1.11 |
| Private services etc. | -0.23 | -0.40 | -0.61 | -0.63 |
| Total | -0.17 | -0.30 | -0.62 | -0.73 |

As can be seen from tables 6 and 7, the investment in the open sectors of the economy, manufacturing and forestry, is much more price-elastic than in the closed sectors. The figures in table 7 can also be interpreted as elasticities with respect to the value added deflator, omitting only the minus signs.

The elasticities are not quite independent of the levels and growth rates of the variables involved, since the equations are not loglinear in variables. The above tables are based on data for the period 1975 - 1985. The capital depreciation coefficients also have an influence on the results. Capital depreciation (consumption) rates are exogenous variables in BOF4. In 1985 the annual rates were as shown in the following table.

Table 8. Depreciation Rates of Fixed Capital in 1985 (annual rates)

| | |
|---|---|
| Agriculture | 8.43 % |
| Forestry | 8.41 % |
| Manufacturing | 8.08 % |
| Private services etc. | 7.88 % |

The 1985 figures in the depreciation rate table give a fairly good idea of the situation in other years too, since in the estimates of the Central Statistical Office (on which the above numbers are based) the depreciation rates do not change much over time.

A much discussed property of the investment functions is the elasticity with respect to changes in the rate of interest. In a way this is captured by the elasticity with respect to the real user cost of capital (table 6), but in practice the conversion from the user cost elasticity to interest rate elasticity is not straightforward owing to the complexity of the formula for user cost. To facilitate interpretation, we present the semi-elasticities of the sectoral user costs with respect to the rate of interest in table 9. One can easily obtain the semi-elasticities of investment with respect to the interest rate by multiplying the user cost elasticities in table 6 by the figures in table 9.

Table 9. Semi-elasticities of the Sectoral User Costs of Capital with respect to the After-tax Rate of Interest. 1980 - 1985 averages.

| | |
|---|---|
| Agriculture | 12.0 |
| Forestry | 12.2 |
| Manufacturing | 12.2 |
| Private services etc. | 12.7 |

### 4.2 Housing Investment

The specification of the equation for housing investment has not been changed much from the previous version of the model (see Tarkka & Willman, 1985).

Housing investment is implicitly divided into two parts, state--financed and freely-financed production of dwellings. The former is assumed to to be directly proportional to the amount of central government finance used, while the latter is based on the Tobin's "q" approach to investment, i.e the construction of new dwellings is a function of the market price of dwellings relative to their production costs (Tobin (1969)). Hence the following relation for housing investment IH can be written:

(17) $IH = a \cdot (FH/PIH) + b \cdot [\log(PH/PIH)] \cdot KH$

where FH is the flow of government housing loans, PIH the index of housing construction costs, PH the index of the market price of dwellings and KH the stock of dwellings. In (17) KH is used as a proxy for housing construction capacity.

In the estimated equation (I.9) the market price of dwellings has been reduced to its determinants as follows. First, the market price of dwellings, including of course newly produced dwellings, is equal to the discounted present value of the price of housing services (an imputed rent or user cost concept) as

(18) $PH = PCH/r^e$

where PCH is the price of housing services and $r^e$ refers to an expected long-term real after-tax rate of interest faced by households. In the model this is assumed to be a linear function of the present real after-tax rate on bank loans (note that the Finnish housing loan system has traditionally been based mainly on variable-rate contracts).

Secondly, the interaction of the demand for housing and the existing stock of housing units determines the price of housing services PCH. The households demand housing services provided by the stock of residential capital. In the consumption block of BOF4, the demands for different subcategories of consumption were specified to be loglinear functions of total private consumption and the price of the particular consumption category relative to the overall private consumption deflator. In deriving the housing investment equation we have not estimated the price and income elasticities of the demand for housing services. Instead, we have utilized estimates published by Virén (1983). He presents an income elasticity of 1.0213 and an uncompensated price elasticity of -0.7373. These imply a compensated price elasticity of -0.5538 (the buget share of housing costs being 18 % on average). If the supply of housing services is proportional to the stock of residential capital, these elasticities imply the following equation for the price of housing services:

(19) $\log PCH = \log PCP + 1.844 \cdot \log C - 1.806 \cdot \log KH + \text{constant}$

where PCP is the deflator of private consumption and C is the volume of private consumption.

The estimated equation (I.9) was obtained after substituting equations (18) and (19) into (17) and including a partial adjustment mechanism in the reactions of construction to changes in the housing market.

Possible credit rationing effects are captured by an ad hoc varible defined as the difference between the bank loan rate and the short-term money market rate.

The properties of the residential construction equation are described in the following table with the help of "income" (consumption), price and interest rate elasticities of housing investment. The interest rate elaticities are semi-elasticities with respect to a one percentage point change in all interest rates.

Table 13. Elasticities of Residential Construction

| Variable | Immediate elasticity | One-year elasticity | Long-run elasticity |
|---|---|---|---|
| Consumption | 0.29 | 0.45 | 0.95 |
| Building costs | -0.25 | -0.44 | -0.67 |
| Interest rate | 0.00 | -0.22 | -0.67 |

The elasticities are evaluated from data for the period 1975 - 1985, and the dependence of the stock of residential capital on investment is taken into account.

## 5 INVENTORY INVESTMENT

Inventory investment is treated as a single aggregate in BOF4. No disaggregation into, say, raw materials and finished goods or by production sectors is attempted. The equation is almost exactly the same as in BOF3 (see Tarkka & Willman, 1985).

The inventory investment equation is based on the buffer stock-accelerator approach. Firms are seen to operate under demand uncertainty. Both production and storage costs are assumed to be convex functions of output and the level of inventories, repectively. In these circumstances it is optimal for firms to absorb part of the demand shocks by selling from inventories (in the case of a positive demand surprise) or by accumulating them (in the case of a negative demand surprise). This allows the firm to produce more economically by smoothing the time profile of output.

Application of dynamic optimization to the problem sketched out above (see Tarkka & Willman, 1985, pp. 148 - 152 and 175 - 177 for details) yields the following inventory equation:

$$(20) \qquad \Delta KI = s \cdot KI^{*} + s \cdot KI_{-1} + s \cdot (SALE^{*} - SALE)$$

where KI is the stock of inventories, $KI^{*}$ is the optimal long-run stock of inventories (in the sense that the cost of holding and managing inventories is minimized), SALE is sales of storable goods (which is equal to the production of storables less inventory change) and $SALE^{*}$ is the expected long-run normal level of sales.

The optimal level of inventories is specified as:

$$(21) \qquad K^{*} = (a + a \cdot r^{e}) \cdot SALE^{*}$$

Where $r^{e}$ is the expected real rate of interest. Equation (21) implies that in equilibrium, when sales are at their normal level and all inventory adjustments in response to past demand shocks have been completed, the turnover time of inventories ($K^*/SALE^*$) is a linear function of the real rate of interest. Assuming that the expected long-run normal level of sales and the expected real rate of interest are adjusted adaptively, inventory investment can be written as a function of current and lagged sales, the real rate of interest scaled by the sales variable, the inherited (lagged) level of inventories and the lagged inventory change (see equation I.10 of the model).

In the equation, the sales variable is calculated from the final demand components by subtracting from the total final demand the consumption of services, government consumption and imports of goods. Adjustment is also made for the difference between production and final demand figures caused by net indirect taxes and the national accounts statistical discrepancy.

In other investment equations of the BOF4 model, inflation expectations were operationalized using a special variable related to consumer prices. In inventory investment, however, better results were obtained with a lagged rise in import prices.

According to the equation, 64 per cent of changes in sales are absorbed by inventory changes in the quarter when they occur. This means that the immediate reaction of production to demand changes is only 36 per cent. Inventory adjustments are, however, only temporary, and in the longer run the production of storables must respond fully to permanent changes in sales. It takes three quarters of a year before production grows to the level corresponding to increased demand. Thereafter production slightly exceeds the level of sales until inventories have grown to the new target level. In all, this adjustment process takes about 7 years before being completed. Thus inventories partly neutralize the transmission of random variations in the demand for storable goods to production.

The estimated interest rate sensitivity of inventory demand is modest from the macroeconomic point of view: an increase of one percentage point in the real rate of interest causes an immediate reduction in inventory investment of only 0.08 per cent of sales (150 millions of 1985 FIM). The response is somewhat larger in the medium run and decreases again in the long run as the adjustment of the inventory stock to the change in the real rate of interest approaches completion.

APPENDIX 1

Table 1. Dynamic Output Elasticities of the Stock of Capital

| | Time span of the elasticity (years) | | |
|---|---|---|---|
| Sector | 1 | 5 | 10 |
| Agriculture | 0.01 | 0.07 | 0.16 |
| Forestry | 0.01 | 0.13 | 0.35 |
| Manufacturing | 0.03 | 0.49 | 0.86 |
| Private services etc. | 0.05 | 0.42 | 0.77 |
| Total | 0.04 | 0.38 | 0.70 |

Table 2. Dynamic Price Elasticities of the Stock of Capital With Respect to the Real User Cost of Financial Capital

| | Time span of the elasticity (years) | | |
|---|---|---|---|
| Sector | 1 | 5 | 10 |
| Agriculture | 0.00 | -0.04 | -0.10 |
| Forestry | 0.00 | -0.10 | -0.23 |
| Manufacturing | 0.00 | -0.24 | -0.51 |
| Private services etc. | 0.00 | -0.07 | -0.12 |
| Total | 0.00 | -0.12 | -0.22 |

Table 3. Dynamic Price Elasticities of the Stock of Capital With Respect to the Real Price of Capital Goods

| | Time span of the elasticity (years) | | |
|---|---|---|---|
| Sector | 1 | 5 | 10 |
| Agriculture | -0.01 | -0.07 | -0.15 |
| Forestry | -0.01 | -0.20 | -0.50 |
| Manufacturing | -0.01 | -0.21 | -0.57 |
| Private services etc. | -0.03 | -0.22 | -0.41 |
| Total | -0.02 | -0.20 | -0.43 |

APPENDIX 2

C. KULUTUS
CONSUMPTION

C.1 Yksityisen kulutuksen määrä
Total Private Consumption, Volume

$$\log C = \underset{(0.4034)}{3.05838}$$

$$+ \underset{(0.0668)}{0.35939} \cdot \Delta\log(YD/PCP)$$

$$+ \underset{(0.0817)}{0.60266} \cdot \log(YD_{-1}/PCP_{-1})$$

$$+ \underset{(0.0849)}{0.36032} \cdot \log C_{-1}$$

$$- \underset{(0.1476)}{0.40031} \cdot (\log(PCP/PCP_{-1}) - INFL/4)$$

$$- \underset{(0.0430)}{0.05606} \cdot (RB_{-1}/100 - INFL)$$

$$+ \underset{(0.0333)}{0.08695} \cdot \log[(CUR_{-1} + KDP_{-1})/YD]$$

where $INFL = 0.4 \cdot INF_{-1} + 0.3 \cdot INF_{-2} + 0.2 \cdot INF_{-3} + 0.1 \cdot INF_{-4}$

$\bar{R}^2 = 0.997$ DW = 2.127 SE = 0.0129 63.1 - 85.4

| | |
|---|---|
| C | Total private consumption, millions of 1985 FIM |
| CUR | Currency in circulation, FIM million |
| INF | Expected inflation over four periods, per cent |
| KDP | Bank deposits by the public, FIM million |
| PCP | Private consumption prices, 1985 = 100 |
| RB | Market yield on tax-free bonds, per cent |
| YD | Household disposable income, FIM million |

C.2 Yksityisen kulutuksen määrä, palvelukset ym.
Private Consumption, Services, Volume

$$\log CS = \underset{(0.1924)}{-\,3.68074} + \underset{(0.0185)}{1.24514} \cdot \log C - \underset{(0.1989)}{0.36430} \cdot \log(PCS/PCP)$$

$\bar{R}^2 = 0.997$ RHO = 0.610 SE = 0.0187 61.1 - 85.4

C.3 Yksityisen kulutuksen määrä, kestokulutustavarat
Private Consumption, Durables, Volume

$$\log CD = \underset{(0.7850)}{-\,6.46462} + \underset{(0.0737)}{1.39808} \cdot \log C - \underset{(0.1894)}{1.19498} \cdot \log(PCD/PCP)$$

$\bar{R}^2 = 0.952$ DW = 1.538 SE = 0.1059 61.1 - 85.4

C.4 Yksityisen kulutuksen määrä, lyhytikäiset ja puolikestävät tavarat
Private Consumption, Non-Durables and Semi-Durables, Volume

CND = C - CD - CS

| | |
|---|---|
| C | Total private consumption, millions of 1985 FIM |
| CD | Private consumption, durables, millions of 1985 FIM |
| CND | Private consumption, non-durables and semi-durables, millions of 1985 FIM |
| CS | Private consumption, services, millions of 1985 FIM |
| PCD | Private consumption prices, durables, 1985 = 100 |
| PCP | Private consumption prices, 1985 = 100 |
| PCS | Private consumption prices, services, 1985 = 100 |

C.5 Julkisen kulutuksen määrä
Total Public Consumption, Volume

CG = CCG + CLG

C.6 Kulutuksen määrä
Total Consumption, Volume

CTOT = C + CG

C.7 Yksityisen kulutuksen arvo
Total Private Consumption, Value

CV = CSV + CDV + CNDV

C.8 Yksityisen kulutuksen arvo, palvelukset
Private Consumption, Services, Value

CSV = CS • PCS/100

C.9 Yksityisen kulutuksen arvo, kestokulutustavarat
Private Consumption, Durables, Value

CDV = CD • PCD/100

C.10 Yksityisen kulutuksen arvo, lyhytikäiset ja puolikestävät tavarat
Private Consumption, Non-Durables and Semi-Durables, Value

CNDV = CND • PCND/100

| | |
|---|---|
| C | Total private consumption, millions of 1985 FIM |
| CCG | Central government consumption, millions of 1985 FIM |
| CD | Private consumption, durables, millions of 1985 FIM |
| CDV | Private consumption, durables, FIM million |
| CG | Total public consumption, millions of 1985 FIM |
| CLG | Local government consumption, millions of 1985 FIM |
| CND | Private consumption, non-durables and semi-durables, millions of 1985 FIM |
| CNDV | Private consumption, non-durables and semi-durables, FIM million |
| CS | Private consumption, services, millions of 1985 FIM |
| CSV | Private consumption, services, FIM million |
| CTOT | Total consumption, millions of 1985 FIM |
| CV | Total private consumption, FIM million |
| PCD | Private consumption prices, durables, 1985 = 100 |
| PCND | Private consumption prices, non-durables and semi-durables, 1985 = 100 |
| PCS | Private consumption prices, services, 1985 = 100 |

C.11 Valtion kulutusmenojen arvo
Central Government Consumption, Value

$$CCGV = CCG \cdot PCCG/100$$

C.12 Kuntien kulutusmenojen arvo
Local Government Consumption, Value

$$CLGV = CLG \cdot PCLG/100$$

C.13 Julkisen kulutuksen arvo
Total Public Consumption, Value

$$CGV = CCGV + CLGV$$

C.14 Kulutuksen arvo
Total Consumption, Value

$$CTOTV = CV + CGV$$

C.15 Odotettu inflaatio
Expected Inflation

$$INF = \underset{(0.0115)}{0.00217} + \underset{(0.0912)}{0.83559} \cdot \log(PCP/PCP_{-4}) + \underset{(0.0735)}{0.23150} \cdot \log(PFXG/P4)$$

where INF = $\log(PCP_{+4}/PCP)$ at estimation.

$\bar{R}^2 = 0.557$ DW = 0.371 SE = 0.0276 69.1 - 85.4

| | |
|---|---|
| CCG | Central government consumption, millions of 1985 FIM |
| CCGV | Central government consumption, FIM million |
| CGV | Total public consumption, FIM million |
| CLG | Local government consumption, millions of 1985 FIM |
| CLGV | Local government consumption, FIM million |
| CTOTV | Total consumption, FIM million |
| CV | Total private consumption, FIM million |
| PCCG | Central government consumption prices, 1985 = 100 |
| PCLG | Local government consumption prices, 1985 = 100 |
| PCP | Private consumption prices, 1985 = 100 |
| PFXG | Competitors' prices on foreign markets, 1985 = 100 |
| P4 | Prices in manufacturing, 1985 = 100 |

# I. INVESTOINNIT JA PÄÄOMAKUSTANNUKSET
INVESTMENT AND CAPITAL COSTS

## I.1 Kiinteiden investointien määrä, maatalous
Private Fixed Investment, Agriculture, Volume

$$
\begin{aligned}
IF1/KF1_{-1} - CCR1 = & - \underset{(0.0023)}{0.00367} \\
& + \underset{(0.0103)}{0.01216} \cdot (4 \cdot MPK1 \cdot PGDP1/PIF1) \\
& - \underset{(0.0047)}{0.00990} \cdot (UC1_{-4}/PIF1_{-4}) \\
& + \underset{(0.1093)}{0.48181} \cdot (IF1_{-1}/KF1_{-2} - CCR1_{-1}) \\
& + \underset{(0.0001)}{0.00020} \cdot (TREND + TREND74)
\end{aligned}
$$

where $MPK1 = 0.6826 \cdot (GDP1/KF1_{-1})^{1.0281}$

$\bar{R}^2 = 0.437$  DW = 2.043  SE = 0.0013  70.1 - 85.4

## I.2 Pääoman laskennallinen vuokra, maatalous
User Cost of Fixed Capital, Agriculture

$$
\begin{aligned}
UC1 = & PIF1 \cdot (RB/100 + 4 \cdot CCR1 - INF) \cdot \\
& ((1 - MTAX \cdot ALFA/(RB/100 + ALFA))/(1 - MTAX))
\end{aligned}
$$

| | |
|---|---|
| ALFA | Tax Depreciation coefficient |
| CCR1 | Capital consumption rate, agriculture |
| GDP1 | Production at factor cost, agriculture, millions of 1985 FIM |
| IF1 | Private fixed investment, agriculture, millions of 1985 FIM |
| INF | Expected inflation, per cent |
| KF1 | Net stock of fixed capital, agriculture, millions of 1985 FIM |
| MTAX | Personal marginal tax rate, estimate |
| PGDP1 | Value added deflator in agriculture, 1985 = 100 |
| PIF1 | Fixed investment prices, agriculture, 1985 = 100 |
| RB | Market yield on tax-free bonds, per cent |
| TREND | Linear trend: 60.1 = .25, 60.2 = .50 etc. |
| TREND74 | Linear trend: 60.1 = 15, 60.2 = 14.75, ..., 74.4 = .25 |
| UC1 | User cost of fixed capital, agriculture |

I.3 Kiinteiden investointien määrä, palvelukset ym.
Private Fixed Investment, Services, Volume

$$IF2/KF2_{-1} - CCR2 = -\underset{(0.0011)}{0.00182}$$

$$+ \underset{(0.0183)}{0.08283} \cdot (4 \cdot MPK2 \cdot PGDP2/PIF2)$$

$$- \underset{(0.0050)}{0.01155} \cdot (UC2_{-4}/PIF2_{-4})$$

$$+ \underset{(0.0832)}{0.61308} \cdot (IF2_{-1}/KF2_{-2} - CCR2_{-1})$$

where $MPK2 = 0.8513 \cdot e^{-0.0191 \cdot TREND} \cdot [(GDP2 - 0.049 \cdot KH_{-1}/4)/KF2_{-1}]^{1.6050}$

$\bar{R}^2 = 0.895$ DW = 2.204 SE = 0.0016 70.1 - 85.4

I.4 Pääoman laskennallinen vuokra, palvelukset ym.
User Cost of Fixed Capital, Services

$$UC2 = PIF2 \cdot (RB/100 + 4 \cdot CCR2 - INF) \cdot ((1 - (TYCR + TLGR) \cdot ALFA/(RB/100 + ALFA))/(1 - TYCR - TLGR))$$

| | |
|---|---|
| ALFA | Tax Depreciation coefficient |
| CCR2 | Capital consumption rate, services |
| GDP2 | Production at factor cost, services etc., millions of 1985 FIM |
| IF2 | Private fixed investment, services etc., millions of 1985 FIM |
| INF | Expected inflation, per cent |
| KF2 | Net stock of fixed capital, service etc., millions of 1985 FIM |
| KH | Net stock of private residential capital, net, millions of 1985 FIM |
| PGDP2 | Value added deflator in services etc., 1985 = 100 |
| PIF2 | Fixed investment prices, services, 1985 = 100 |
| RB | Market yield on tax-free bonds, per cent |
| TLGR | Average local government tax rate |
| TREND | Linear trend: 60.1 = .25, 60.2 = .50 etc. |
| TYCR | Corporate tax rate in central government taxation |
| UC2 | User cost of fixed capital, services etc. |

I.5 Kiinteiden investointien määrä, metsätalous
Private Fixed Investment, Forestry, Volume

$$IF3/KF3_{-1} - CCR3 = \underset{(0.0005)}{-\ 0.00105}$$

$$+ \underset{(0.0019)}{0.00539} \cdot (4 \cdot MPK3 \cdot PGDP3 - UC3)/PIF3$$

$$+ \underset{(0.0429)}{0.86780} \cdot (IF3_{-1}/KF3_{-2} - CCR3_{-1})$$

where $MPK3 = 0.3303 \cdot (GDP3/KF3_{-1})^{0.6739} \cdot e^{0.0009 \cdot TREND}$

$\bar{R}^2 = 0.951$  DW = 2.698  SE = 0.0012  70.1 - 85.4

I.6 Pääoman laskennallinen vuokra, metsätalous
User Cost of Fixed Capital, Forestry

$$UC3 = PIF3 \cdot (RB/100 + 4 \cdot CCR3 - INF) \cdot ((1 - (TYCR + TLGR) \cdot ALFA/(RB/100 + ALFA))/(1 - TYCR - TLGR))$$

| | |
|---|---|
| ALFA | Tax Depreciation coefficient |
| CCR3 | Capital consumption rate, forestry |
| GDP3 | Production at factor cost, forestry, millions of 1985 FIM |
| IF3 | Private fixed investment, forestry, millions of 1985 FIM |
| INF | Expected inflation, per cent |
| KF3 | Net stock of fixed capital, forestry, millions of 1985 FIM |
| PGDP3 | Value added deflator in forestry, 1985 = 100 |
| PIF3 | Fixed investment prices, forestry, 1985 = 100 |
| RB | Market yield on tax-free bonds, per cent |
| TLGR | Average local government tax rate |
| TREND | Linear trend: 60.1 = .25, 60.2 = .50 etc. |
| TYCR | Corporate tax rate in central government taxation |
| UC3 | User cost of fixed capital, forestry |

I.7 Kiinteiden investointien määrä, teollisuus
Private Fixed Investment, Manufacturing, Volume

$$IF4/KF4_{-1} - CCR4 = -\underset{(0.0007)}{0.00081}$$

$$+ \underset{(0.0066)}{0.01428} \cdot (4 \cdot MPK4 \cdot PGDP4 - UC4)/PIF4$$

$$+ \underset{(0.0107)}{0.03761} \cdot \Delta \log GDP4$$

$$+ \underset{(0.1157)}{0.64340} \cdot (IF4_{-1}/KF4_{-2} - CCR4_{-1})$$

$$+ \underset{(0.1123)}{0.24778} \cdot (IF4_{-2}/KF4_{-3} - CCR4_{-2})$$

where $MPK4 = 0.4924 \cdot (GDP4/KF4_{-1})^{1.1429} \cdot e^{-0.0044 \cdot TREND}$

$\bar{R}^2 = 0.837$  DW = 1.454  SE = 0.0025  70.1 - 85.4

I.8 Pääoman laskennallinen vuokra, teollisuus
User Cost of Fixed Capital, Manufacturing

$$UC4 = PIF4 \cdot (RB/100 + 4 \cdot CCR4 - INF) \cdot ((1 - (TYCR + TLGR) \cdot ALFA4/(RB/100 + ALFA4))/(1 - TYCR - TLGR))$$

| | |
|---|---|
| ALFA4 | Tax depreciation coefficient, manufacturing |
| CCR4 | Capital consumption rate, manufacturing |
| GDP4 | Production at factor cost, manufacturing, millions of 1985 FIM |
| IF4 | Private fixed investment, manufacturing, millions of 1985 FIM |
| INF | Expected inflation, per cent |
| KF4 | Net stock of fixed capital, manufacturing, millions of 1985 FIM |
| PGDP4 | Value added deflator in manufacturing, 1985 = 100 |
| PIF4 | Fixed investment prices, manufacturing, 1985 = 100 |
| RB | Market yield on tax-free bonds, per cent |
| TLGR | Average local government tax rate |
| TREND | Linear trend: 60.1 = .25, 60.2 = .50 etc. |
| TYCR | Corporate tax rate in central government taxation |
| UC4 | User cost of fixed capital, manufacturing |

I.9 Yksityisten investointien määrä, asuinrakennukset
Residential Construction, Volume

$$IH/KH_{-1} = \underset{(0.0035)}{0.01550}$$

$$+ \underset{(0.0008)}{0.00311} \cdot (\log(PCP/PIH) + 1.844 \cdot \log C - 1.806 \cdot \log KH_{-1})$$

$$- \underset{(0.0047)}{0.00951} \cdot (RLB_{-1} \cdot (1 - MTAX)/100 - INF)$$

$$+ \underset{(17.9641)}{66.51898} \cdot FCGH/(PIH \cdot KH_{-1})$$

$$- \underset{(0.0036)}{0.00365} \cdot (RS_{-1} - RLB_{-1})/100$$

$$+ \underset{(0.0863)}{0.57309} + IH_{-1}/KH_{-1}$$

$$+ \underset{(0.0021)}{0.00530} \cdot DTR66$$

$\bar{R}^2 = 0.851$ DW = 1.847 SE = 0.0010 64.1 - 85.4

| | |
|---|---|
| DTR66 | Dummy for tax exemption of rent income |
| C | Total private consumption, millions of 1985 FIM |
| FCGH | Central government housing loans, drawings, FIM million |
| IH | Residential construction, millions of 1985 FIM |
| INF | Expected inflation, per cent |
| KH | Net stock of private residential capital, net, millions of 1985 FIM |
| MTAX | Personal marginal tax rate, estimate |
| PCP | Private consumption prices, 1985 = 100 |
| PIH | Residential construction prices, 1985 = 100 |
| RLB | Bank lending rate, per cent |
| RS | Money market rate, per cent |

I.10 Varastojen muutoksen määrä
Change in Inventories, Volume

$$II = -\ 1069.17233 \quad (560.2019)$$

$$-\ 0.63583 \cdot \Delta SALE \quad (0.0702)$$

$$+\ 0.10154 \cdot SALE_{-1} \quad (0.0399)$$

$$+\ 0.00078 \cdot (100 \cdot (PMG_{-1} - PMG_{-5})/PMG_{-5} - RS_{-1}) \cdot SALE_{-1} \quad (0.0003)$$

$$+\ 0.72461 \cdot II_{-1} \quad (0.0634)$$

$$-\ 0.03185 \cdot KII_{-2} \quad (0.0141)$$

where SALE = CTOT - CS + ITOT + XG - MG + STD - TIN - GDPG

$\bar{R}^2 = 0.754$ DW = 2.390 SE = 670.7911 62.1 - 85.4

I.11 Yksityisten tuotannollisten investointien määrä
Private Non-Residential Investment, Volume

IF = IF1 + IF2 + IF3 + IF4

I.12 Yksityisten investointien määrä
Private Fixed Investment, Volume

I = IF + IH

| | |
|---|---|
| CS | Private consumption, services, millions of 1985 FIM |
| CTOT | Total consumption, millions of 1985 FIM |
| GDPG | Production at factor cost, general government, millions of 1985 FIM |
| I | Private fixed investment, millions of 1985 FIM |
| IF | Private non residential investment, millions of 1985 FIM |
| IF1 | Private fixed investment, agriculture, millions of 1985 FIM |
| IF2 | Private fixed investment, services etc., millions of 1985 FIM |
| IF3 | Private fixed investment, forestry, millions of 1985 FIM |
| IF4 | Private fixed investment, manufacturing, millions of 1985 FIM |
| IH | Residential construction, millions of 1985 FIM |
| II | Change in inventories, millions of 1985 FIM |
| ITOT | Total fixed investment, millions of 1985 FIM |
| KII | Stock of inventories, millions of 1985 FIM |
| MG | Imports of goods, total, millions of 1985 FIM |
| PMG | Import prices of goods, 1985 = 100 |
| RS | Money market rate, per cent |
| STD | Statistical discrepancy, millions of 1985 FIM |
| TIN | Indirect taxes less subsidies, millions of 1985 FIM |
| XG | Exports of goods, millions of 1985 FIM |

I.13 Julkisten investointien määrä
Total Public Investment, Volume

IG = ICG + ILG

I.14 Investointien määrä
Total Investment, Volume

ITOT = I + IG

I.15 Kiinteiden investointien arvo, maatalous
Private Fixed Investment, Agriculture, Value

IFV1 = IF1·PIF1/100

I.16 Kiinteiden investointien arvo, palvelukset ym.
Private Fixed Investment, Services, Value

IFV2 = IF2·PIF2/100

I.17 Kiinteiden investointien arvo, metsätalous
Private Fixed Investment, Forestry, Value

IFV3 = IF3·PIF3/100

I.18 Kiinteiden investointien arvo, teollisuus
Private Fixed Investment, Manufacturing, Value

IFV4 = IF4·PIF4/100

| | |
|---|---|
| I | Private fixed investment, millions of 1985 FIM |
| ICG | Central government investment, millions of 1985 FIM |
| IF1 | Private fixed investment, agriculture, millions of 1985 FIM |
| IF2 | Private fixed investment, services etc., millions of 1985 FIM |
| IF3 | Private fixed investment, forestry, millions of 1985 FIM |
| IF4 | Private fixed investment, manufacturing, millions of 1985 FIM |
| IFV1 | Private fixed investment, agriculture, FIM million |
| IFV2 | Private fixed investment, services, FIM million |
| IFV3 | Private fixed investment, forestry, FIM million |
| IFV4 | Private fixed investment, manufacturing, FIM million |
| IG | Total public investment, millions of 1985 FIM |
| ILG | Local government investment, millions of 1985 FIM |
| ITOT | Total fixed investment, millions of 1985 FIM |
| PIF1 | Fixed investment prices, agriculture, 1985 = 100 |
| PIF2 | Fixed investment prices, services, 1985 = 100 |
| PIF3 | Fixed investment prices, forestry, 1985 = 100 |
| PIF4 | Fixed investment prices, manufacturing, 1985 = 100 |

I.19 Yksityisten investointien arvo, asuinrakennukset
Residental Construction, Value

IHV = IH•PIH/100

I.20 Yksityisten tuotannollisten investointien arvo
Private Non-Residential Investment, Value

IFV = IFV1 + IFV2 + IFV3 + IFV4

I.21 Yksityisten investointien arvo
Private Fixed Investment, Value

IV = IFV + IHV

I.22 Julkisten investointien arvo
Total Public Investment, Value

IGV = ILGV + ICGV

I.23 Investointien arvo
Total Investment, Value

ITOTV = IV + IGV

I.24 Kiinteän pääoman nettokanta, maatalous
Net Stock of Fixed Capital, Agriculture, Volume

$KF1 = IF1 + (1 - CCR1) \cdot KF1_{-1}$

| | |
|---|---|
| CCR1 | Capital consumption rate, agriculture |
| ICGV | Central government investment, FIM million |
| IF1 | Private fixed investment, agriculture, millions of 1985 FIM |
| IFV | Private non-residential investment, FIM million |
| IFV1 | Private fixed investment, agriculture, FIM million |
| IFV2 | Private fixed investment, services, FIM million |
| IFV3 | Private fixed investment, forestry, FIM million |
| IFV4 | Private fixed investment, manufacturing, FIM million |
| IGV | Total public investment, FIM million |
| IH | Residential construction, millions of 1985 FIM |
| IHV | Residential construction, FIM million |
| ILGV | Local government investment, FIM million |
| ITOTV | Total fixed investment, FIM million |
| IV | Private fixed investment, FIM million |
| KF1 | Net stock of fixed capital, agriculture, millions of 1985 FIM |
| PIH | Residential construction prices, 1985 = 100 |

I.25 Kiinteän pääoman nettokanta, palvelukset ym.
Net Stock of Fixed Capital, Services, Volume

$$KF2 = IF2 + (1 - CCR2) \cdot KF2_{-1}$$

I.26 Kiinteän pääoman nettokanta, metsätalous
Net Stock of Fixed Capital, Forestry, Volume

$$KF3 = IF3 + (1 - CCR3) \cdot KF3_{-1}$$

I.27 Kiinteän pääoman nettokanta, teollisuus
Net Stock of Fixed Capital, Manufacturing, Volume

$$KF4 = IF4 + (1 - CCR4) \cdot KF4_{-1}$$

I.28 Kiinteän pääoman nettokanta, valtio
Net Stock of Fixed Capital, Central Government, Volume

$$KFCG = ICG + (1 - CCRG) \cdot KFCG_{-1}$$

I.29 Kiinteän pääoman nettokanta, kunnat
Net Stock of Fixed Capital, Local Government, Volume

$$KFLG = ILG + (1 - CCRG) \cdot KFLG_{-1}$$

I.30 Nettopääomakanta, asunnot
Net Stock of Private Residential Capital, Volume

$$KH = IH + (1 - CCRH) \cdot KH_{-1}$$

| | |
|---|---|
| CCR2 | Capital consumption rate, services |
| CCR3 | Capital consumption rate, forestry |
| CCR4 | Capital consumption rate, manufacturing |
| CCRG | Capital consumption rate, general government |
| CCRH | Capital consumption rate, residential construction |
| ICG | Central government investment, millions of 1985 FIM |
| IF2 | Private fixed investment, services etc., millions of 1985 FIM |
| IF3 | Private fixed investment, forestry, millions of 1985 FIM |
| IF4 | Private fixed investment, manufacturing, millions of 1985 FIM |
| IH | Residential construction, millions of 1985 FIM |
| ILG | Local government investment, millions of 1985 FIM |
| KF2 | Net stock of fixed capital, service etc., millions of 1985 FIM |
| KF3 | Net stock of fixed capital, forestry, millions of 1985 FIM |
| KF4 | Net stock of fixed capital, manufacturing, millions of 1985 FIM |
| KFCG | Net stock of fixed capital, central government, millions of 1985 FIM |
| KFLG | Net stock of fixed capital, local government, millions of 1985 FIM |
| KH | Net stock of private residential capital, net, millions of 1985 FIM |

I.31 Varastokannan määrä
Stock of Inventories, Volume

$$KII = II + KII_{-1}$$

I.32 Varastojen muutoksen ja tilastovirheen määrä
Inventory Investment and Statistical Discrepancy, Volume

$$IIS = II + STD$$

I.33 Varastojen muutoksen ja tilastovirheen arvo
Inventory Investment and Statistical Discrepancy, Value

$$IISV = GDPV + MV - CTOTV - ITOTV - XV$$

I.34 Kiinteän pääoman kuluminen
Consumption of Fixed Capital

$$CCTV = \underset{(0.00003)}{0.00948} \cdot PIF \cdot [CCR1 \cdot KF1_{-1} + CCR2 \cdot KF2_{-1} + CCR3 \cdot KF_{-1}$$

$$+ CCR4 \cdot KF4_{-1} + CCRG \cdot (KFLG_{-1} + KFCG_{-1}) + CCRH \cdot KH_{-1}]$$

$\bar{R}^2 = 0.997$  RHO $\doteq$ 0.45  SE = 111.6741  61.1 - 85.4

| | |
|---|---|
| CCR1 | Capital consumption rate, agriculture |
| CCR2 | Capital consumption rate, services |
| CCR3 | Capital consumption rate, forestry |
| CCR4 | Capital consumption rate, manufacturing |
| CCRG | Capital consumption rate, general government |
| CCRH | Capital consumption rate, residential construction |
| CCTV | Consumption of fixed capital, FIM million |
| CTOTV | Total consumption, FIM million |
| GDPV | GDP in Purchasers' Values, FIM million |
| II | Change in inventories, millions of 1985 FIM |
| IIS | Inventory investment and statistical discrepancy, millions of 1985 FIM |
| IISV | Inventory investment and statistical discrepancy, millions of FIM |
| ITOTV | Total fixed investment, FIM million |
| KF1 | Net stock of fixed capital, agriculture, millions of 1985 FIM |
| KF2 | Net stock of fixed capital, services etc., millions of 1985 FIM |
| KF3 | Net stock of fixed capital, forestry, millions of 1985 FIM |
| KF4 | Net stock of fixed capital, manufacturing, millions of 1985 FIM |
| KFCG | Net stock of fixed capital, central government, millions of 1985 FIM |
| KFLG | Net stock of fixed capital, local government, millions of 1985 FIM |
| KII | Stock of inventories, millions of 1985 FIM |
| KH | Net stock of private residential capital, net, millions of 1985 FIM |
| MV | Imports of goods and services, FIM million |
| PIF | Private non-residential investment prices, 1985 = 100 |
| STD | Statistical discrepancy, millions of 1985 FIM |
| XV | Exports of goods and services, FIM million |

REFERENCES

ABEL, A. (1980) Empirical Investment Equations: An Integrative Framework. In Karl BRUNNER and Allan MELTZER (eds.): Carnegie-Rochester Conference Series on Public Policy 12. North Holland.

BANK OF FINLAND (1987) The BOF4 Model of The Finnish Economy: Equations. Bank of Finland Research Department, TU 6/87.

DEATON, A. (1977) Involuntary Saving Through Unanticipated Inflation. American Economic Review 67.

DEATON, A. and J. MUELLBAUER (1980) Economics and Consumer Behaviour. Cambridge University Press, Cambridge.

FRIEDMAN, M. (1959) A Theory of the Consumption Function. Princeton University Press, Princeton.

GOULD, J.P. (1968) Adjustment Costs in the Theory of Investment of the Firm. Review of Economic Studies 35, No. 1.

HICKMAN, B. and R.M. COEN (1976) An Annual Growth Model of the U.S. Economy. North-Holland, Amsterdam.

JORGENSON, D. (1963) Capital Theory and Investment Behaviour. American Economic Review 53, No. 2.

KING, M. (1985) The Economics of Saving: A Survey of Recent Contributions. In Kenneth ARROW and Seppo HONKAPOHJA (eds.): Frontiers of Economics. Basil Blackwell. Oxford.

KOSKENKYLÄ, H. (1985) Investment Behaviour and Market Imperfections with an Application to the Finnish Corporate Sector. Bank of Finland B:38.

LUCAS, R. (1967) Adjustment Costs and the Theory of Supply. Journal of Political Economy 75, No. 4.

MUTH, J. (1960) Optimal Properties of Exponentially Weighted Forecasts. Journal of American Statistical Association 55, No. 3.

TARKKA, J. and A. WILLMAN (1985) The BOF3 Quarterly Model of the Finnish Economy. Bank of Finland D:59.

TARKKA, J. and A. WILLMAN (1988) Exports and Imports in the BOF4 Quarterly Model of the Finnish Economy. Bank of Finland Discussion Papers 3/88.

TARKKA, J., WILLMAN, A. and C-M. RASI (1988) Production and Employment in the BOF4 Quarterly Model of the Finnish Economy. Bank of Finland Discussion Papers 14/88.

TARKKA, J., WILLMAN, A. and C-M. RASI (1988) Labour Supply, Prices and Wages in the BOF4 Quarterly Model of the Finnish Economy. Bank of Finland Discussion Papers (forthcoming).

TOBIN, J. (1969) A General Equilibrium Approach to Monetary Theory. Journal of Money, Credit, and Banking 1, No. 1.

VIRÉN, M. (1983) Yritysten kulutusmenojen rakenne ja kehitys Suomessa vuosina 1950 - 1986. (The Structure and Development of Private Consumption Expenditure in Finland in 1950 - 1986; in Finnish) ETLA B:37, Helsinki.

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