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Economics Department

27.2.1995

The Interest Rate Sensitivity of Output in Finland

SUOMEN PANKIN KESKUSTELUALOITTEITA • FINLANDS BANKS DISKUSSIONSUNDERLAG

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Abstract

Monetary policy affects the economy through the exchange rate and interest rates. It is assumed that the relationship between interest rates and GDP is negative and that interest rates affect GDP more powerfully than the other way around. These conclusions are confirmed here. Estimated elasticities — which compare annual percentage changes in GDP to annual percentage changes in the interest rate — produce interest rate elasticity close to unity. It should also be stressed that a nominal interest rate effect is found instead of a real rate effect both in GDP and its components.

For private consumption, the interest rate measures the relative future price of consumption, which includes substitution and income effects. According to estimations the interest rate elasticity for non-durable consumption is around –0.4, which indicates the dominance of the substitution effect. For durable purchases, the interest rate elasticity is much higher and is also volatile. Rough estimate showed that the interest rate elasticity for durables could be around –4.0.

For private investment, the interest rate measures the opportunity cost of investment and a cost factor in debt financing. Financial deregulation has obscured the importance of interest rates in determining manufacturing investment. It seems that during the boom years domestic lending rates lost their significance in affecting investment plans. A rough estimate for a long-term interest rate elasticity of manufacturing investment could be –2. On the other hand financial deregulation has clearly increased the power of interest rates in determining the level of housing investment. During 1980s the real lending rate became a significant determinant of housing investment, and we cannot reject the hypothesis of unitary elasticity, ie. elasticity of –1.

Tiivistelmä

Rahapolitiikka vaikuttaa talouteen ensisijaisesti valuuttakurssien ja korkojen kautta. Yleensä oletetaan, että korkojen nousulla ja rahapolitiikan kiristämisellä on negatiivinen vaikutus taloudelliseen aktiviteettiin. Toisaalta koron nousun on joissakin maissa havaittu ennakoivan aktiviteetin nousua ja inflaatiota. Suomen aineistolla edellinen riippuvuus vaikuttaa voimakkaammalta. BKT:n korkoreaktioiden voimakkuudesta ei sen sijaan ole useinkaan varmaa tietoa. Tässä selvityksessä arvioidaan BKT:n ja sen tärkeimpien yksityisten komponenttien korkojoustot.

BKT:n volyymin ja koron välinen riippuvuus on lisäksi — ehkä hieman yllätyksellisesti — nimelliskoron ja BKT:n välinen riippuvuus. Tarkastelujen perusteella ei ole järin mielekästä yrittää arvioida BKT:n korkojoustoa sellaisenaan, vaan yrittää estimoida käyttäytymisyhtälöiden avulla BKT:n yksityisten alaerien korkoreaktioita. Korkojoustot arvioidaan tässä koron muutoksen vaikutuksena tarkasteltavan muuttujan vuosimuutokseen.

Yksityisen kulutuksen kannalta korko edustaa tulevan kulutuksen suhteellista hintaa, johon liittyy substituutio- ja tulovaikutus. Estimointien perusteella ei-kestävän kulutuksen korkojousto on noin –0.4, mikä viittaa substituutiovaikutuksen hallitsevuuteen. Kestävien hyödykkeiden korkojousto on selvästi suurempi ja vaihtelevampi. Kestävän kulutuksen korkojousto on kokoluokkaa –4.

Yksityisille investoinneille korko edustaa investoinnin vaihtoehtoiskustannusta sekä velkarahoituksen kustannusta. Mallitusten perusteella rahamarkkinoiden vapauttaminen on hämärtänyt koron merkitystä teollisuusinvestointeihin. Pahimpaan ylikuumenemisaikaan 1988—1990 lainarahan hinnalla ei näyttänyt olevan merkitystä teollisuusinvestointien kannalta. Pidemmällä aikavälillä hyvä arvaus teollisuusinvestointien korkojoustolle on –2. Toisaalta rahamarkkinoiden vapauttaminen on korostanut selkeästi koron merkitystä asuntoinvestointien kannalta. Tämä vaikuttaa luontevalta, sillä säännöstellyillä rahamarkkinoilla lainarahan hinnalla ei — tarkasteltuna ennen korkon vähennysoikeutta — ollut asunnonostajien kannalta juurikaan merkitystä. 1980-luvun lopulta lähtien korolla on ollut merkitsevä vaikutus asuntoinvestointeihin. Asuntoinvestointien korkojousto on estimointien perusteella yksikköjoustavaa.

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1 Introduction

This paper evaluates interest rate effects on GDP. The previous studies from abroad about the effects of the interest rate on GDP have not been particularly unambigious (see eg. Friedman 1989, Akhtar and Harris 1987, Hirtle and Kelleher 1990). This may not be surprising, since it could be argued that the interest rate sensitivity of different GDP components may differ widely. Even if interest rate sensitivity were constant for consumption and investment, the varying GDP contributions of these components could make interest rate elasticity non-constant.

Significant sectoral differences are also expected to be found in the transmission of interest rates to the real economy. First, it may not be a good idea to assume that public expenditure has the same interest elasticity as private expenditure. In fact, for public expenditure, the interest rate has a role merely of an imputed opportunity cost. Secondly, we may expect that interest rate sensitivities of consumption and investment can be different. One obvious reason for this is that the economic planning horizon of consumption and investment are typically not the same. Therefore dynamic adjustment of these GDP components to interest rate change could differ.

Thirdly, it is also likely that the interest rate does not have homogenous effects on different components of consumption and investment. For example, it is known that durable consumption is more sensitive to interest rates than non-durable or services consumption. Housing investment might react to changes in interest rates with stronger effect than fixed private investment, simply because the maturity of housing loans is longer. Fourthly, the relevant interest rate affecting different GDP components may be different. In Finland housing loans were largely tied to the central banks' base rate until 1988, thereafter to 3—5 year market interest rates and during 1990s increasingly to banks prime rates. Therefore market interest rates have had a gradually increasing effect on housing loans. Private manufacturing investment has been more closely related to short term market interest rates. As a reference interest rate measure, we use the average interest rate of new loans by banks to the public.[1] To summarize, we must approach the GDP vs. interest rate relationship from a disaggregated viewpoint.

This paper tries to measure the effect of interest rate changes on output and the components of demand. However, the analysis starts by looking at the relationship between GDP and bank interest rates. It is reasonable to assume that the relationship between GDP and interest rates could be time-varying. The period under study includes the financial deregulation in 1986—1992, which has certainly affected the interest rate sensitivity of GDP. Although private consumption forms the major part of GDP, it is not clear whether GDP reflects these interest rate effects. The first limitation we consider is to exclude the public sector from GDP and to focus the analysis on private GDP reactions to interest rates. The effect of the interest rate has probably been subject to change because of growing indebtedness in the late 1980s. The household and corporate sectors may have become less sensitive to credit rationing but increasingly sensitive to interest rates

[1] The interest rate on new loans is available only from 1987; before that we used the average interest rate on the outstanding loan stock as a proxy for the interest rate. From 1987 onwards new bank rates have had relatively high correlation with money market interest rates like the 3-month Helsinki Interbank Offer Rate (Helibor).

for lending and borrowing. The growth in interest payments and debt service costs due to higher indebtedness may have affected the demand structure and the recovery from the recession (King 1993).

In determining all the various effects of interest rates on output, we must disaggregate GDP and try to model the marginal effect of the interest rate as an additional variable. I feel it is not valid to investigate the dependence between the interest rate and GDP components simply within two variable partial systems. The analysis must be based on behavioural equations, taking account of other possibly much stronger relationships. Therefore the interest rate effects are analysed in the context of proper consumption and investment functions.

It may not be reasonable to assume that the interest elasticity of non-durable consumption should be the same as the interest elasticity of housing investment. By and large these are empirical matters, which cannot be assessed without modelling and estimation. On the production side, it may not be proper to assume that the interest rate reaction could be the same for different industries, since capital intensity, share of debt financing and overall indebtedness vary widely depending on the production sector. Therefore disaggregation to proper behavioural equations cannot be avoided even if we try to assess the average interest rate sensitivity of total output. However, we may check that as a reference benchmark.

2 Private GDP and the interest rate

The basic question in GDP sensitivity to interest rate changes concerns the aggregation properties of the demand and supply components. The interest rate effects of consumption and investment demand may be diluted to some extent in time aggregation even if the qualitative effect is negative on both items. However, it may still be advisable to look at whether a stable relationship can be found between interest rates and GDP.

In looking at the predictive content of interest rates as an indicator of future economic activity, we first plotted the GDP changes and bank lending rates. Figure 1 indicates that the relationship may have changed quite radically after financial deregulation. The relationship is strongly negatively correlated only from about 1986 onwards. However, one may argue that the interest rate should be lagged by one year to make the timing of these variables more or less coincident.[2] The qualitative results are preserved but the negative correlation in the period 1987—93 is weakened somewhat.

Simple bivariate Granger causality tests showed that predictive explanatory power runs more likely from lending rates to GDP changes than the other way around. The common presumption also agrees with the idea that rises in the interest rate will precede declines in economic activity. Monetary tightening also relies on squeezing economic activity with higher interest rates, eg. through limiting the money supply. This result is based on nominal interest rates since

[2] The interest rate measures the price of money (borrowing or lending) averaged from quarterly data one year ahead, whereas GDP is measured from the corresponding quarter of the previous year to the current quarter.

there exists clear dependence for the whole sample period 1962—1993.[3] Inflation must therefore have some integral part in the transmission of interest rates into economic activity. Figures 3 and 4 reveal a couple other features from the relationship between inflation and GDP growth. Apart from the oil crisis, which was a clear price shock, GDP and inflation have been positively correlated. Lowering demand should match with lower inflation. The positive correlation is rather strong after 1987, although there is clear difference between two indicators of inflation, namely consumer price index (CPI) and implicit private consumption deflator (PCP).[4]

Figure 5 shows clearly that most of the variation in real interest rate comes from the variance in inflation. The effect of deregulation starting in autumn 1986 could be seen also in the short-run variation in nominal lending rates. One might suspect that the importance of nominal and real interest rates for GDP has changed because of financial deregulation. Although deregulation strongly affected gross interest payments and therefore could have changed the multiplier effects, we would expect that the importance of real interest rates has increased. The role of the real interest rate appears to be important only after financial deregulation started around 1986. However, it is important to note that these observations match well with what would be expected. The overall explanatory power of the nominal lending rate and inflation on GDP is still rather limited (Figure 6). Next we should turn to questions that give us insight on the marginal role of interest rates in determining GDP changes.

The dependence relationship between output and interest rate should be restricted to private output (Figure 7). It can be seen that fiscal policy, narrowly defined as public GDP has been smoothing with respect to private GDP in most cases (eg. the oil crisis, overheating at the end of the 1980s). The current recession is an exception, since as the public sector has become heavily indebted, decreasing public spending has made public GDP changes negative. The correlation between private and public GDP components seems to be somewhat different (Figure 8). Therefore, we chose to separate these effects.

Another way to approach interest rate elasticity of GDP is to estimate it directly, although economic theory does not to give any straightforward model for this relationship. Thus a simple way to estimate the interest rate elasticity of GDP is to use an autoregressive model with the real interest rate and inflation as additional regressors (Table 1). The idea here is to take into account the effect of other

[3] Granger causality tests showed that real interest rates had significant predictive power for private GDP changes in 9-lag autoregression. However, this result appeared only for the longer period 1970—93, but not with period 1980—93. GDP did not Granger cause real interest rates for any period. The same relationship was found between nominal lending rate and GDP changes with significance level p = .012 with 5 lags. GDP changes predicted the lending rate only with significance level p = .241. However, it should be pointed out that the annual average lending rate for new loans is highly autocorrelated, which makes the interest rate process a near unit root process, while the autocorrelation function of GDP changes collapses quite rapidly making it a I(0) process.

[4] The main difference between these inflation indicators due to measurement of housing cost. CPI inflation reacts through a user cost measure to housing prices, whereas PCP measures housing costs through service cost based on implicit rents. This distinction was introduced into Finnish CPI from 1989.

variables by means of autoregression. However, if we use long autoregressions, the possibility of endogenous feedback effects through interest rate reactions increases. Therefore, the interest rate effects become seriously mixed up with the effects of other variables and no conclusive structural inference can be made. The result shows a near unitary interest elasticity of real lending and inflation, which can be summarized as a nominal interest rate effect. The equality of the real interest rate and inflation effects was however rejected according to a Wald-test with probability of 0.03, but it is sensitive to the length of the AR model. The diagnostics of this model are satisfactory, except for the autocorrelation in the residuals.[5] The recursive regression coefficients for the real interest rate and inflation are presented in Figure 9. To get some idea about the stability of the interest rate elasticity we also estimated a rolling regression with 6-year lag window for the model. The rolling estimate for the interest rate elasticity is presented in Figure 10.

Table 1 **Autoregressive model for private GDP,**
Period: 1975/Q1—1993/Q4

Variable	Coefficient	Std.Error	t-value	t-prob	PartR²
Constant	9.3754	2.3285	4.026	0.0001	0.1838
D4LNPGDP_1	0.76500	0.061804	12.378	0.0000	0.6803
D4LCPI	−0.88952	0.22553	−3.944	0.0002	0.1777
RRLBN	−0.72886	0.19007	−3.835	0.0003	0.1696

Model performance		Residual diagnostics		Stat.	P-value
R^2 =	0.766	AR(1–5)	F(5,67) =	5.2786	(.0004)**
σ =	2.262	ARCH 4	F(4,64) =	1.2523	(.2980)
DW =	2.11	Normality	χ^2 (2) =	0.5853	(.7463)
RSS =	368.3	Xi^2	F(6,65) =	0.7507	(.6111)
		Xi*Xj	F(9,62) =	0.7781	(.6371)
		RESET	F(1,71) =	1.0607	(.3065)

Wald-test for nominal interest rate effect restriction:
ß(D4LCPI) = ß(RRLBN): F(1,72) = 5.03 (p = 0.03)*

Variables:

D4LPGDP = Annual log-differences of gross private domestic product
D4LCPI = Annual log-difference of consumer price index
RRLBN = Real lending rate on new bank loans

The most conspicuous feature of Finlands' recent economic performance has been the deep recession of the 1990s. The recession has clearly been one of the most severe in the OECD market economies. The cumulative fall in total GDP from

[5] If an AR(5) model for GDP is estimated, autocorrelation is eliminated and the problem is corrected. Longer autoregressions do not change the significance of the real interest rate or inflation as regressors.

1990/Q3 to 1993/Q4 has been 14.3 percentage points according to preliminary estimates. It is however worthwhile to note that sectoral differences in production are quite large (Figure 11). The collapse of manufacturing production alone was around −12 percentage points in 1991, while the collapse in GDP was −7 percentage points (Figure 12). Devaluation and onset of the floating of the markka pushed manufacturing into a phase of rapid growth from 1992 onwards.

Figure 1

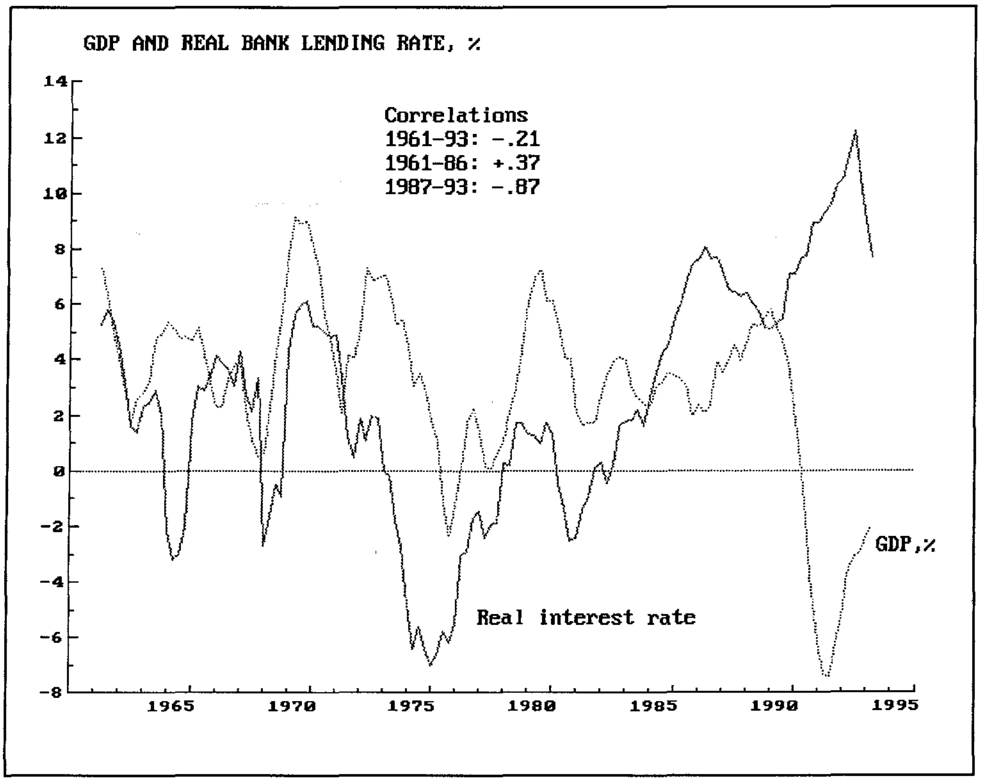


Figure 2

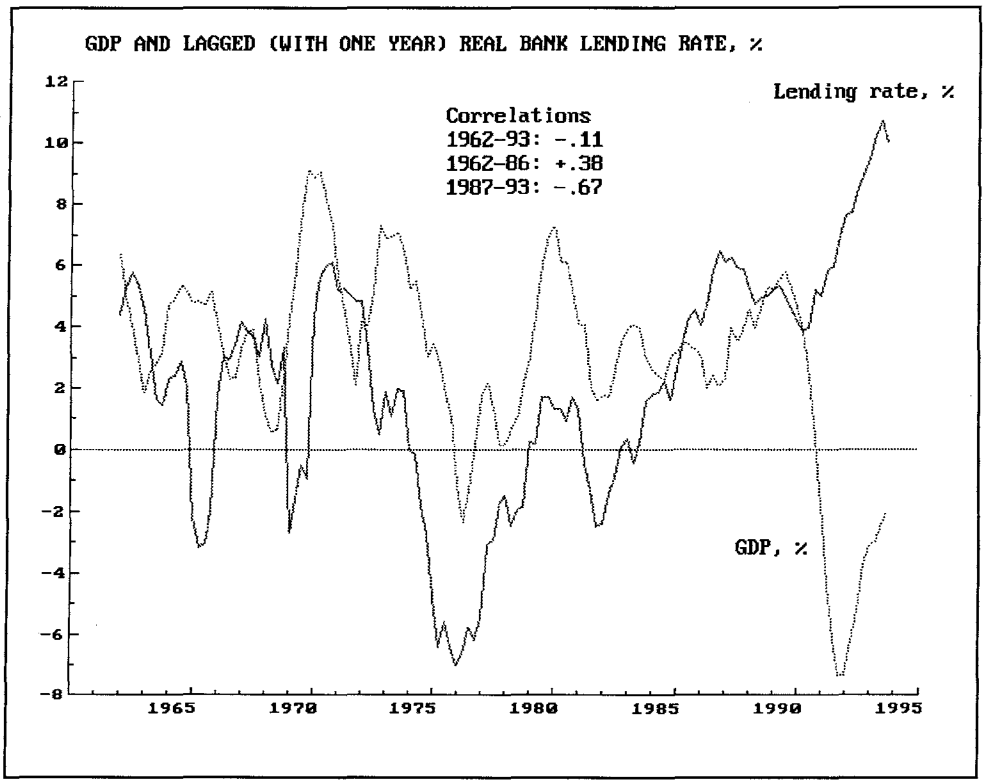


Figure 3

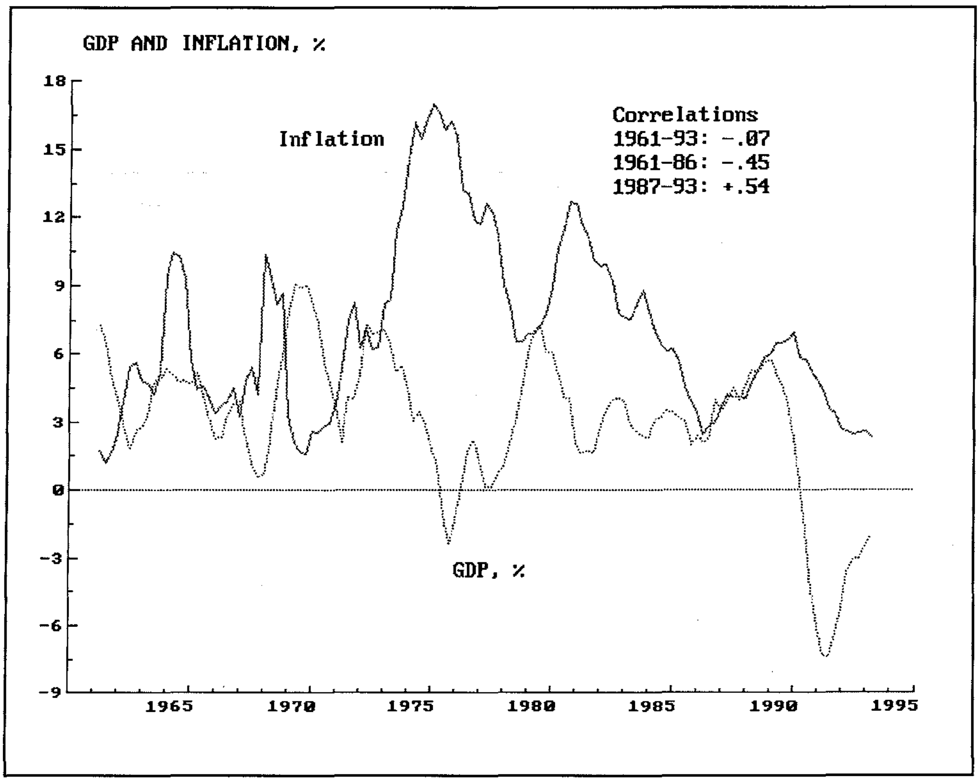


Figure 4

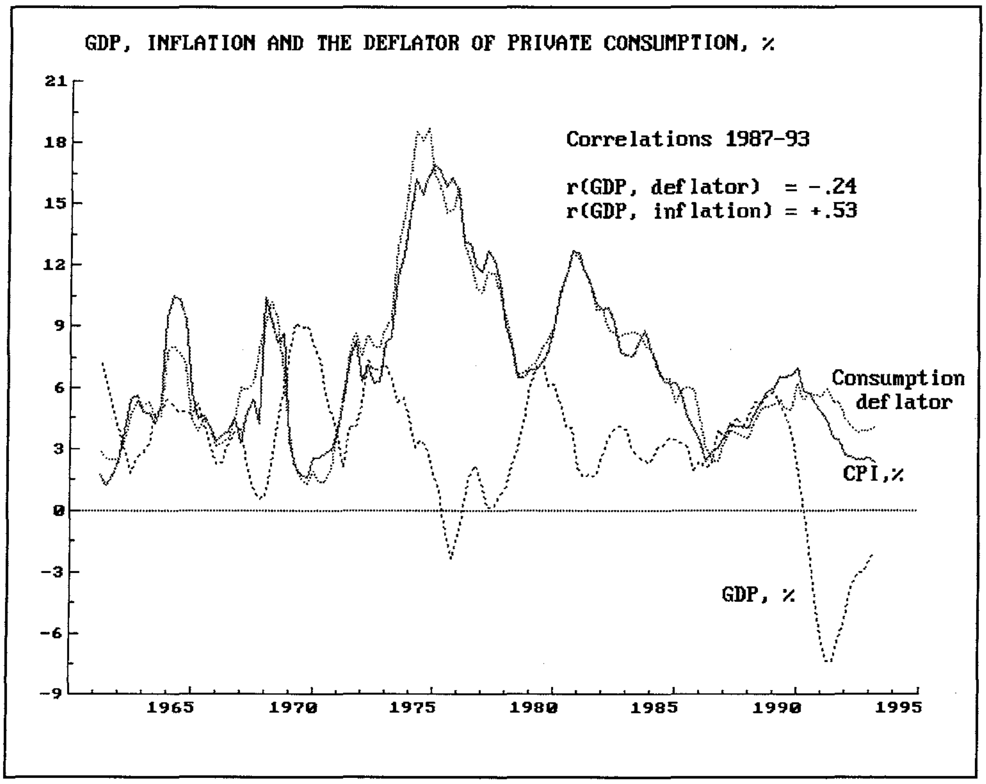


Figure 5

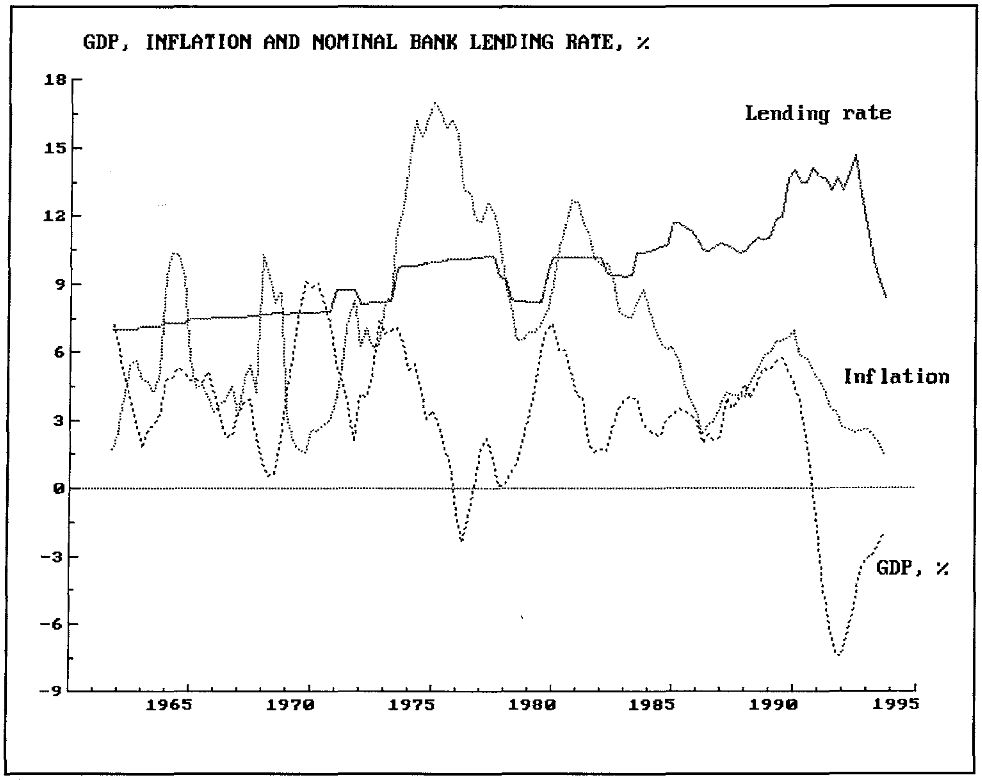


Figure 6

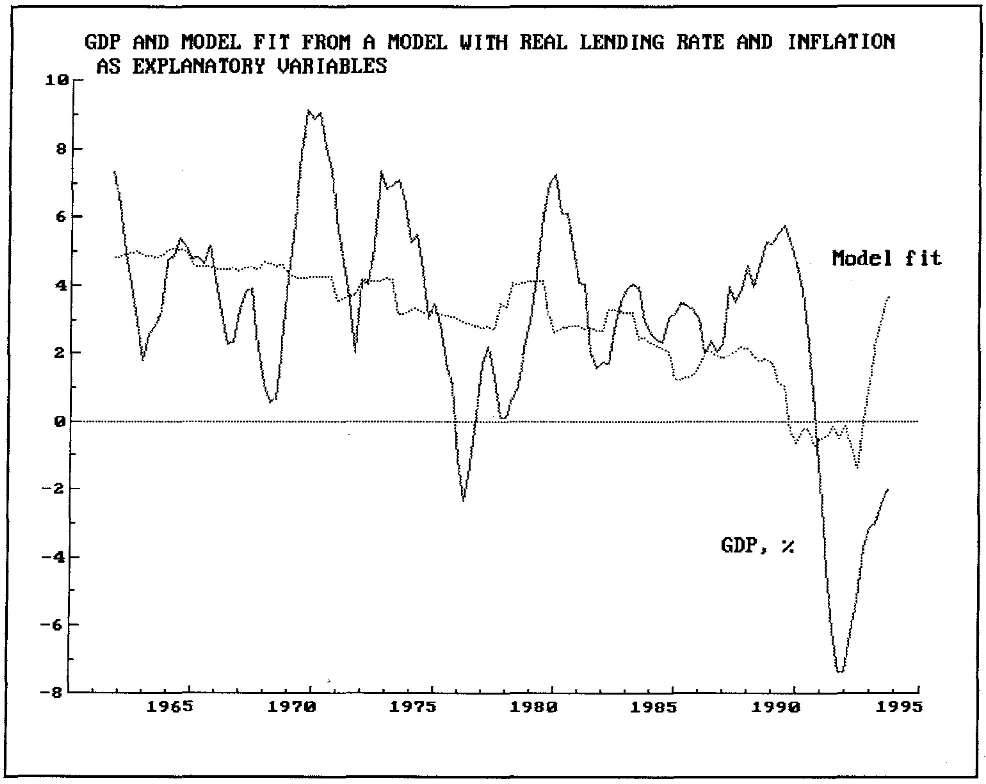


Figure 7

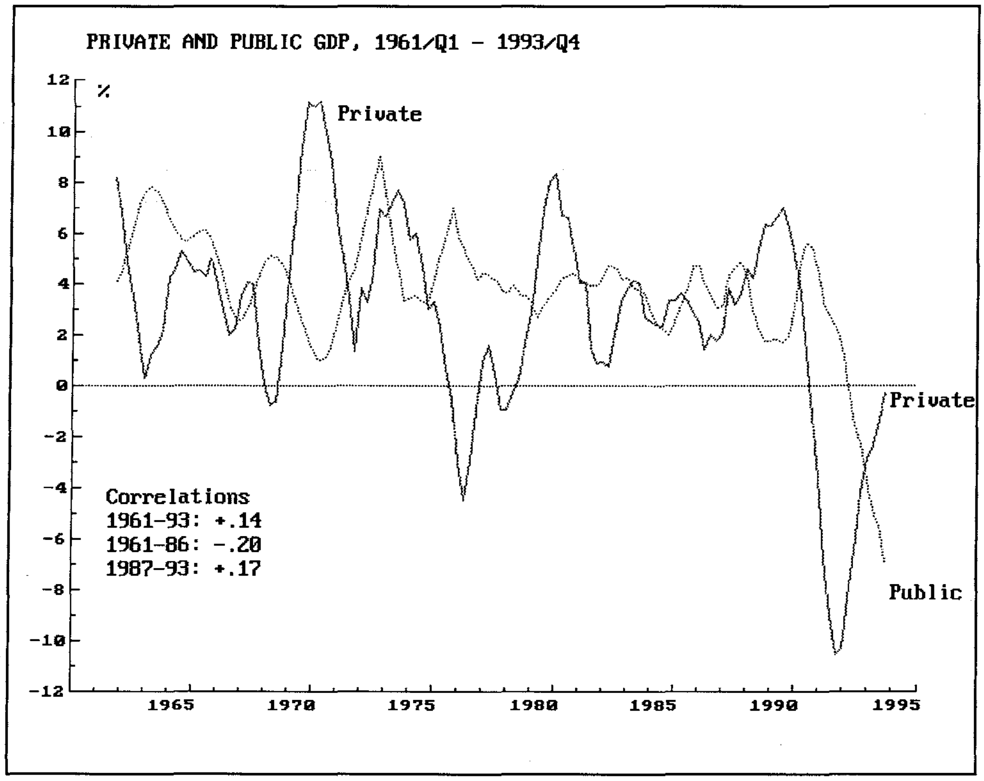


Figure 8

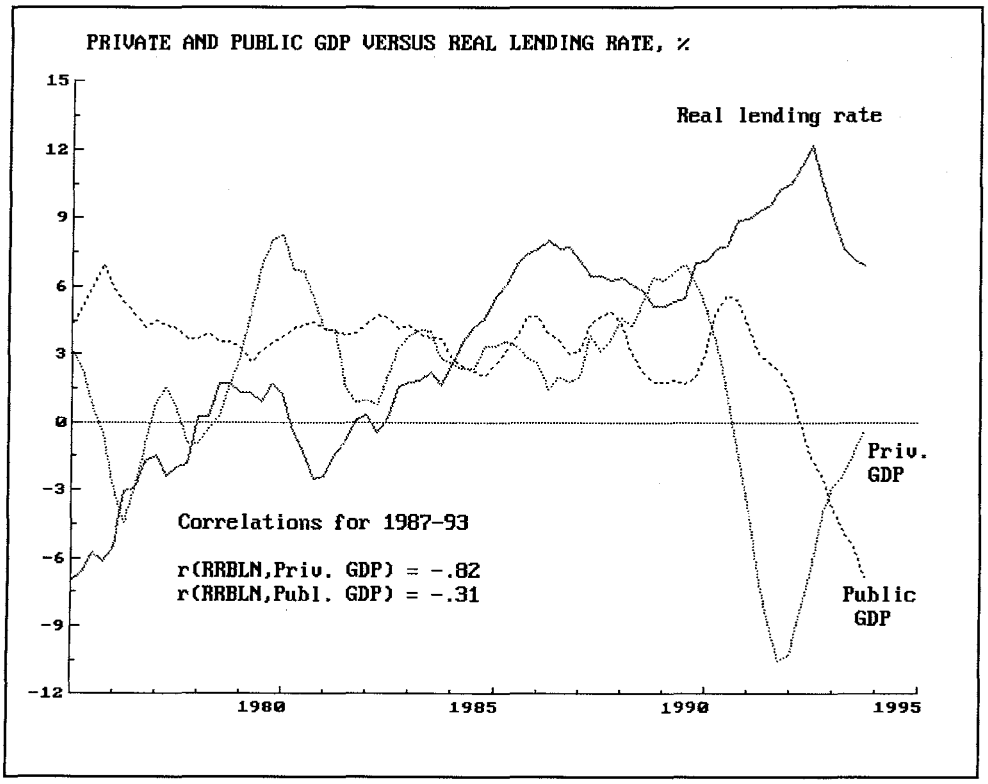


Figure 9 **Interest rate and inflation elasticity of private GDP and the t-values of coefficients**

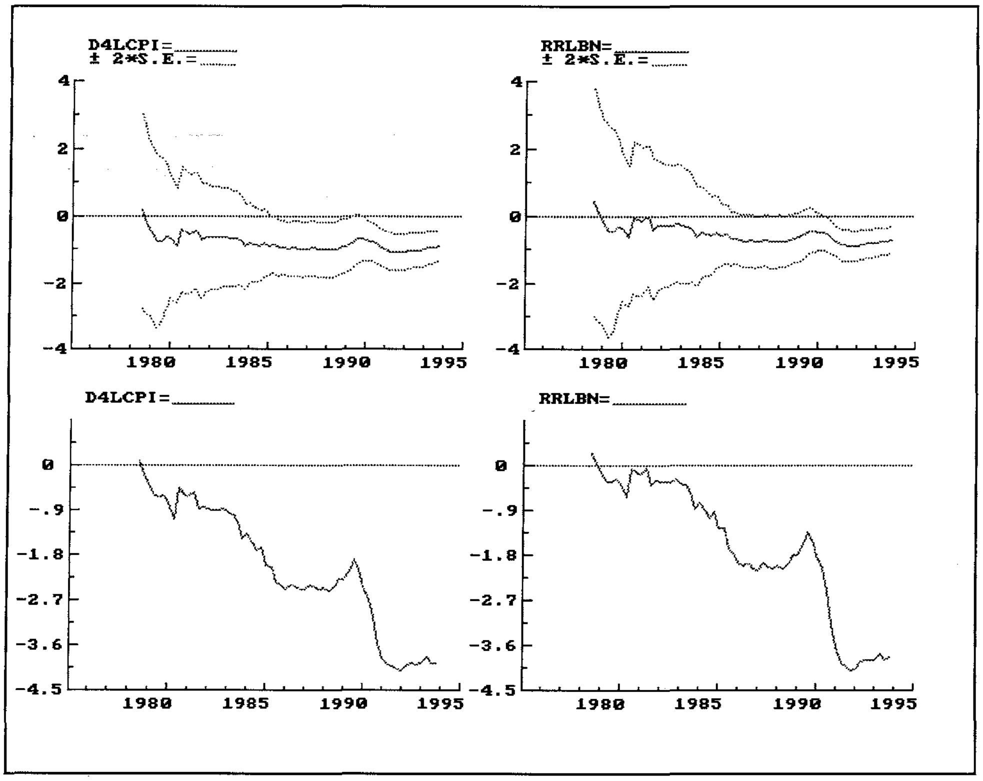


Figure 10 **Rolling interest rate elasticity of private GDP**

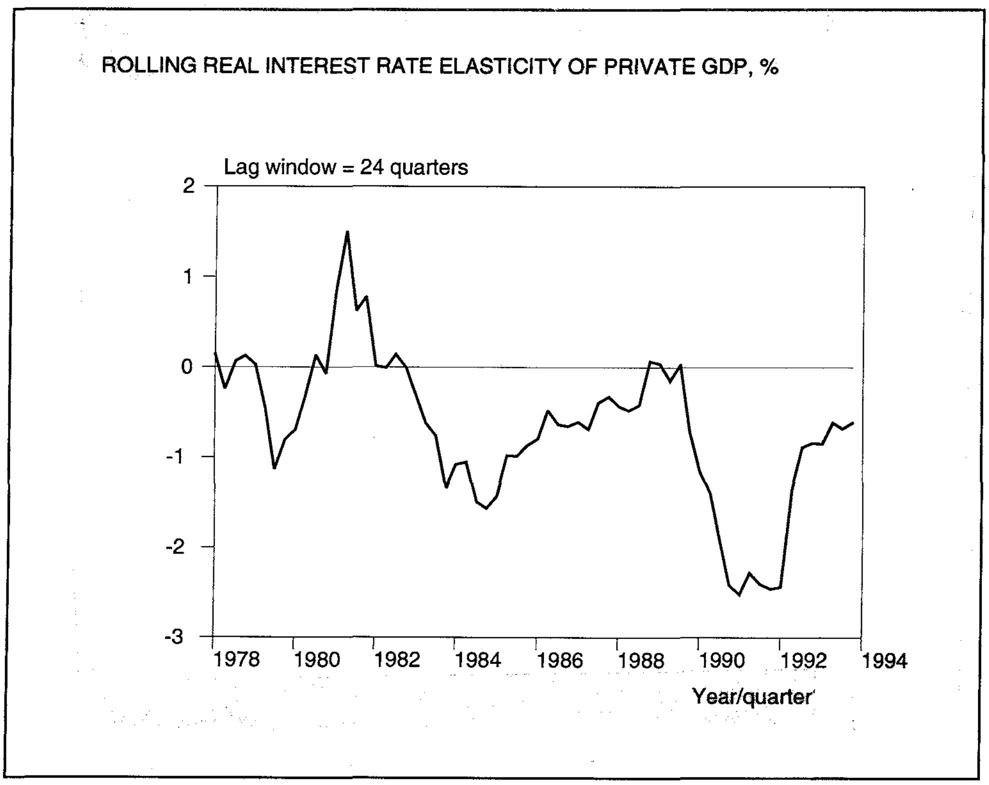


Figure 11

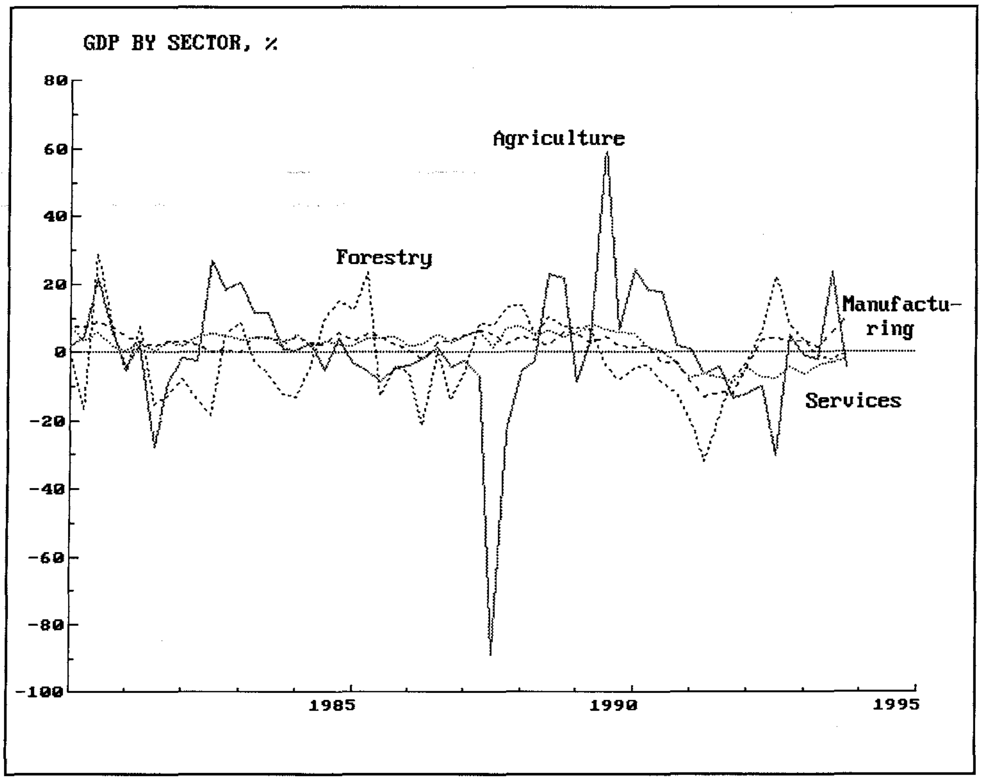
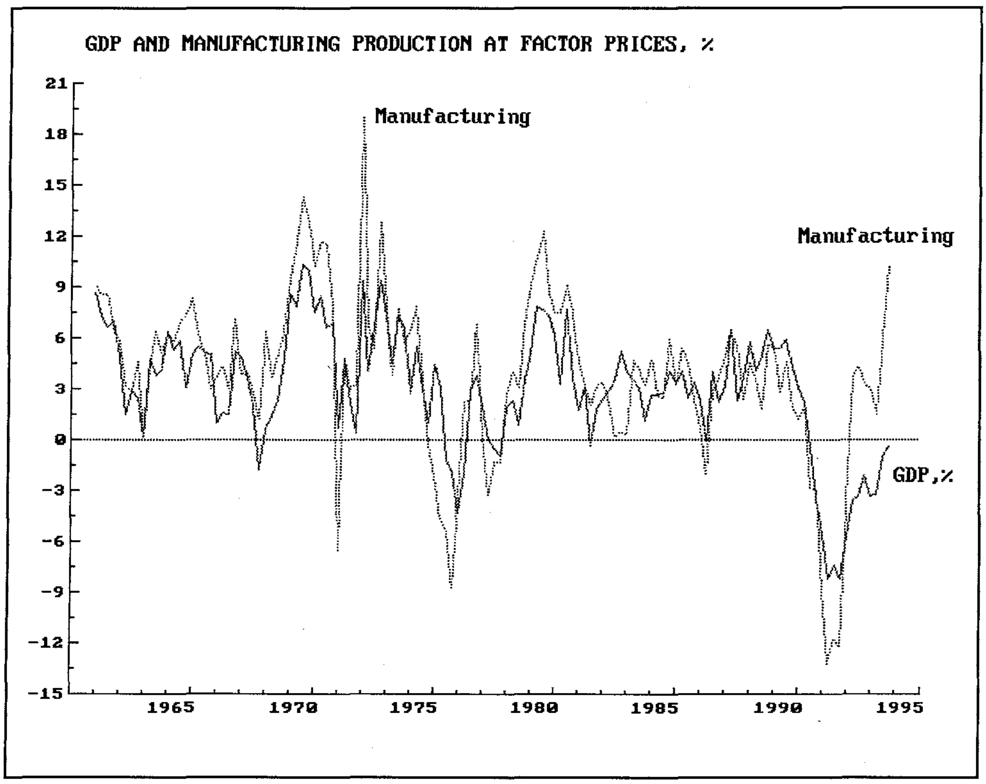


Figure 12



3 Interest rates and consumption

Private consumption and investment account for 66 percent of GDP in Finland. If public consumption and investment are added to private expenditure, they account for 92 percent of GDP. Consumer theory asserts that the interest rate measures the intertemporal price of consumption. If the interest rate rises, the cost of current consumption will increase and thus the relative price of current consumption will increase. Therefore, an increase in the interest rate should lead to decreasing consumption and increasing saving. This is the substitution effect. The income effect of consumption may work in the opposite direction. In some cases this effect may even override the negative dependence between the real interest rate and private demand.[6] However, the overall relationship between private demand and the real interest rate should be negative, if we assume the absence of money illusion.

Table 1 presents an error-correction form of the consumption function for annual differences of non-durable consumption. Following the results in Takala (1994) the ECM is based on a five-variable cointegration system of in non-durable consumption, disposable income and disaggregated net wealth (financial wealth, housing wealth and debt).

$$c_t = \mu + \beta_1 y_t + \beta_2 fw_t + \beta_3 rw_t - \beta_4 debt_t,$$

where c is non-durable consumption, y is real disposable income, fw is real financial wealth, rw is deflated real estate wealth and debt denotes real gross debt.

The error correction form of this static long-run equation is then

$$\Delta c_t = \alpha_1 \Delta y_t + \alpha_2 \Delta fw_t + \alpha_3 \Delta rw_t - \alpha_4 \Delta debt_t + \alpha_5 [c_{t-1} - K(\beta_1 y_{t-1} + \beta_2 fw_{t-1} + \beta_3 rw_{t-1} - \beta_4 debt_{t-1})].$$

The variables that are included in the core cointegration vector and the error correction term are all significant, except for real gross debt. The coefficient for debt should in fact be negative. The positive insignicant coefficient might have resulted from the multicollinearity between financial wealth and debt.

Because of the evident endogeneity of disposable income, the model was estimated also with instrumental variable (IV) estimation using lagged values of income as instruments.[7] Stabilizing feedback effects coming through the error correction term may also reflect changes in assets that affect consumption. When consumption and income are not equal, there is saving, which affects cumulative

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[6] The income effect is supposed to be weaker than the substition effect as is has opposite signs for lenders and borrowers. For lenders, an increase in the deposit rate will raise capital income, which offsets the substitution effect. While for net borrowers, an increase in the lending rate will lower the present discounted value of wealth and will reinforce the substitution effect.

[7] Because of the method of instrumenting, the significance of disposable income increases. It should be noted that in IV estimation the sign of debt becomes negative, although it is not statistically significant.

savings, namely wealth. Including lagged ECM in the consumption function was found to have a significant effect on the parameters of other explanatory variables. It must be remembered that a pure difference equation without an error-correction term has no equilibrium solution, but could still be consistent with a steady-state solution.

The real interest rate does not belong to the system of endogenous cointegrated variables. Rather the status of the real interest rate is a weakly exogenous variable that affects the short-run adjustment of the system. Unit root tests showed that the real interest rate is integrated of order zero. Being stationary, shocks to it are temporary. Univariate time series tests may sometimes indicate that the nominal interest rate and inflation could each have a unit root while their difference, ie. the real interest rate, is stationary. This should be the case even in periods of hyper-inflation. Interest rate shocks do affect the short-run equilibrium between consumption and consumption resources, but it does not affect the long-run equilibrium. The significance of the effect of the real interest rate on consumption (both non-durables and durables) has clearly increased since financial deregulation (Figures 13—14). It must be remembered, however, that the effect of real interest rates on consumption is partly disguised, since interest rates affect consumption also indirectly through asset prices. According to the present value formula, a permanent increase in the interest rate will lower the price of stocks or housing wealth and thus reduce consumption through the wealth effect. In addition an interest rate increase can signal lower investment activity and therefore declining expected earnings.

The results from the estimated model are well in accordance with the permanent income hypothesis. The dependent variable and model fit are compared in Figure 15 without any dummies for outliers. The diagnostics show no serious defiencies with respect to residual autocorrelation, heteroscedasticity, normality or functional form, when the effect of a few outliers is taken into account. The stability of the regression coefficients is also sufficient. The specification includes a couple of stationary variables (terms of trade, inflation) that are supposed to explain the short-run adjustment in consumption.

Even though the real interest rate had a significant role in this equation, its significance varied with different specifications. According to t-test the significance limits is around 5 percent level. The interest rate elasticity of the change in consumption was estimated to be –0.4 in the OLS equation and -0.2 in the IV-estimation, which is far below unit elasticity. In comparison with several earlier estimates, which report significant positive interest rate elasticities, the difference is striking (see Starck 1990).[8]

Consumption theory is formulated in real terms as consumers gain no utility from nominal increases. The real interest rate correlates with the subjective time preference, which measures the intertemporal relative price of consumption ie. the

[8] It is likely that earlier findings relate mostly to the credit rationing period and partly to misspecified error-correction formulation missing the net wealth variable in the consumption function. Starck (1990) proposes that positive interest rate elasticity can be compatible with a life-cycle model, in which interest rate elasticity depends on the age distribution of the population. However, he does not explicitly test this hypothesis.

rate of deflation in consumption.[9] Subjective time preference is bounded to be positive as future consumption must always be more uncertain than present consumption. It is easy to see that the coefficients of the real lending interest rate and inflation are almost the same. These effects could be combined in a **nominal interest rate effect**. Using the Wald-test, the hypothesis of equal regression coefficients for real interest rate and inflation was not rejected. The relationship between consumption and inflation therefore require a closer look.

Inflation may affect consumption in several ways. One explanation assumes that when prices raise rapidly consumers cannot distinguish between the changes in relative prices and changes in the overall price level. In order to protect themselves from inflation and loss of purchasing power, consumers step up their consumption (especially of durables). Another way to maintain purchasing power is to demand higher inflation premium for saving. Therefore, as expected, both inflation and nominal interest rates increase. This also affects gross interest income. Because households are net lenders to other sectors, their interest income rises as a result of inflation.

Hendry and von Ungern-Sternberg (1981)[10] argue that large increases in nominal interest receipts are balanced by capital losses in financial assets, but whereas gross interest income is included in disposable income, capital losses are not. Therefore the national income statistics do not fully reflect the economic real income as perceived by the agents.[11] However, it is clear that increasing unexpected inflation could cause major losses to owners of non-indexed financial assets like deposits and capital gains to debtors.

In Finland this interpretation does not apply to the latest fall in the saving rate in the late 1980s, which was more likely due to increased spending on durables and housing. If inflation were responsible for the decline in the saving rate during the financial liberalization, there should be a significant negative correlation between changes in financial assets and inflation. Such a phenomenon could not be found in the late 1980s. Muellbauer and Murphy (1989) argue that consumers who are not liquidity constrained would be affected by increases in real interest rates, which reduce the willingness to borrow. On the other hand households could be affected by nominal interest rates as well, since the nominal burden of debt will increase the debt service payments and therefore reduce consumption.

In Finland the debt service costs of households have not been very sensitive to interest rates, since before 1988 housing loans were tied to the central bank base rate, which has been changed only for political reasons. What has affected debt service costs is the increasing indebtedness. One further complication due to real interest rates is the role of expectations. If a raise in interest rates is perceived to be permanent it could have a strong effect, eg. on prices of real estate wealth.

[9] With representative consumer models, this is a natural assumption, since consumers are assumed to be identical.

[10] Reprinted with new introduction in Hendry (1993)

[11] Hendry and von Ungern-Sternberg conclude that if the income elasticity of consumption is unity in the long-run, the fall in the consumption-income ratio during the 1970s must be related to incorrect measurement of income due to inflation effects.

Thus the net wealth effect on consumption could be large. Because the real interest rate should be stationary and therefore an increase in it would be expected to be temporary, it may not have such an effect. Therefore one must look at the yield curve as well and the evolvement of long-term interest rates.

A separate model was constructed for purchases of durables as well. Here, the modelling was not based on error correction behaviour, since the consumption of durables is in fact miscalculated in the acturial national accounts. The true imputed consumption is much smoother than the observed purchases of durables. Annual GDP change was found to be a better predictor of purchases decisions than the disposable income. The interest rate elasticity of durables was consumption expectedly much higher than that of non-durables and significantly negative. The interest rate elasticity of durables consumption could be as high as –4. Therefore the weighted interest rate elasticity for total private consumption is approximately –0.7.

Here again a nominal interest rate effect was found instead of a pure real interest dependence. The specification of the durables model is not by all means satisfactory, but may serve to make the point about negative interest rate elasticity. As an additional variable, the relative price of durables and non-durables seems to carry useful information about consumption plans. Because of serious autocorrelation, the model is presented as an autoregressive residuals (RALS) model. Fitted values and the post-sample prediction test for the last three years are plotted in Figure 16.

Table 2 **Modelling non-durable consumption (D4LNONCD)**

Sample period: 1971/Q1—1993/Q4

Variable	Coefficient	Std.Error	t-value	t-prob	PartR²
D4LRYD	0.256	0.040	6.339	0.0000	0.324
D4LRHW	0.051	0.017	2.963	0.0040	0.095
D4LRFW_1	0.143	0.051	2.815	0.0061	0.086
D4LRLBL_1	0.036	0.049	0.732	0.4661	0.006
CF:ECM_3	–0.288	0.066	–4.373	0.0000	0.186
D4LCPI	–0.407	0.115	–3.556	0.0006	0.131
RRLBN_1	–0.396	0.104	–3.802	0.0003	0.146
TERMSK	0.033	0.009	3.654	0.0004	0.137

Model performance			Residual diagnostics			Stat.	P-value
R^2	=	0.8995	AR(1–5)	F(5,79)	=	2.8874	(.0191)*
σ	=	1.1593	ARCH 4	F(4,76)	=	0.1740	(.9511)
DW	=	1.26	Normality	$\chi^2(2)$	=	2.0780	(.3538)
RSS	=	112.8	Xi^2	F(16,67)	=	1.2804	(.2358)
			Xi*Xj	F(44,39)	=	0.7914	(.7748)
			RESET	F(2,82)	=	2.3996	(.0971)

Wald-test for restriction upon nominal interest rate effect:
ß(D4LCPI) = ß(RRLBN): F(1,84) = 0.10 (.752)

Modelling D4LNONCD by IVE
The present sample is: 1971 (1) to 1993 (4)

Variable	Coefficient	Std.Error	t-value	t-prob
D4LRYD	0.547	0.119	4.612	0.0000
D4LRHW	0.056	0.022	2.546	0.0127
D4LRFW_1	0.125	0.065	1.918	0.0585
D4LRLBL_1	–0.060	0.071	–0.840	0.4031
CF:ECM_3	–0.393	0.092	–4.265	0.0001
D4LCPI	–0.262	0.155	–1.689	0.0949
RRLBN_1	–0.203	0.150	–1.352	0.1800
TERMSK	0.018	0.013	1.415	0.1607

Additional Instruments used:
D4LRYD_1 D4LRYD_2 D4LRYD_3 D4LRYD_4
σ = 1.47335
DW = 1.72
RSS = 182.344

2 endogenous and 7 exogenous variables with 11 instruments
Reduced Form σ = 1.21248
Specification $\chi^2(3)$ = 0.824 [0.8437]
Testing ß = 0: $\chi^2(8)$ = 243.38 [0.0000] **

Variables:

D4LNONCD	= Annual log-difference of non-durable private consumption
D4LRYD	= Annual log-difference of real disposable income
D4LRHW	= Annual log-difference of real housing wealth
D4LRFW	= Annual log-difference of real financial wealth
CF:ECM_3	= Lagged error correction term from static long-run equation between non-durable consumption, real income and net wealth
D4LCPI	= Annual log-difference of consumer price index
RRBLN	= Real bank lending interest rate on new loans

Figure 13

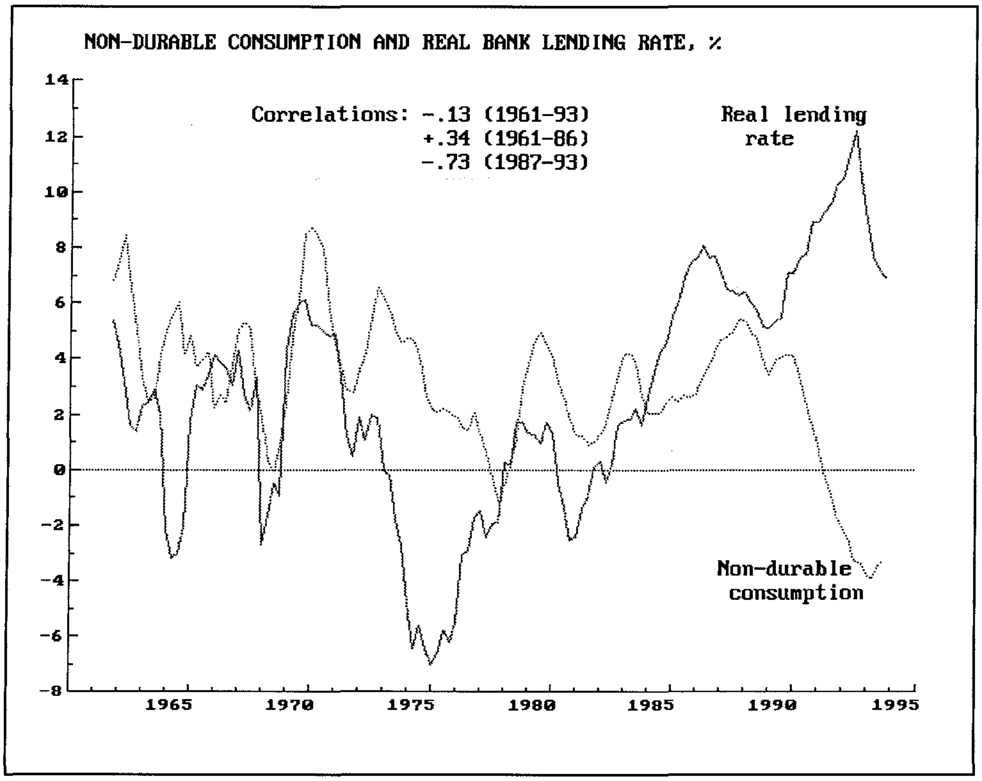

Figure 14

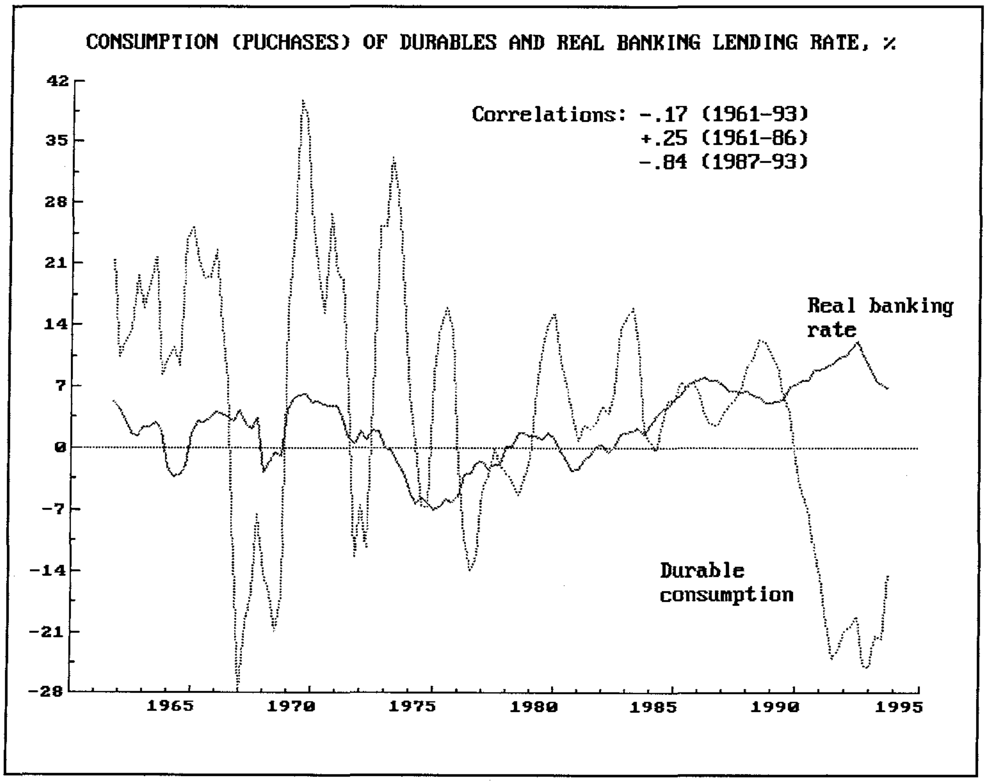

Figure 15 **Non-durable consumption function diagnostics**

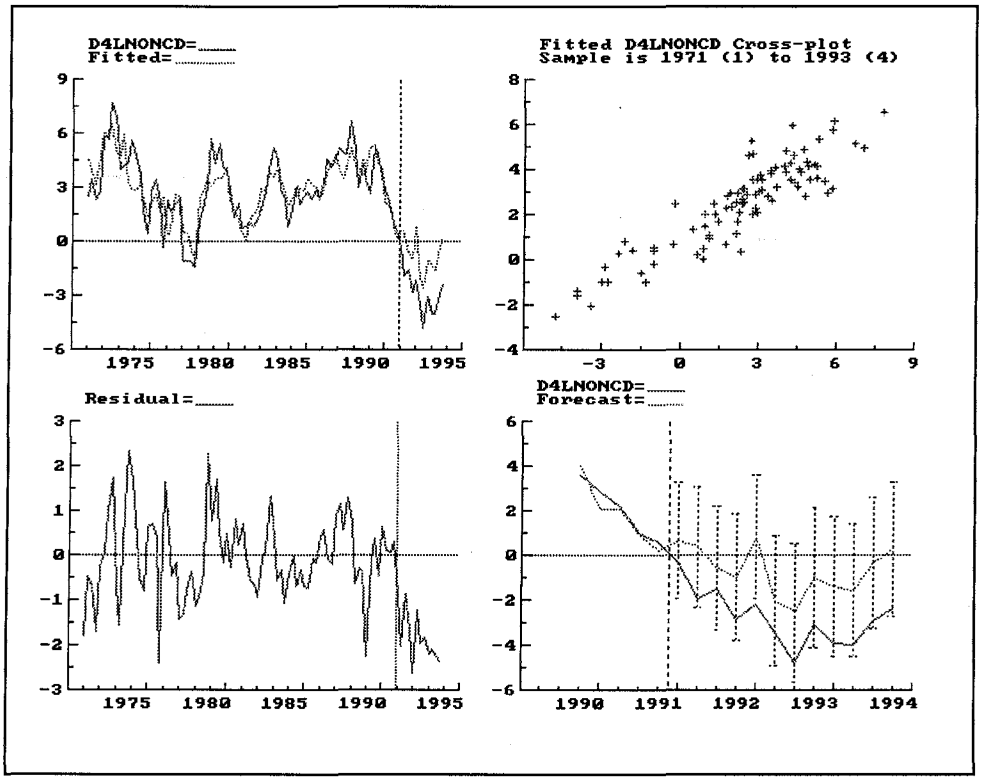

Figure 16 **Durable consumption diagnostics (RALS estimation)**

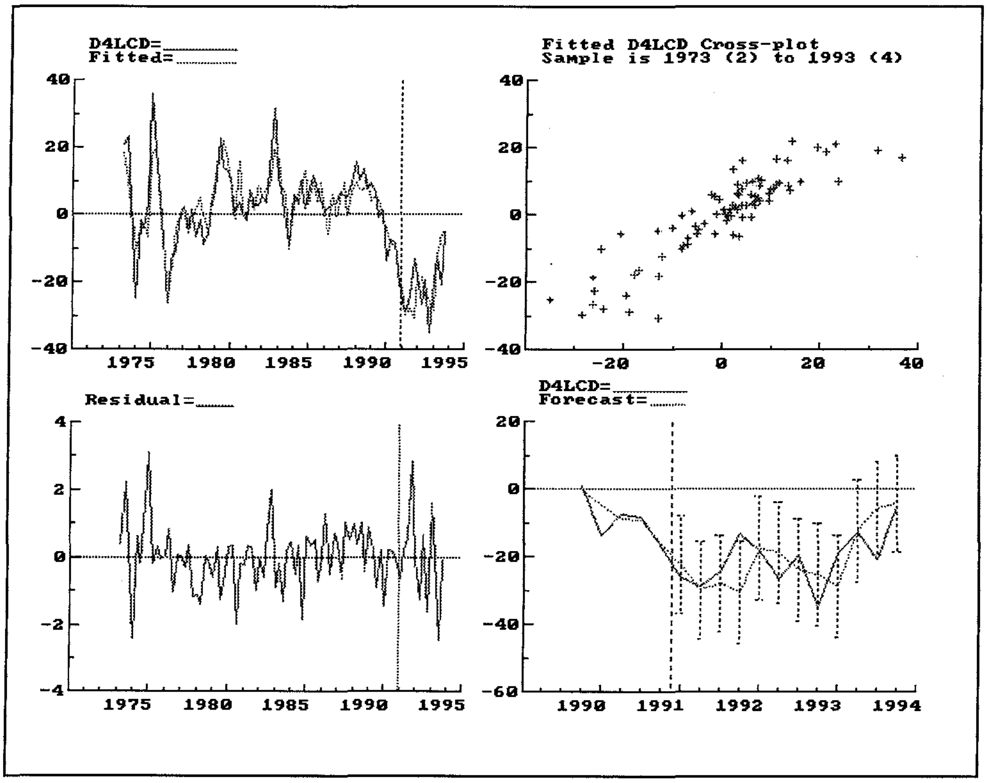

Table 3 **Modelling consumption of durables (D4LCD) by RALS**
Sample period: 1972/Q2—1993/Q4

Variable	Coefficient	Std.Error	t-value	t-prob
Constant	105.19	34.678	3.033	0.0033
D4LGDP	2.841	0.367	7.739	0.0000
PCDrPCND	–70.090	30.532	–2.296	0.0243
Uhat_1	0.428	0.103	4.145	0.0001
RRLBN_1	–3.434	0.817	–4.203	0.0001
D4LCPI	–3.259	0.918	–3.549	0.0006

Wald-test for restriction on nominal interest rate effect:
ß(D4LCPI) = ß(RRLBN): F(1,83) = 0.665 (0.417)

Model performance		Residual diagnostics		Stat.	P-value
R^2 =	0.664				
σ =	8.093	ARCH 1	F(1,74)	= 1.155	(.3377)
$\Sigma y(t)^2$ =	19514.6	Normality	$\chi^2(2)$	= 14.807	(.0006)**
		Xi^2	F(8,73)	= 2.278	(.0362)*
		Xi*Xj	F(14,67)	= 2.106	(.0223)*

Post-sample analysis of 1-step forecasts

Date	Actual	Forecast	Y – Yhat	Forecast SE	t-value
1991 1	–26.129	–22.249	–3.879	7.131	–0.5440
1991 2	–28.573	–29.763	1.190	7.197	0.1653
1991 3	–24.155	–27.672	3.517	7.068	0.4976
1991 4	–13.004	–30.379	17.37	7.551	2.3009
1992 1	–18.111	–17.480	–0.631	7.675	–0.0822
1992 2	–26.343	–18.613	–7.729	7.453	–1.0369
1992 3	–19.527	–23.593	4.065	7.547	0.5387
1992 4	–34.943	–24.998	–9.944	7.600	–1.3084
1993 1	–18.963	–28.650	9.687	7.509	1.2899
1993 2	–12.460	–12.128	–0.331	7.532	–0.0440
1993 3	–20.749	–5.613	–15.135	6.935	–2.1823
1993 4	–4.932	–4.147	–0.784	7.103	–0.1104

Tests of parameter constancy over: 1991 (1) to 1993 (4)

Forecast $\chi^2(12)$ = 1.8118 [0.9996]
Chow F(12, 61) = 1.7024 [0.0884]

Variables:

D4LGDP = Annual log-difference in GDP, %
RRLBN_1 = Real bank lending rate on new loans, % (lagged one quarter)
D4LCPI = Inflation, %
PCDrPCND = Ratio of price index of durables to price index of non-durables
Uhat_1 = First order autoregressive terms for the residual

4 Interest rates and private investment

For investment plans the interest rate represents an opportunity cost. Raising interest rates will increase the return demanded for investment and the volume of investment should therefore decrease. In addition, the increasing interest rate means increasing the cost of debt financing, which should also decrease the willingness to invest. However, there are smaller marginal effects, like increasing interest payment deductions or increasing real asset prices, which increase the willingness to invest. These effects are usually included in the user cost variable, but since we are interested in the interest rate effects, we keep them separate.

Next we try to analyse the effects of interest rates on investment. As emphasized earlier, we proceed in the context of an investment function to avoid a misleading partial analysis. Unlike the analysis of the consumption function, this will be done under the assumption of certainty. Our main focus is on Tobin q-theory models, which have proved successful for Finnish manufacturing and housing investment functions (Takala & Tuomala 1990, 1991; Dufwenberg, Koskenkylä & Södersten 1994). The emphasis in q theory is not directly on desired capital or the related adjustment mechanism. Tobins' q theory uses Keynes' idea that investment plans depend on the profitability of new investment as measured by the ratio of the market value of new capital to its replacement cost.[12]

4.1 Real interest rate and manufacturing investment

The q theory stresses the importance of price signals in guiding manufacturing investment activity. Therefore stock prices, for example, could have significant predictive value for investment plans. One way of assessing the impact of stock market movements is to look at the relationship of the rate of investment to Tobin's q, ie. the ratio of the market's valuation of capital within the firm to the current acquisition cost of that capital. This model was originally developed by Tobin (1969) and has been further developed by Summers (1981) and Hayashi (1982), among others. The idea of the q model is that the firm will expand its capital stock until the market values its capital above the current price of capital goods. Actual investment should be an increasing function of q

$$I_t = I(q), \quad \partial I/\partial q > 0. \tag{1}$$

The marginal cost of newly installed capital is an increasing function of investment and the firm will continue to invest up to the point where the marginal cost of investment equals the q ratio. If the relative price of new capital is high ie. q > 1, firms should invest; otherwise the capital stock should be reduced.

The important feature of Tobin's q is that it reflects the relative price of new and old capital, which makes the whole theory **price-determined**. In the capital market, prices are supposed to adjust more quickly than quantities, and therefore

[12] It could be said that q theory incorporates adjustment costs as part of the profit maximization problem determining the optimal rate of investment (Abel 1990).

prices signal investment opportunities. Tobin's model is reduced to a level where the aggregate production function is omitted and investment is driven by the q ratio, which contains all the relevant information. In practice, this may seem to be an overly rationalistic view.

The demand for final products is taken as given and a firm operating under conditions of perfect competition equates the marginal cost of new capital to the discounted net income it produces. However, like neoclassical theory, there is no explicit background theory for the adjustment process in Tobin's q theory. It has been claimed by Fischer (1989) that in empirical models the q theory does not provide a sufficient framework for the relation between q and investment. In this context many factors such as taxation, liquidity constraints and variability in risk-taking may interfere with the activity in the capital market. Econometrically, these problems relate to the misspecification of the investment equation.[13]

Secondly, managerial investors know more precisely the production function of the firm needed to optimize investment with respect to marginal q, ie. the shadow value of the additional value of capital. Outside investors base their valuations on the average q, ie. the value of existing capital stock, rather than on marginal or expected values. In this sense, owners look only at the current value, while managers are more interested in future earnings flows. The stock market reflects mainly the average q, and only partly the marginal q.[14]

US evidence in particular shows that stock returns are efficient predictors of changes in investment. Barro (1990) argues that the stock market is a better predictor of investment than is the traditional Tobin q proxy. However, when profits, earnings or production are controlled, the predictive power of market valuations seems to vanish. According to Barro (1990), this may reflect the endogeneity of production, profits and investment. The attractive feature in using q is that it relieves the economist of the need to calculate the expected present value of future cash flows by using q instead (Abel 1990 p. 766). It is worthwhile to emphasize however that q static may not be sufficient, which will show up in the autocorrelation of the residuals of the investment equation.

Fischer and Merton (1984) argue that investment should respond to stock market changes anyway, even when the stock market does not indicate the same fundamentals that managers may have in mind. There are some objections to this argument. For example average q and marginal q may vary with the actions of the firm, share issues can be used as a signaling device in the stock market etc. The empirical relevance of these objections is an open matter. Takala and Tuomala (1991) test several empirical investment functions for Finnish manufacturing

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[13] In an efficient capital market, financial and investment decisions are assumed to be separable from each other, which has been called the Modigliani-Miller theorem. If these decisions are related, the public sector can use taxation to control or change the profitability of investment. In principle, the financial cost is determined from the capital payments after the gains from inflation and tax relief has been deducted. Changes in taxation affect the after-tax return on investment, but these should be incorporated in the q ratio.

[14] For managers it is important to know why q and marginal q differ, since it affects eg. the level and timing of investment decisions. If marginal $q < q$ the emission of new shares involves a transfer from old shareholders to new shareholders (Blanchard, Rhee & Summers 1990). In addition, if managerial compensation depends on the performance of the firm, which is measured by stock value, managers should base investment decisions on market valuation of asset prices.

investment. It was found that very simplified q models cannot explain all the observed features in the data.

Therefore another candidate for the investment model could be the Mullins & Wadhwani (1989) version of the **flexible accelerator formulation**, which includes various additional explanatory factors affecting investment without restriction:

$$\alpha_1(L)I_t/K_t = \alpha_2 + \alpha_3(L)\Delta \ln Y_t + \alpha_4(L)r_{Dt} + \alpha_5(L)d_t + \alpha_6(L)DE_t +$$

$$\alpha_7(L)BDE_t + \alpha_8(L)q_t + \alpha_9(L)(P_I/P),$$

where P_I = investment deflator, P = GDP deflator, r_D = government bond yield, DE = debt-equity ratio, BDE = debt-equity ratio at book value, K = replacement cost of net capital stock for the private sector, I = manufacturing investment, Y = level of output, d = dividend yield and L is the lag operator and q the Tobin q proxy.

Investment plans include an internal rate of return which is compared to the cost of financing eg. the interest rate of debt financing. For an individual consumer the alternative asset return could be a rate of return which is payed for a financial asset, ie. the deposit rate. This formulation of an investment function is rather permitting concerning the effects of interest rates in costs of capital. It may often be the case that the effect of interest rate change is blurred in the empirical estimations. Abel (1990, p. 761) points out that if there is an exogenous increase in the real interest rate, the user cost will increase and investment will decrease. Due to simultaneity, it might be difficult to find out a separate user cost effect or distinquish it from the interest rate effect.

In addition, there is the question of the proper measure of an interest rate for the cost of capital. Hall (1977) advocates the short-run interest rate as being a proxy for the service price of capital. However, for Finnish data it was found that with respect to manufacturing investment, the real bank lending rate performed better in estimations than real market interest rate.

The estimation results for mixtures of q models and a flexible accelerator are quite favourable to the theory, but not so clear-cut with respect to real interest rate effect. The real interest rate influence on the manufacturing investment/capital ratio is limited if we compare it to the influence of dividends or the profit/capital ratio (Table 4). However, here we also have a negative effect from real interest rate to investment demand. For manufacturing investment also longer-term interest rates, such as the government bond rate, could be used. The main observation to come out of these estimations is that forward-looking profit seeking aspects have a major influence on manufacturing investment. The Tobin q proxy has a very significant effect on investment behaviour. Indebtedness has the expected limiting effect on the fulfilment of investment plans.

In order to compare interest rate sensitivity of investment with that of the consumption components, we estimated a model for manufacturing investment with annual log-differences (Table 5). The composition of the significant explanatory factors did not change very much. Dividends and the profit/capital ratio were again successful. Indebtedness was confirmed to have a limiting effect with a two year lag. Manufacturing investment is also affected by changes in the terms of trade, since the profitability of the main manufacturing industries (paper, pulp and metal) relies heavily on exchange rates and the terms of trade. These effects will be included in the q variable through stock prices. In Finland terms-of-trade variation has partly affected capacity utilization, since corporations have adjusted their production with respect to price-profitability.

The estimations showed that the interest rate elasticity of manufacturing investment has been relatively high and also variable. Recursive estimates converge to an elasticity of the order –2.5. According to estimation results, there seemed to again appear a nominal interest rate effect as in case of consumption. One possible explanation for this could be that given in Dale and Haldane (1993, p. 27). They argue that the first reaction to an increase in the interest rate would be a rise in corporate borrowing. In the short run we may therefore withness a reduction in corporate deposits as well. On the other hand, for households we may observe an increase in deposits due to an increase in the interest rate return.

In addition to the aforementioned explanatory variables, interest rate uncertainty was modelled by means of an ARCH(1) model, and appeared to be significant in only a few formulations. Abel (1990, p. 771) points out that interest rate uncertainty should force the firm to increase investment, but we found the opposite effect in our data. If we approach investment projects from the point of view of financing, we may assume that interest rates affect investment directly through debt financing. This effect may be limited to the share of debt financing, which is internationally rather high in Finland. An indirect effect is accomplished through opportunity costs.

Even though we have used several suggested explanatory variables, these equations are contaminated with significant residual autocorrelation. This could be eliminated by autoregressive residual models or lagged endogenous variables. Serial autocorrelation has been a nuisance in other empirical investment functions as well, and it has been argued that the nature of investment projects is partly responsible for this kind of phenomenon. In any case, the problem of serial autocorrelation points out dynamic misspecification, which is a difficult to improve. Searching for better dynamic specification does not help much with the existing regressors. This could refer to omitted variables, but it is hard to find stable alternative explanatory variables that would correct the specification. It can however be argued that the serial correlation arises at least partly from the adjustment process of investment itself.

Table 4 **Modelling manufacturing investment/capital ratio** (L[IF4/KF4]), Sample period: 1972/Q1—1993/Q4

Variable	Coefficient	Std.Error	t-value	JHCSE	PartR²	Instab
Constant	−5.166	0.214	−24.103	0.256	0.8763	0.33
LqLIF4	0.498	0.070	7.131	0.089	0.3827	0.38
Dividends	0.117	0.022	5.406	0.027	0.2627	0.38
RRLBN	−0.020	0.005	−3.848	0.004	0.1529	0.16
Profcap_2	0.052	0.019	2.791	0.015	0.0868	0.43
INDEBT	−0.021	0.012	−1.803	0.009	0.0381	0.20

Model performance			Residual diagnostics		Stat.	P-value
R^2	=	0.723	AR(1−5)	F(5,77)	= 24.842	(.0000)**
σ	=	0.127	ARCH 4	F(4,74)	= 12.384	(.0000)**
DW	=	0.408	Normality	$\chi^2(2)$	= 3.5278	(.1714)
RSS	=	1.313	Xi^2	F(10,71)	= 2.3094	(.0205)*
			Xi*Xj	F(20,61)	= 2.2052	(.0095)**
			RESET	F(1,81)	= 6.4133	(.0133)*

Post-sample prediction analysis of 1-step forecasts

Date	Actual	Forecast	Y − Yhat	Forecast SE	t-value
1991 1	−3.818	−3.918	0.1003	0.1438	0.6973
1991 2	−3.946	−4.066	0.1205	0.1774	0.6790
1991 3	−4.007	−4.151	0.1435	0.1815	0.7907
1991 4	−4.055	−4.229	0.1735	0.1830	0.9480
1992 1	−4.073	−4.282	0.2091	0.1990	1.0510
1992 2	−4.027	−4.386	0.3594	0.2181	1.6477
1992 3	−4.128	−4.395	0.2662	0.2084	1.2771
1992 4	−4.150	−4.310	0.1606	0.2038	0.7878
1993 1	−4.203	−4.249	0.0462	0.2089	0.2215
1993 2	−4.279	−4.167	−0.1111	0.1987	−0.5591
1993 3	−4.216	−4.030	−0.1857	0.1771	−1.0486
1993 4	−4.263	−3.943	−0.3197	0.1631	−1.9597

Tests of parameter constancy over: 1991 (1) to 1993 (4)

Forecast $\chi^2(12)$ = 35.962 [0.0003] **
Chow F(12,70) = 2.094 [0.0283] *

Variables

LIF4/KF4	= Manufacturing investment/net stock of fixed capital ratio
Dividends	= Dividends adjusted for new issues
Profcap	= Gross operating surplus in manufacturing/value of net stock of fixed capital in manufacturing
RRBLN	= Real bank lending rate on new loans
LqLIF4	= Tobin q proxy; the manufacturing stock price index divided by the price index for manufacturing investment
INDEBT	= Indebtedness ratio proxy; outstanding loans/production

Table 5 **Modelling manufacturing investment (D4LIF4)**
Sample period: 1973/Q1—1993/Q4

Variable	Coefficient	Std.Error	t-value	t-prob	PartR^2
Constant	44.758	15.526	2.883	0.0051	0.099
D4Divid	6.536	1.682	3.886	0.0002	0.166
D4LqLIF4_2	0.061	0.083	0.730	0.4674	0.007
D4Profca_2	0.041	0.016	2.554	0.0126	0.079
D4LINDEB_8	−1.083	0.332	−3.265	0.0016	0.123
D4TERMS	1.075	0.264	4.069	0.0001	0.179
RRLBN_3	−2.612	1.234	−2.117	0.0376	0.056
D4LCPI_4	−4.262	1.564	−2.725	0.0080	0.089

Wald-test for restriction on nominal interest rate effect:
ß(D4LCPI) = ß(RRLBN): F(1,76) = 8.10, p = 0.006**

Model performance			Residual diagnostics		Stat.	P-value
R^2	=	0.597	AR(1−5)	F(5,71)	= 12.635	(.0000)**
σ	=	12.959	ARCH 4	F(4,68)	= 9.929	(.0000)**
DW	=	0.983	Normality	$\chi^2(2)$	= 0.876	(.6454)
RSS	=	12762	Xi^2	F(14,61)	= 1.727	(.0731)
			Xi*Xj	F(35,40)	= 1.123	(.3594)
			RESET	F(1,75)	= 0.001	(.9747)

Analysis of 1-step forecasts

Date	Actual	Forecast	Y − Yhat	Forecast SE	t-value
1991 1	−32.095	−28.881	−3.213	15.546	−0.206
1991 2	−35.515	−39.472	3.957	16.256	0.243
1991 3	−32.006	−36.620	4.614	16.291	0.283
1991 4	−35.241	−31.155	−4.085	15.758	−0.259
1992 1	−26.477	−30.129	3.650	15.787	0.231
1992 2	−9.2656	−21.701	12.43	15.427	0.806
1992 3	−13.527	−11.106	−2.419	14.989	−0.161
1992 4	−11.091	−16.678	5.586	16.183	0.345
1993 1	−14.808	−20.373	5.565	16.744	0.332
1993 2	−27.509	−21.872	−5.636	15.933	−0.353
1993 3	−11.219	−18.721	7.502	15.790	0.475
1993 4	−13.962	−6.8790	−7.082	14.741	−0.480

Tests of parameter constancy over: 1991 (1) to 1993 (4)

Forecast $\chi^2(12)$ = 2.2637 [0.9989]
Chow F(12, 64) = 0.16057 [0.9993]

Variables

D4LIF4	= Annual log-difference in manufacturing investment
D4Divid	= Annual log-difference in dividends adjusted for new issues
D4Profca	= Annual log-difference in gross operating surplus in manufacturing/value of net stock of fixed capital in manufacturing
D4LqLIF4	= Annual log-difference in Tobin q proxy; the manufacturing stock price index divided by the price index of manufacturing investment
D4LINDEB	= Annual log-difference in indebtedness ratio proxy; outstanding loans/production
D4TERMS	= Annual change in terms of trade
D4LCPI	= Inflation, %
RRBLN	= Real bank lending interest rate on new loans, %

Figure 17 **Manufacturing investment/capital ratio diagnostics**

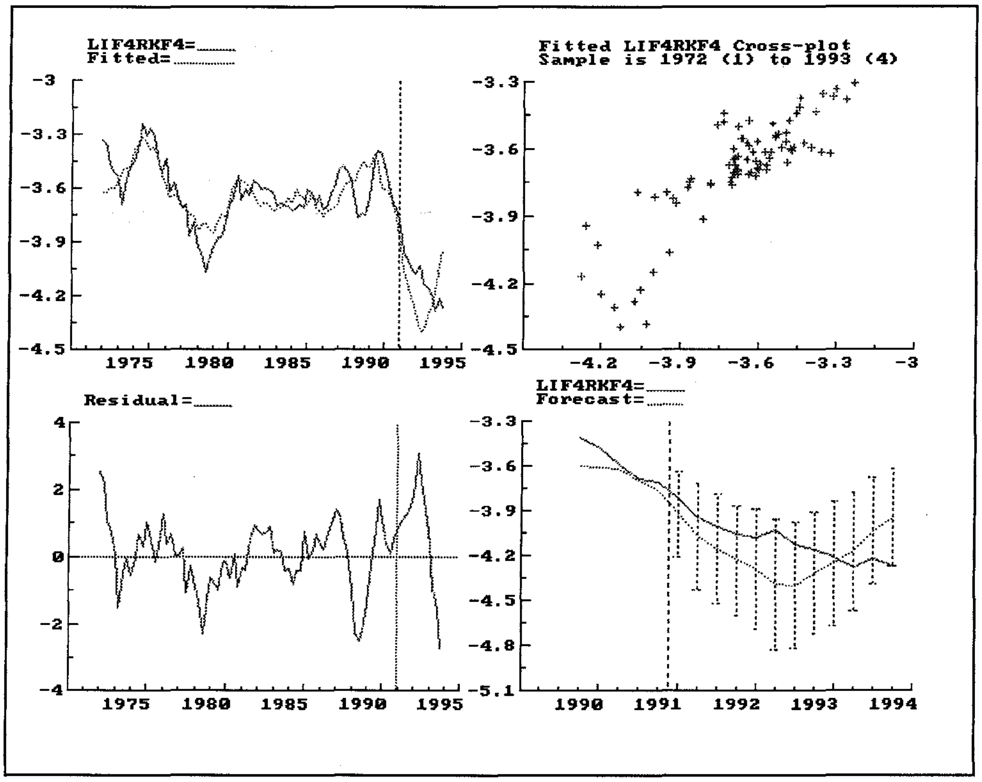
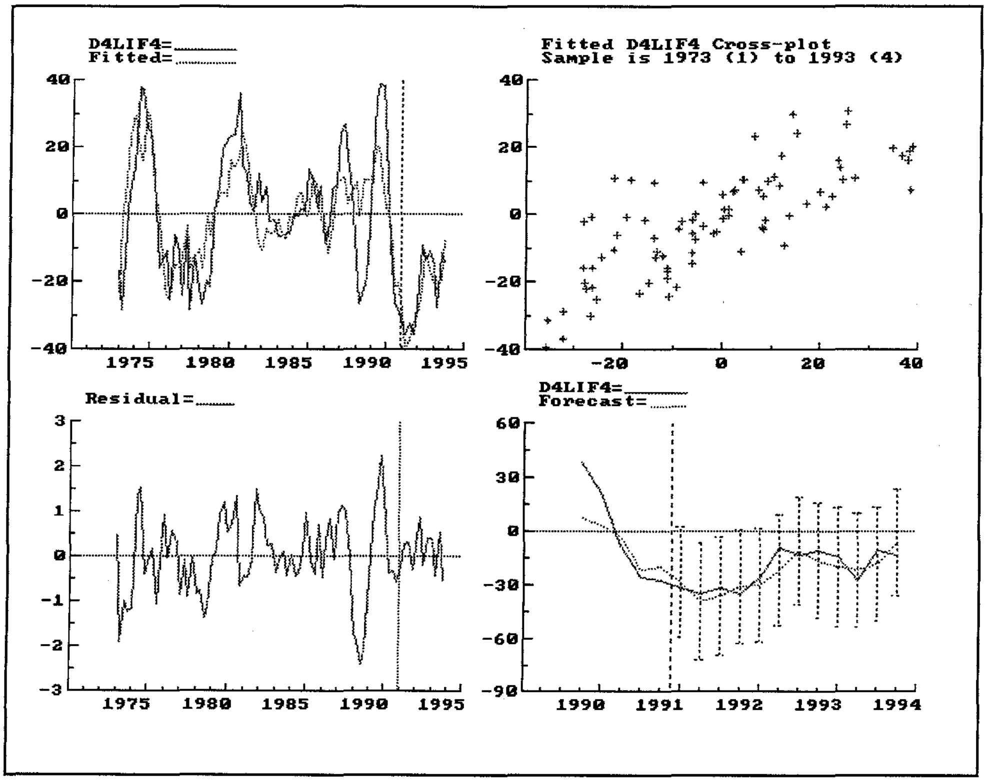


Figure 18 **Manufacturing investment diagnostics**



4.2 Real interest rate and housing investment

In comparison to other capital commodites, houses are exceptionally durable. Depreciation of houses lowers the existing stock only 2—3 per cent annually. According to theory, the price of a house is a deflated present value of future returns, ie. capital income. These returns are deflated by the return on alternative assets. House prices are rather volatile relative to other durables, since the value of houses depends heavily on income expectations. The durability of housing should explain the observed large interest rate sensitivity of housing purchases and housing investment. Even though the imputed capital return of owner-occupied housing is not directly observable, the present value of a house is observable as the price of the house.

Forward-looking consumers have a downward sloping demand curve for housing ie. the marginal benefit from increasing housing services is a decreasing function of the housing stock. On the other hand, the marginal cost of housing is determined by the rental price of housing. The desired level of housing stock can be found from the intersection of these demand and supply curves. The adjustment in housing investment is very slow due to the high positive correlation of the changes of housing investment. One of the major housing market characteristics is the ongoing replacement of old houses with new better equipped houses. Lags in housing production are also responsible for the autocorrelation in housing investment. Modelling problems usually take the form of serially correlated errors in the investment functions.

Housing investment theory emphasizes the role of the present value of returns as a motive for investment. The household's willingness to pay for a house is affected by its expectations about the future earnings. In making investment decisions on housing, construction firms will look closely at the relationship between current housing prices and replacement construction costs. This is precisely what Tobin's q theory tells us: the market climate for investment is determined by the ratio of the market value of a investment to its replacement price. The q approach therefore places a lot of weight on expectations in determining the investment level. Since new housing units form only a minor fraction of the total supply of housing, construction firms can expect to get the market price for their investment. In this sense current house prices are sufficient statistics for housing investment (Topel and Rosen 1988 p. 721). Since the construction industry is highly volatile, we should expect to find reasonable investment supply elasticity with respect to price changes. The durability of houses should therefore make houses strongly interest-rate sensitive.

This modified q model was tested and the main idea appeared again to be very successful (Table 6, Takala and Tuomala 1990). As expected, it can be seen that the interest elasticity of housing investment is higher than for non-durable consumption. In fact, we cannot reject the hypothesis of unitary interest elasticity in housing investment. It should be pointed out however that the real interest rate effect has become negative for housing investment only after 1985. This can be seen in the recursive coefficients of real lending estimated for housing investment (see section 4.3 and figure 24).

The overall economic activity (GDP) was used as variable setting a basic level for housing investment, although there may exist some simultaneity. On many occasions it has been observed that real bank lending can be a significant explanatory variable for housing investment. The relationship between financing a housing investment – which makes up about 37 % of the total of banks' markka lending – and housing investment may not be surprising. In the presented equation inflation was not significant and there is no apparent nominal interest rate effect. However, slight change in specification and sample period can change the results and nominal interest rate effect could be found. In this respect the results are not stable. The diagnostics of the chosen equation can be seen from table 6 and the post-sample performance for the model in figure 20. The post-sample forecasting tests do not indicate any major misspecification.

Table 6 **Modelling housing investment (D4LIH)**

Sample period: 1970/Q1—1993/Q4

Variable	Coefficient	Std.Error	t-value	t-prob	PartR²
Constant	−113.15	33.868	−3.341	0.0012	0.1103
D4LGDP	1.250	0.33342	3.748	0.0003	0.1350
LqPHM	25.000	7.6338	3.274	0.0015	0.1064
D4LRLBP_1	0.465	0.19547	2.380	0.0194	0.0592
RRLBN	−1.211	0.57868	−2.092	0.0393	0.0464
D4LCPI	−0.498	0.62451	−0.797	0.4277	0.0070

Wald-test for restriction on nominal interest rate effect:
ß(D4LCPI) = ß(RRLBN): F(1,90) = 14.1, p = 0.003**

Model performance		Residual diagnostics		Stat.	P-value
R^2	= 0.660	AR(1–5)	F(5,85)	= 7.099	(.0000)**
σ	= 7.112	ARCH 4	F(4,82)	= 2.329	(.0629)
DW	= 1.25	Normality	$\chi^2(2)$	= 0.589	(.7446)
RSS	= 4552.2	Xi²	F(10,79)	= 0.947	(.4958)
		Xi*Xj	F(20,69)	= 0.989	(.4854)
		RESET	F(1,89)	= 1.412	(.2378)

Post sample analysis of 1-step forecasts

Date	Actual	Forecast	Y − Yhat	Forecast SE	t-value
1991 1	−20.166	−20.705	0.5388	8.259	0.0652
1991 2	−25.914	−25.142	−0.7720	8.563	−0.0901
1991 3	−25.079	−25.441	0.3616	8.558	0.0422
1991 4	−22.114	−27.956	5.8419	8.659	0.6745
1992 1	−21.901	−24.396	2.4948	8.474	0.2943
1992 2	−16.522	−22.876	6.3540	8.421	0.7544
1992 3	−10.681	−24.951	14.2704	8.567	1.6656
1992 4	−20.634	−22.897	2.2629	8.417	0.2688
1993 1	−25.229	−23.425	−1.8046	8.478	−0.2128
1993 2	−19.230	−21.511	2.2814	8.621	0.2646
1993 3	−14.886	−18.417	3.5309	8.886	0.3973
1993 4	−1.002	−12.918	11.9165	8.511	1.4001

Tests of parameter constancy over: 1991 (1) to 1993 (4)

Forecast Chi²(12) = 8.3387 [0.7581]
Chow F(12, 78) = 0.47624 [0.9229]

Variables

D4LGDP	= Annual log-difference of gross domestic product, %
LqPHM	= Tobin q proxy; the house price index ratio to construction costs
D4LRLBP	= Annual log-difference of real bank lending, %
D4LCPI	= Inflation, %
RRBLN	= Real bank lending interest rate on new loans, %

Figure 19

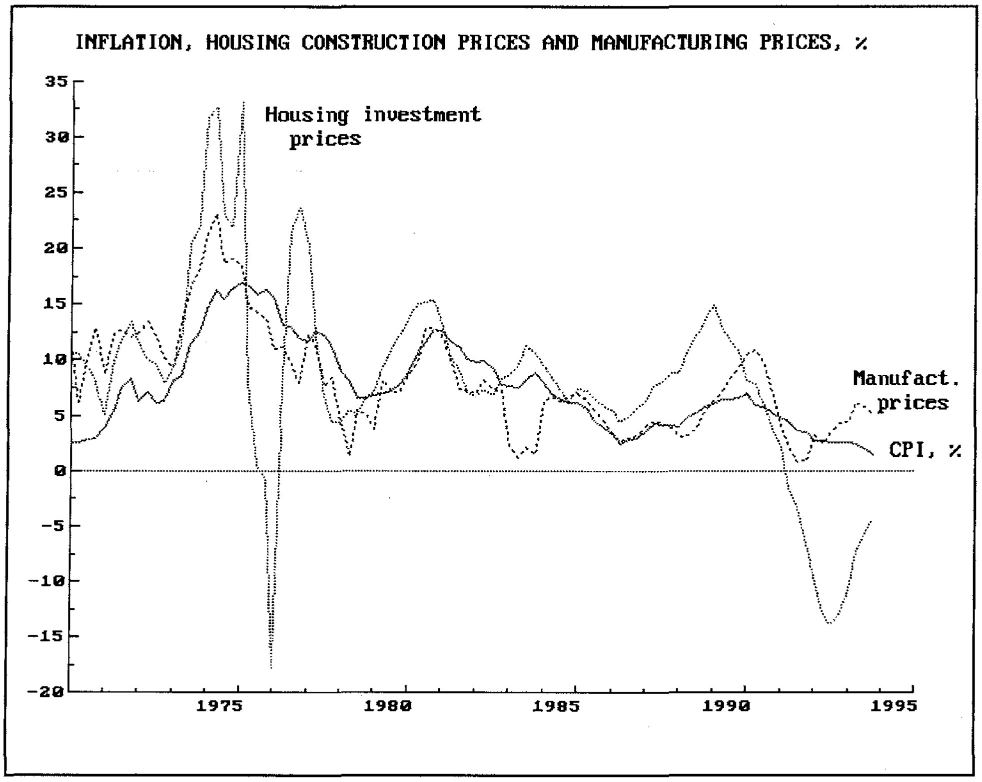
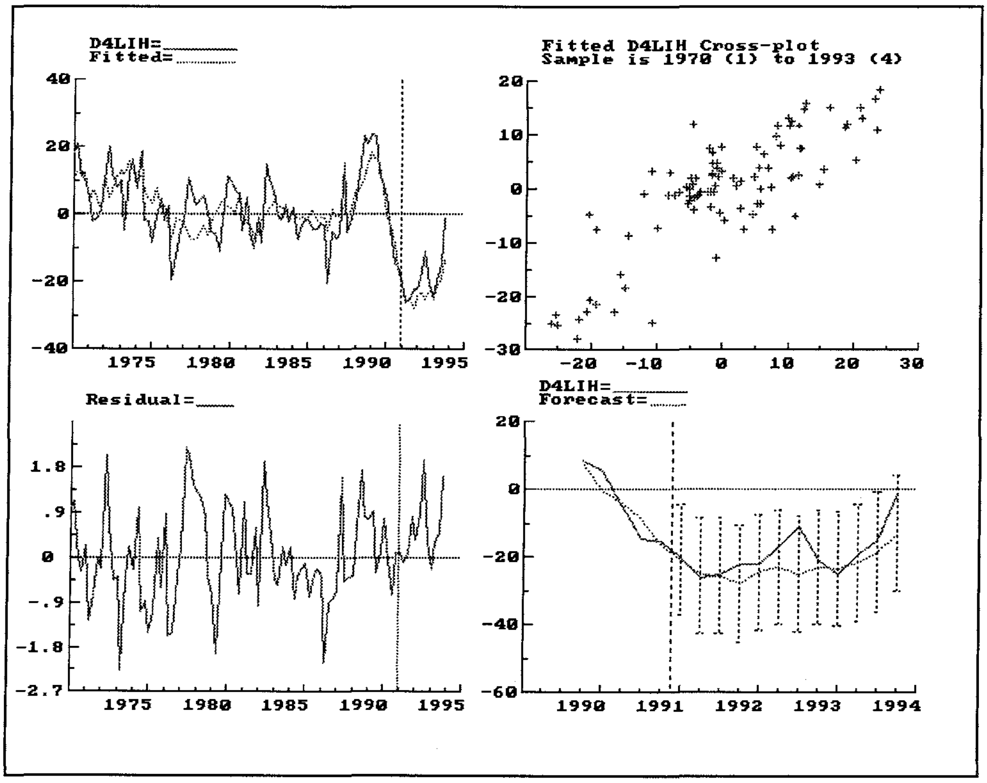


Figure 20 Housing investment model diagnostics



5 Summary of interest rate elasticities

To approach the question of interest rate elasticity of output, we have estimated several behavioural equations for the major demand components. It is clear that the interest rate elasticity is not the same for different GDP components. Even if we knew that the contributions of these components to GDP had been relative constant, there is not much hope that over the past 20 years the interest rate elasticity of GDP has been constant.

To get some idea about the variation in the interest rate elasticity, we can estimate our behavioural function recursively and try to assess confidence limits for the elasticity. Figures 21—24 present the recursive interest rate elasticities for the consumption and investment components. In recursive regressions the convergence of the coefficients may sometimes smooth the volatility of the elasticities, even if one takes into account the narrowing confidence bounds. Therefore rolling interest rate elasticities were also calculated, with a 6-year lag window. Several interesting points can be observed (Figures 25—26). The elasticity of non-durable consumption has been relatively stable during the period of financial liberalization. The elasticity of durables first fell in 1988 but it increased thereafter up to 1993. The most surpricing thing however is the evolvement of manufacturing investment elasticity. According to estimations it turned out that during the strongest boom in manufacturing investment, the interest rate elasticity may have been positive. It seems that during the peak of the deregulation period, the real interest rate was not an important determinant of manufacturing investment. In fact manufacturing corporates shifted their borrowing to foreign loans. At the same time the interest rate margin between domestic and foreign currency lending was wide. As observed already housing investment started to react to the real interest rate only after the mid-1980s. This result is in accordance with the view that during the regime of regulation a large share of households was liquidity constrained and it was profitable to take out a housing loan without paying much attention to the interest rate. This was due mainly tax deductions for interest payments.

Table 7

Comparison of interest rate elasticities to other Finnish studies, *)

Study	Dependent variable	Period	Elasticity
Starck (1990)	Non-durable consumption	1961/Q1—89/Q4	+.386
	Total private consumption	1961/Q1—89/Q4	+.475
BOF4 (1990)	Total private consumption (log-level)	1963/Q1—85/Q4	–.056
	Housing investment	1975/Q1—85/Q4	–.22
Takala, Tuomala (1991)	Manufacturing investment	1966/Q3-89/Q4	-.13
Dufwenberg, Koskenkylä, Södersten (1994)	Manufacturing investment	1965—1990	–.11
Kajanoja L. (1995)	Manufacturing investment (I/K ratio)	1963/Q1-93/Q2	-.0112
	Non-manufacturing investment (I/K ratio)	1963/Q1-93/Q2	-.004
This study (1995) (one-year-elast.)	Non-durable consumption	1971/Q1-93/Q4	-.4
	Durable consumption	1972/Q2-93/Q4	-3.4
	Manufacturing investment (I/K ratio)	1972/Q1-93/Q4	-0.02
	Manufacturing investment	1973/Q1-93/Q4	-2.61
	Housing investment	1970/Q1-93/Q4	-1.21

*) It is somewhat difficult to compare the different elasticities, since they are typically reported in varying time span. Interest rate concept is also not always the same. Investment equations are reported in BOF4 (1990) and Kajanoja (1995) using investment/capital ratios as dependent variable. Dufwenberg et. al (1994) use one year differences, since they use annual data, but do not directly report the interest rate elasticity, but instead gives the elasticity of the user cost measure for capital.

BOF4's private consumption interest rate elasticity is estimated in log-levels ie. as long-term elasticity. Starck (1990) reports elasticities using one quarter log-differences.

Figure 21 **Interest rate elasticity of non-durable consumption**

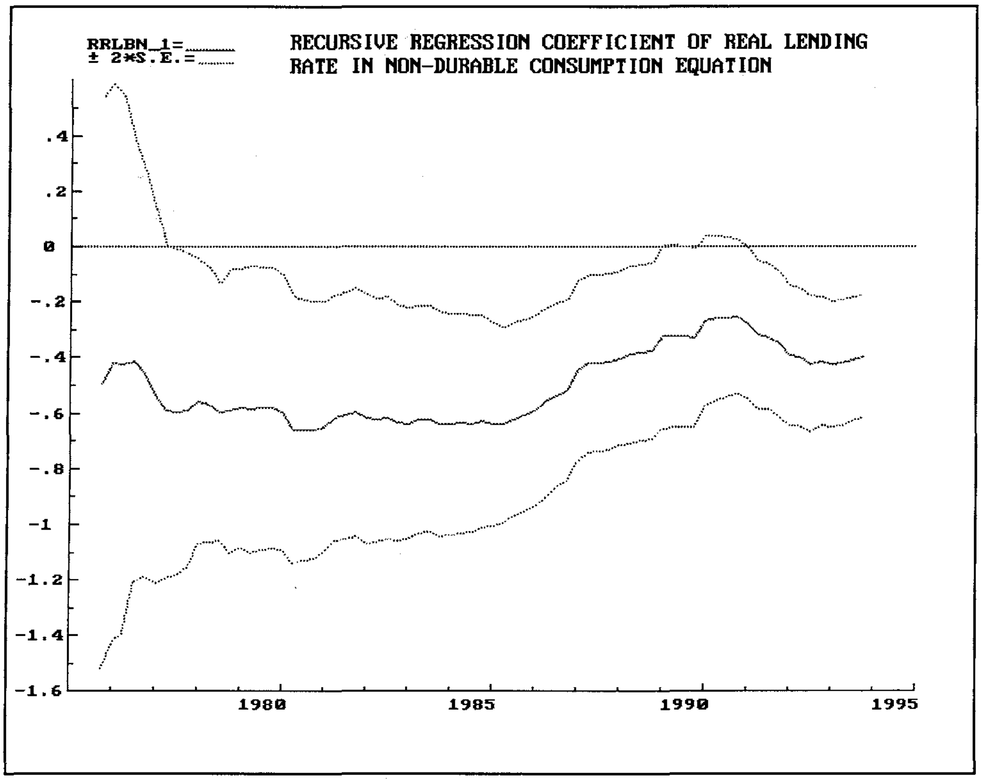


Figure 22 **Interest rate elasticity of durable consumption**

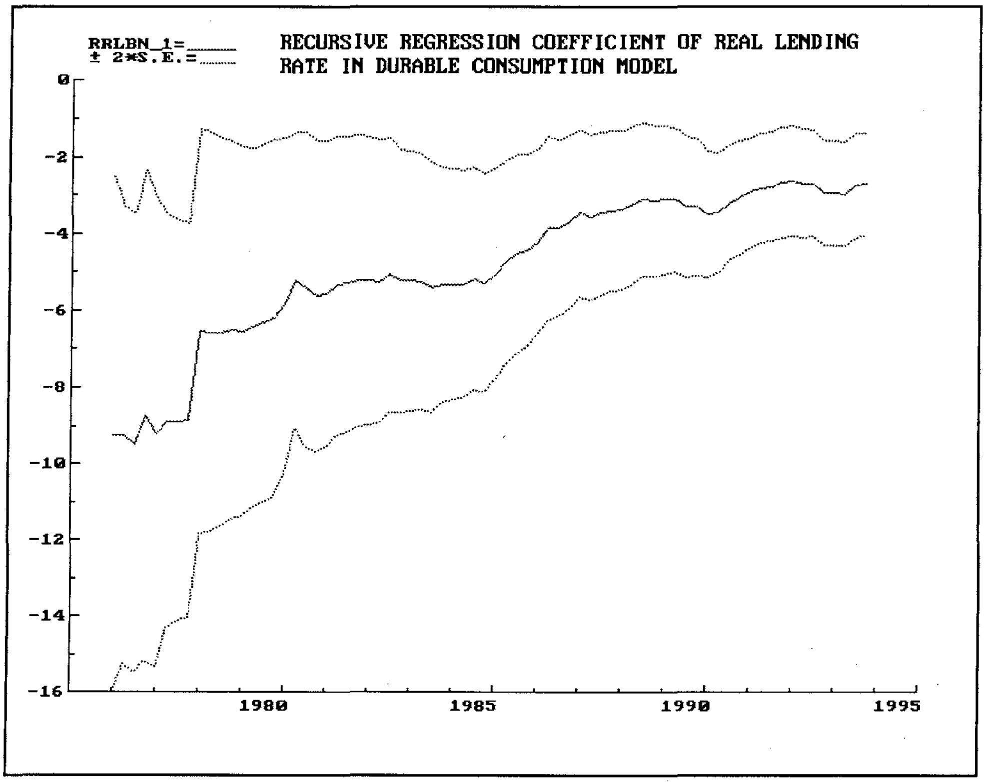


Figure 23 **Interest rate elasticity of manufacturing investment**

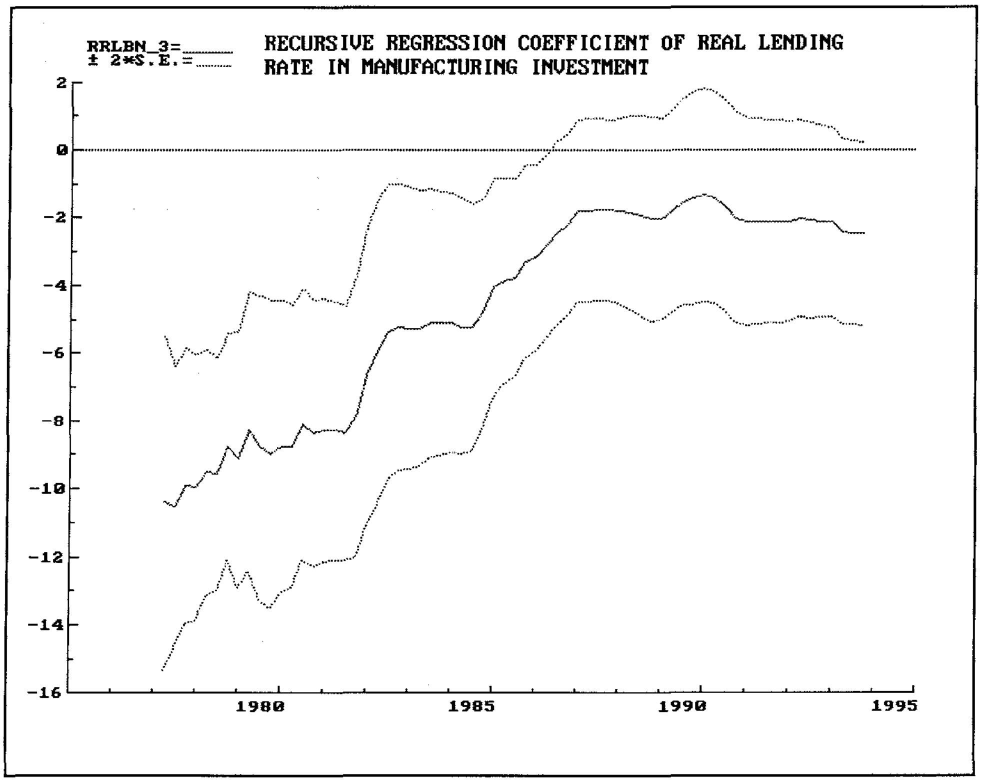


Figure 24 **Interest rate elasticity of housing investment**

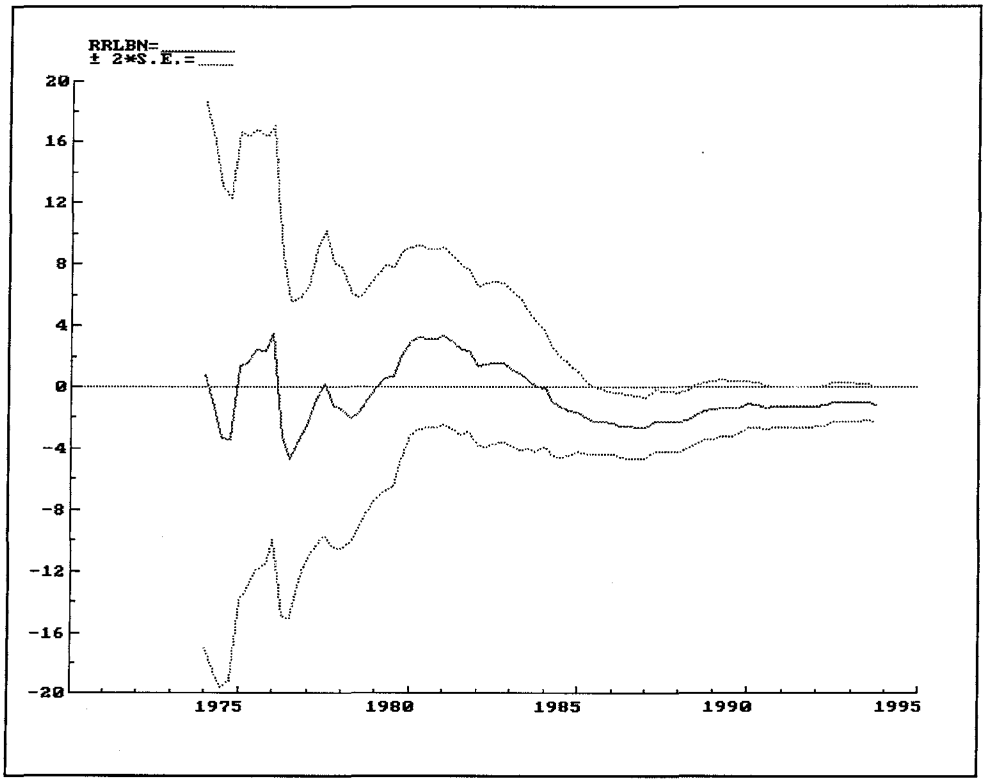


Figure 25 **Rolling interest rate elasticity of consumption**

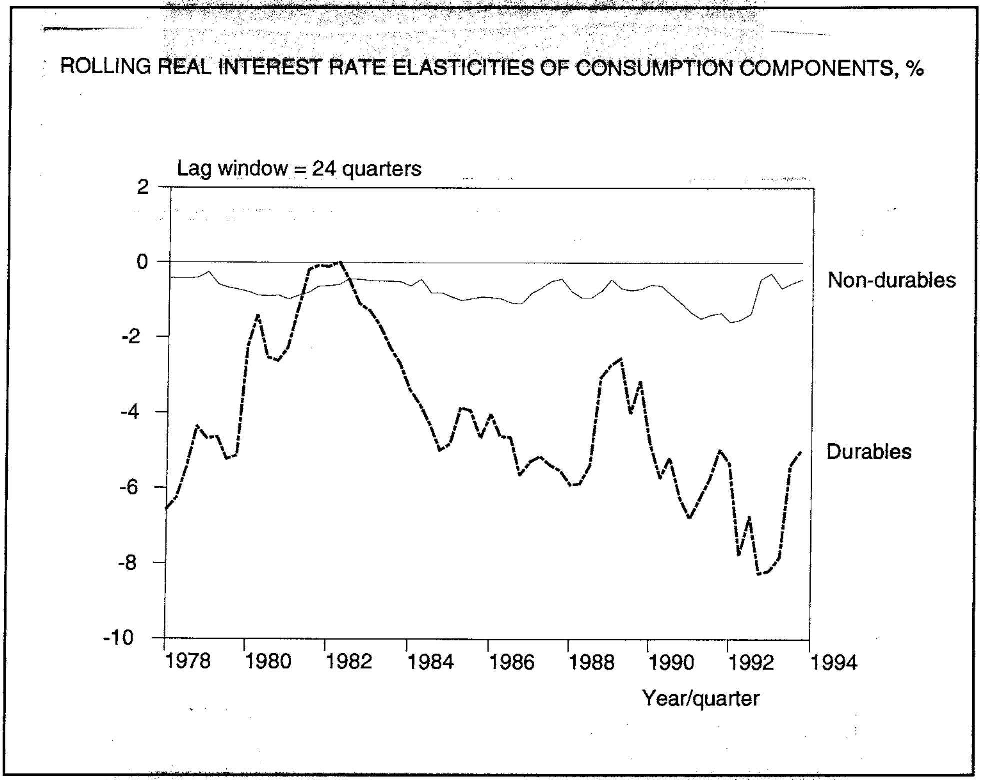
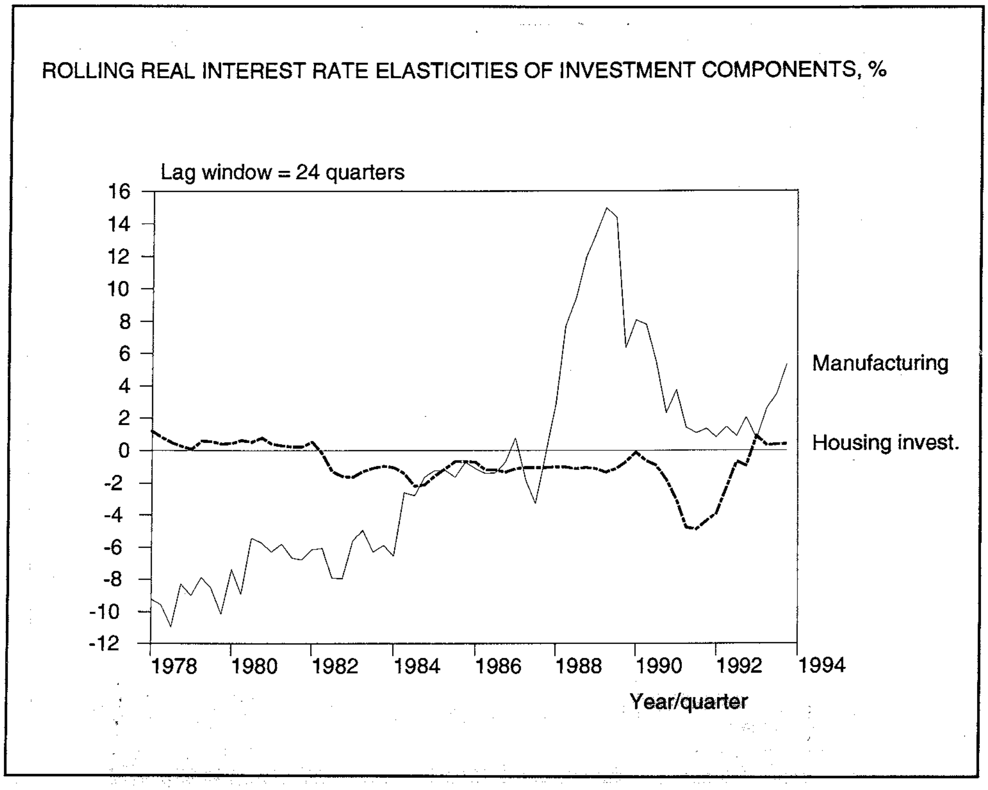


Figure 26 **Rolling interest rate elasticities of investment**



6 Inflation and interest rates

It has been somewhat surprising to find a nominal interest rate effect in both the consumption equations and possibly in investment equations. Since the regression coefficients for inflation and the real interest rate are practically the same, it makes no difference whether we speak about real or nominal interest rate effects. In order to understand this nominal interest rate effect, we have to consider also the relationship between inflation and real interest rates. One obvious reason for a nominal interest rate effect could be that of both these variables are strongly affected by foreign exogenous shocks.

Finland is a small open economy, where inflation and interest rates closely follow their international (mainly EU) counterparts. In addition, Finlands' inflation history has suffered from devaluation-inflation cycles. Recently the fixed exchange rate regime was abandoned. Since then, the Bank of Finland has attempted to monitor monetary aggregates and to aim at an explicit inflation target. It is therefore important to know how quickly changes in monetary policy, eg. interest rates, will affect price inflation.

From time series properties of interest rates we observe that the main source of variability in real interest rates comes from the variability of inflation. We can decompose the variance of the interest rate into the real interest rate, inflation and their covariance. The covariance is strongly negative, which means that the variance of nominal interest rate is much smaller than the variance of its two components.

$\sigma^2(RLBN) = \sigma^2(RRLBN) + \sigma^2(D4LCPI) + 2*Cov(RRLBN, D4LCPI)$, where

RLBN = Nominal bank lending rate, %
RRLBN = Real bank lending rate deflated by consumer price index, %
D4LCPI = Inflation measured by consumer price index, %

This variance decomposition produced the following results (table 8).

Table 8 **Variance decomposition of nominal lending rate**

Period	σ(RLBN)	σ(RRLBN)	σ(D4LCPI)	Corr(RRLBN, D4LCPI)
1962–93	1.92	4.29	3.86	–.694
1970–93	1.67	4.73	4.08	–.938
1980–93	1.53	5.19	6.02	–.925

The nominal interest rate has been almost constant and inflation has varied. Therefore the correlation between the real interest rate and inflation is strongly negative. This correlation is even stronger if we match the timing of these variables, eg. by lagging the real interest rate by one year or alternatively leading inflation by four quarters. Since inflation is in any case quite symmetrical with respect to time, this distinction does not affect the empirical calculations very much.

The Fisher hypothesis asserts that the real interest rate is stationary (or constant) and inflation expectations affect the evolvement of nominal interest rates, so that

$$R_t = \mu + E_t(p_{t+1}) + \varepsilon_t,$$

where μ is the estimated real rate of interest, $E_t(p_{t+1})$ is the expected inflation and ε is the white noise error. This equation can be tested by a two-stage procedure by modelling first the inflation, eg. with a univariate model, and then using the one-step forecast as a proxy for expected inflation in the model (Viren 1987).

By modelling inflation with a structural time series model, we can get weakly rational expectations for inflation. However, it was found that inflation is quite nearly a pure random walk process. A monthly series for annual inflation did not contain even any significant seasonal component or irregular noise. Therefore inflation shocks seem to be permanent and there makes little difference whether we use current inflation instead of expected inflation in the Fisher equation. This means also that inflation does not have a distinct transitory component which could be separated from the process.

According to Fisher equation inflation affects only nominal interest rate and not real interest rate. This was checked with Granger causality tests (Table 9). It was found however, that **there is no unambiguous dynamic bivariate relationship** between inflation and interest rates, either nominal and real. Of course this result leaves open the question of whether some more complex system would produce a more clear-cut relationship between these two variables.

It is often assumed that nominal interest rates have an effective floor of zero, since banks cannot pay negative interest rates. Otherwise the public would hold only cash instead of deposits. If inflation is close to zero, this means that the real interest rate should always be positive. This matches with the fact that pure time preference has to be positive. It is plausible that free capital movements have affected the real interest rate requirement in such a way that real interest rates have to be positive, since households are able to save in any currency.

Table 9 **Bivariate Granger causality tests between interest rates and inflation**

Significance level of F-test using 5 lags

Dependent	Regressor	1962–93	1962–85	1986–93
RLBN	D4LCPI	.999	.994	.303
D4LCPI	RLBN	.268	.378	.126
RRLBN	D4LCPI	.061	.092	.202
D4LCPI	RRLBN	.268	.378	.126

Neoclassical economic theory as such assumes price homogeneity of degree one in economic decision making, ie. the absence of pure inflation effects. However, there exists evidence that 'Hicksian' accounting procedures may induce inflation effects, especially during high inflation periods. The most apparent effect of inflation is to introduce cyclical variation into real interest rates. The role of inflation is otherwise obscure. In number of countries inflation may have affected the interest rate sensitivity of output to changes in nominal interest rates. For example Hirtle and Kelleher (1990) assert that in the 1970s inflation stemming from the oil crisis may have affected the way price expectations are formed. The removal of indexation during the 1970s may also led to changes in inflation effects.

In the 1990s higher domestic interest rates together with higher international interest rates have affected the interest rate sensitivity. However, in studying the interest rate effect we must control for inflation, since the variability of inflation dominates the variation in real interest rates, as we just saw. Both Sims (1992) and Bernanke & Blinder (1992) point out that in some countries interest rate increases predict higher inflation, which conflicts with the view that stricter monetary policy will reduce economic activity.

In Finland monetary policy kept the nominal interest rates constant during the regulation period in order to keep real interest rates down. Households were tightly credit constrained and the return on deposits was regulated. However, it was not possible to regulate real interest rates since it was not possible to control inflation or inflation expectations (Figure 27). As we can see, nominal interest rates have began to vary only recently. The important question is whether changes in nominal interest rates now reflect changes in the stance of monetary policy and in money market variation or changes in inflation expectations. Since the variation in the real interest rate is affected by inflation at least in the short-run, we may end up using nominal interest rates in measuring the effects of monetary policy.

In a small open economy it is not possible (or reasonable) to adjust imported (international) inflation affecting domestic inflation. Time series evidence points out that domestic inflation is affected by import inflation with a very short lag of about two months (Figure 28). According to Granger causality tests, causation runs unidirectionally from weighted OECD inflation to domestic inflation as would be expected.

It is not difficult to see that the integration of the world capital markets has affected the close interrelationship of interest rates as well. In Finland deregulation has increased the correlation between European interest rates and domestic money market rates. Since the markka was floated Finnish interest rates have converged to eg. German short-term interest rates (Figure 29). We may even expect that domestic and European interest rates could be cointegrated in the long run. Therefore the nominal interest rate effect in GDP could also be due to exogenous foreign shocks.

We have above discussed the nominal interest rate effect found in many real macroeconomic demand components. It has been suggested that the nominal interest rate effect could arise from deficiencies in national accounting (mainly consumption), money-balances due to budget constraints between the corporate and household sectors or external foreign effects reflecting international dependence in inflation and interest rates.

Figure 27

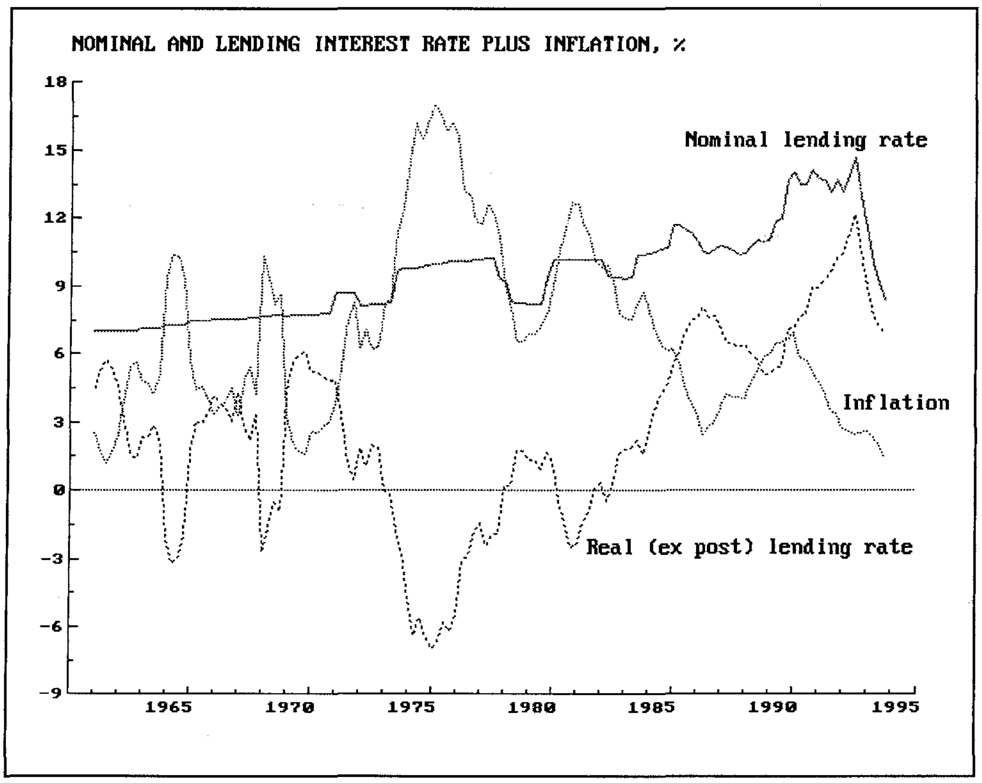


Figure 28

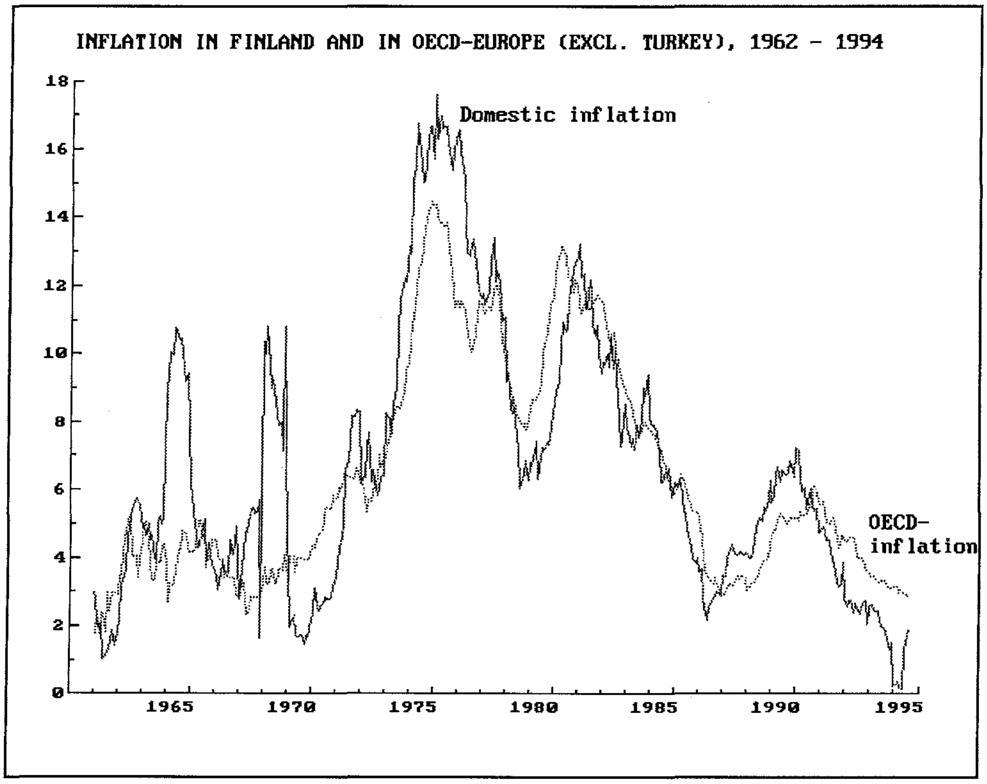
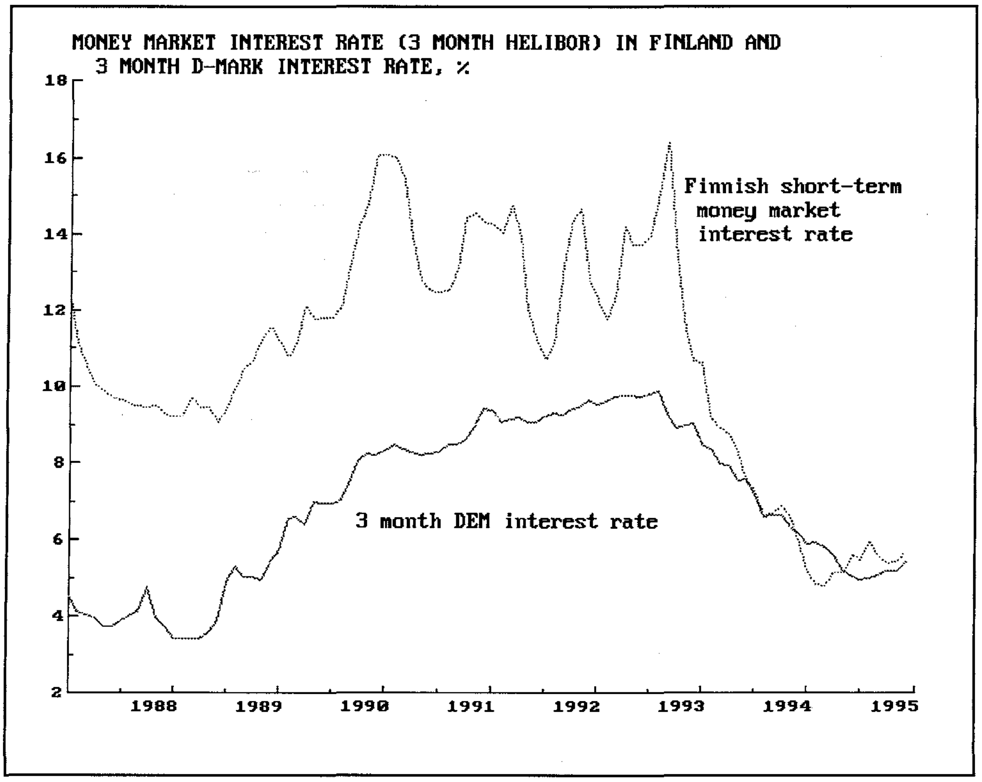


Figure 29



MONEY MARKET INTEREST RATE (3 MONTH HELIBOR) IN FINLAND AND
3 MONTH D-MARK INTEREST RATE, %
18
16
14
12
10
8
6
4
2
1988
1989
1990
1991
1992
1993
1994
1995
Finnish short-term
money market
interest rate
3 month DEM interest rate

7 Conclusions

This paper has evaluated the interest rate sensitivity of demand and output in Finland. The relationship between interest rates and economic activity has become more significant and more interesting since the financial deregulation. The link from monetary policy to interest rates appear through changes in the money supply, which influence bank lending. There are also more direct links.

With the respect to consumption, the interest rate measures the relative future price of consumption, which includes substitution and income effects. According to estimations, the interest rate elasticity for non-durable consumption is around –0.4, which supports the domination of the substitution effect. For durable purchases, the interest rate elasticity is much higher and volatile. Rough estimations indicate that the interest rate elasticity for durables could be around –4.0. Therefore the weighted interest rate elasticity for total private consumption is approximately -0.7.

For private investment, the interest rate measures the opportunity cost of investment and a cost factor in debt financing. Financial deregulation has affected the importance of interest rates in determining manufacturing investment. It seems that during the boom years domestic lending rates have been loosing their significance in affecting investment plans. A good guess for a long-term interest rate elasticity of manufacturing investment might be –2. On the other hand, financial deregulation has clearly increased the power of interest rates in determining the level of housing investment. The real lending rate has become a significant determinant of housing investment the during 1980s and we cannot reject the hypothesis of unitary elasticity.

The comparison with former Finnish elasticity estimates shows an increased significance of the real interest rate in particular for non-durable consumption and housing investment. It is quite plausible that financial deregulation has affected interest rate sensitivity. Comparison with earlier empirical findings in other countries shows some discrepancies in the significance of interest rates. For example with respect to the US Benjamin Friedman (1989) concludes that there has not been a large net effect on economic activity due to interest rate changes either through Fed's monetary policy nor otherwise. Financial deregulation has not affected the net impact of real interest rates on aggregate output. These findings may partly reflect the debate on the difference between Keynesian and new neoclassical monetary policy views. Akhtar and Harris (1987) however find that interest rate effects may have even become stronger during the 1980s. Controlling for credit constraints reveals increased interest rate sensitivity in consumer durables and decreased interest rate sensitivity in housing. Bosworth (1989) finds that the lags in monetary policy may have become longer and more variable and man therefore have weakened the effect of interest rates on economic activity. Comparison of these studies reveals some differences concerning the proper measure of the interest rate. By concentrating on real interest rates Friedman limits the interest rate sensitivity. Nominal interest rates include shocks due to inflation and taxes, which emphasize the role of interest rates as a predictive measures of economic activity.

With our Finnish data we found rather persuasive evidence of a nominal interest rate effect rather than a real interest rate effect. This has been observed in the case of consumption in many countries, but it was surprising to find signs of it also in private investment and private GDP.

References

Abel A.B. (1980) **Empirical Investment Equations: An Interactive Framework**, in Brunner & Meltzer (eds.): Carnegie-Rochester Conference Series on Public Policy 12, North-Holland.

Abel A.B. (1990) **Consumption and Investment**, Handbook of Monetary Economics, vol. 2, edited by B.M. Friedman and F.H. Hahn.

Akhtar M.A. & Harris E.S. (1987) **Monetary Policy Influence on the Economy: An empirical analysis**, Federal Reserve Bank of New York Quarterly Review, Winter 1987 pp. 19—33.

Barro R.J. (1990) **The Stock Market and Investment**, The Review of Financial Studies, 3, pp. 115—131.

Bernanke B.S. (1986) **Alternative Explanation of the Money-Income Correlation**, Carnegie-Rochester Conference Series on Public Policy, Autumn, pp. 49—100.

Bernanke B.S. & Blinder A.S. (1992) **The Federal Funds Rate and the Channels of Monetary Transmission**, American Economic Review, 82, No. 4, 901—921.

BIS (1994) **National Differences in Interest Rate Transmission**, Bank for International Settlements, C.B. 393, Basle March 1994.

Blanchard O., Rhee C. & Summers L. (1990) **The Stock Market, Profit and Investment**, NBER WP 3370, May 1990.

BOF4 (1990) **The BOF4 (Bank of Finland) Quarterly Model of the Finnish Economy**, Bank of Finland, D:73.

Chadha, B. & Tsiddon, D. (1994) **Inflation, nominal interest rates and the variability of output**, CEPR, Discussion paper No. 1068, London.

Dale S. & Haldane A.G. (1993) **Interest Rates and the Channels of Monetary Transmission: Some Sectoral Estimates**, Bank of England Working Paper, No. ??.

Doornik A.J. & Hendry D.F. (1994) **PcGive 8.0, An Interactive Econometric Modelling System**, International Thomson Publishing, London.

Dufwenberg M., Koskenkylä H. & Södersten J. (1994) **Manufacturing Investment and Taxation in the Nordic Countries**, Scandinavian Journal of Economics, 93, No. 3, 443—461.

EEC Economic Unit (1993) **The Impact of Changes on Official Rates on Private Domestic Expenditure in EC Countries: Some Evidence**, Committee of Governors of the Central Banks of the Member States of the European Economic Community/Economic Unit.

Fischer S. (1989) **Comments to Mullins and Wadhwani**, European Economic Review, 33, 956—961.

Fischer S. & Merton R.C. (1984) **Macroeconomics and Finance: The Role of the Stock Market**, Carnegie-Rochester Conference Series on Public Policy 21, 57—108, North-Holland.

Friedman B. (1989) **Changing effects of Monetary Policy on Real Economic Activity**, in Monetary Policy of the 1990s, Federal Reserve Bank of Kansas City.

Hall R.E. (1977) **Investment, Interest Rates and the Effects of Stabilization Policies**, Brookings Papers on Economic Activity 1, 61—103.

Hayashi F. (1982) **Tobin's marginal q and average q: A Neoclassical Interpretation**, Econometrica, 50, 213—224.

Hendry D.F. (1993) **Econometrics, Alchemy or Science?**, Blackwell, Oxford UK.

Hendry D.F. & von Ungern-Sternberg T. (1981) **Liquidity and Inflation Effects on Consumer's Expenditure**, in A. Deaton (ed.), Essays in Theory and Measurement of Consumer Behaviour, 237—60, Cambridge University Press.

Hirtle B. & Kelleher J. (1990) **Financial Market Evolution and the Interest Sensitivity of Output**, Federal Bank of New York, Quarterly Review/Summer 1990, 56—70.

Kajanoja L. (1995) **Aggregate Investment and Corporate Indebtedness: Some Empirical Evidence from Finland**, Bank of Finland Discussion Papers 10/95.

Keynes J.M. (1936) **The General Theory of Employment, Interest and Money**, Macmillan.

King M.A. (1993) **Debt Deflation, Theory and Evidence**, European Economic Review, 38, 419—445.

Muellbauer J. & Murphy A. (1989) **Why has UK Personal Saving Collapsed?**, in CSFB Economics, Credit Suisse First Boston, July 1989.

Mullins M. & Wadhwani S.B. (1989) **The Effect of the Stock Market on Investment, A Comparative Study**, European Economic Review 33, 939—961.

Sims C.A. (1986) **Are Forecasting Models Usable for Policy Analysis?**, Federal Reserve Bank of Minneapolis, Quarterly Review, 2—16.

Sims C.A. (1992) **Interpreting the Macroeconomic Time Series Facts, The Effects of Monetary Policy**, European Economic Review, 36, 975—1011.

Starck C. (1990) **The Interest Rate Elasticity of Aggregate Consumption: A Time Varying Parameter Approach**, Bank of Finland Discussion Papers No. 28/90.

Takala K. (1994) **Consumption Function Revisited**, unpublished manuscript.

Takala K. & Tuomala M. (1990) **Housing Investment in Finland**, Finnish Economic Papers, 3, No. 1, 41—53.

Takala K. & Tuomala M. (1991) **Stock Prices and Manufacturing Investment in Finland**, University of Jyväskylä, Department of Economics and Management, Working Paper 117/1991.

Tobin J. (1969) **A General Equilibrium Approach to Monetary Theory**, Journal of Money, Credit and Banking, 1, 15—29.

Topel R. & Rosen S. (1988) **Housing Investment in the United States**, Journal of Political Economy, 96, 718—740.

Virén M. (1987) **Inflation and Interest Rates: Some Time Series Evidence from 6 OECD Countries**, University of Helsinki, Discussion Papers, No. 255.

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