BANK OF FINLAND
DISCUSSION PAPERS

10/95

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ISBN 951-686-449-X
ISSN 0785-3572

Suomen Pankin monistuskeskus
Helsinki 1995

Abstract

The purpose of this study was to examine whether evidence of the possible effects of firms' indebtedness on their investment decisions can be found in empirical aggregate investment equations.

Three different types of equations for aggregate investment in Finland were estimated. The equations were estimated separately for manufacturing and non-manufacturing investment. An indebtedness variable was used as an additional explanatory variable in every equation. The results support the view that non-manufacturing firms' indebtedness has had a negative effect on their investment in Finland. In the manufacturing sector no such evidence was found.

Tiivistelmä

Tutkimuksen tarkoituksena oli empiirisesti tutkia, löytyykö aggregaatti-investointi-yhtälöistä näyttöä yritysten velkaantuneisuuden vaikutuksesta niiden investointi-päätöksiin.

Tutkimuksessa estimoitiin kolme erilaista Suomen aggregaatti-investointiyhtälöä. Teollisen ja ei-teollisen sektorin yhtälöt estimoitiin erikseen. Velkaantuneisuus-muuttujaa käytettiin ylimääräisenä selittäjänä jokaisessa yhtälössä. Tulokset tukevat näkemystä velkaantuneisuuden negatiivisesta vaikutuksesta ei-teollisen sektorin investointeihin. Teollisuuden osalta velkaantuneisuudella ei osoittautunut olevan investointeja vähentävää vaikutusta.

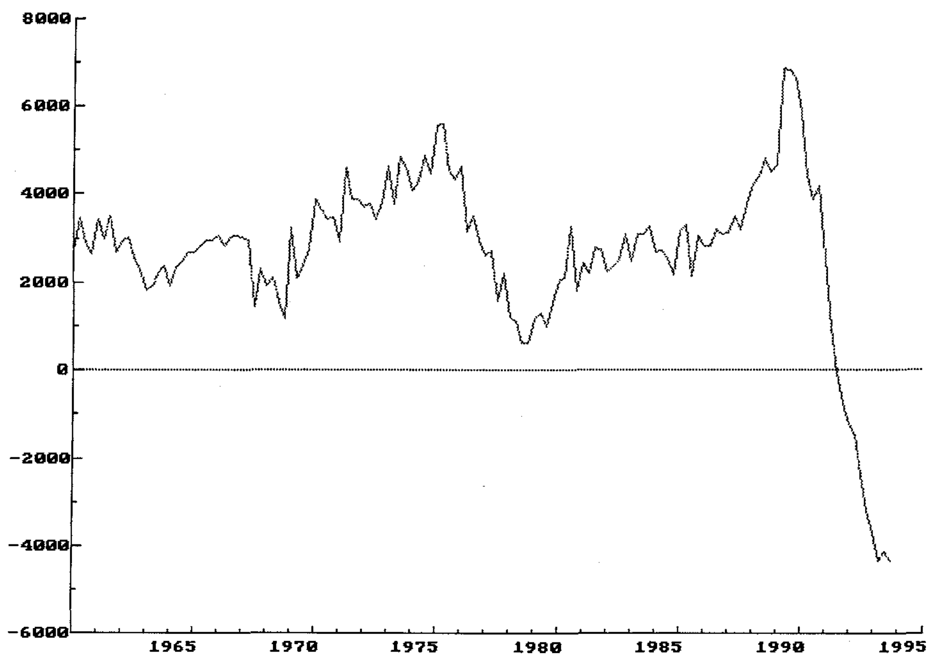
Contents

1 Introduction

Fixed investment spending tends to vary with the business cycle. In the deep recession of the early 1990s fixed investment spending in Finland reached record low levels: net investment became negative, since gross investment were lower than estimated capital depreciation (Figure 1).

It has been argued that one of the reasons for the low level of investment during the last four years has been the high net indebtedness of Finnish firms. The indebtedness increased rapidly in the latter half of the 1980s.

Figure 1 **Private non-residential fixed investment, net of depreciation, at constant prices**, millions of 1985 FIM



This paper analyzes the relationship between corporate indebtedness and investment by estimating aggregate investment functions including a variable that measures the level of firms' indebtedness. Investment functions using three different modeling strategies were estimated, ie flexible accelerator, neoclassical and Tobin's q.

The empirical modeling strategies are presented in section 2. Sections 3–6 cover the equations to be estimated, the data and the estimation results. Concluding remarks are presented in section 7.

2 Empirical investment models

The purpose of empirical investment equations is to try to explain investment using certain explanatory variables, which are thought to cause changes in investment or to indicate the causes. The dependent variable in these equations is usually net investment, defined as gross investment per capital stock less the rate of depreciation.

In this paper some experiments are presented where a variable measuring corporate indebtedness is included as an explanatory variable in aggregate empirical investment equations. Flexible accelerator, neoclassical and Tobin's q type investment equations, each augmented by the same additional indebtedness variable, were estimated.

All equations were estimated separately for the private manufacturing and non-manufacturing[1] sectors of the economy.

In flexible accelerator and neoclassical models, investment is assumed to follow changes in the desired amount of capital with a time lag. In accelerator models the desired amount of capital is assumed to depend on the level of output only. Neoclassical models assume that capital and labor are substitutes in production, and thus the desired amount of capital depends not only on output but also on the relative price of capital.

In Tobin's q investment models, net investment is assumed to depend on an empirical variable which directly reflects the capitalized future net income stream from marginal investment. Such a variable, Tobin's q,[2] is the ratio of the financial value of firms to the replacement cost of their existing capital stock[3]. The financial value of firms is usually measured using stock price indices, so the q approach tries to capture the relationship between stock prices and investment.[4]

There are perhaps not as sound grounds for adding a variable measuring corporate indebtedness to a q equation as to a neoclassical equation. The q variable reflects expectations about the future performance of a firm, which partly depends on the ability of the firm to borrow funds. As a consequence, the q variable may already include information concerning the indebtedness of the firm.

[1] The non-manufacturing sector includes services, argiculture and forestry. Services dominate the sector.

[2] The so-called average q

[3] Regarding the problems in constructing q variables for this study, see section 6.

[4] Regarding the intuition underlying the q theory and some of the problems, see eg Chirinko 1993b, pp. 1888–1891.

3 Measures of corporate indebtedness

In recent years there have been attempts to trace the possible effects of financial constraints on investment by adding variables like indebtedness and cash flow to different types of empirical investment equations. It seems that there is no generally accepted specific way to introduce these variables into investment equations.

The approach used here was to add an indebtedness variable[5] as such to the right hand side of each estimated equation. Since there are neither theoretical nor empirical grounds for assuming a linear causal relationship between corporate indebtedness and investment, some transformations of the indebtedness variable were also tried. However, the results were not significantly changed by these experiments.

Also a cash flow variable was introduced as an additional explanatory variable. In some equations, the cash flow variable got significant parameter values, but since they did not change the basic results, the estimation results including the cash flow variable are not presented in this paper.

Especially in the case of the non-manufacturing sector, the value of the indebtedness variable increased quite steadily over the estimation period. Thus, it seemed possible that the parameter estimate of the indebtedness variable could be biased in the sense that it would capture the effect of some omitted variable including a trend. This problem was handled by adding a linear trend to the right hand side of the equations. Since the inclusion of the linear trend did not in general change the results substantially, the equations with the linear trend variable are not presented.

The fact that indebtedness may be an important variable for individual firms making investment decisions does not mean that aggregate investment equations would necessarily capture this relation. It is natural to assume that changes in a firm's indebtedness affect its investment decisions only when the indebtedness is already high, that is when the debt is getting close to some possible "maximum level". Because some firms are considerably less indebted than others, movements in *aggregate* indebtedness do not tell us the whole story about changes in the financial constraints affecting investment in the economy as a whole. As a consequence, it is not surprising that most empirical evidence comes from panel data estimations.[6]

[5] Indebtedness variable = gross debt / capital stock. Regarding the problems involved in constructing indebtedness variables for this study, see section 6.

[6] See eg Fazzari — Hubbard — Petersen (1988), Hubbard — Kashyap — Whited (1993) and for Finnish data Brunila (1994).

4 Estimated equations

Two different equations for each of the three different types of models were estimated for both manufacturing and non-manufacturing investment. First, each equation was estimated using OLS and one or two lagged quarterly values of the dependent variable in the right hand side of the equation. Second, the equations were estimated without the lagged values of the dependent variables. In this case, an AR(1) or AR(2) process error term was added to the right hand side and the equation was estimated using the maximum likelihood method.[7]

Equations and parameter estimates as well as test statistics are presented in Appendix 3. OLS parameter estimates are on the left hand side of each table. The parameter estimates of equations estimated with autoregressive error processes and using the maximum likelihood method are presented on the right hand side of each table under the heading "RALS".

Each estimated equation included a half-year lagged value of the indebtedness variable as an explanatory variable.

In the flexible accelerator equations, the explanatory variables included the three latest values of yearly change in the log of output and an indebtedness variable with a lag of one-half year.

The explanatory variables in the neoclassical type models were the two latest values of the yearly change in the log of output as well as current and one-year lagged values of a real interest rate proxy.

The real interest rate is not a fully sufficient proxy for the relative price of capital in a neoclssical model, since it does not include the effects of wages or taxes. A simple user cost of capital variable was tried in place of the real interest rate. Since the results were practically the same for both specifications, only the results using the real interest rate are presented.

These somewhat "unorthodox" specifications of accelerator and neoclassical models can be derived from the standard equations using certain approximations. See, for example, Chirinko (1993a, fn. 9).

The estimated Tobin's q equations include a half-year lagged value of the Tobin's q variable as an explanatory variable.

The indebtess and q variables were added to the equations with a half-year lag since investment decisions are usually thought to result from processes subject to various information, planning and delivery lags (Berndt 1991, pp. 235—236). The lag of two quarters was supported by the data and seemed reasonable.

[7] The latter way of estimating investment equations is used since investment decisions are complex ones and the omission of important variables is possible (Berndt 1991, p. 233).

5 Data

The equations were estimated using quarterly data from the database of the BOF4 quarterly model of the Finnish economy[8].

The estimation periods were as long as the data allowed, and all equations were estimated for the period beginning in the first quarter of 1963 and ending in the second quarter of 1993. The Tobin's q equations for the non-manufacturing sector were also estimated for the period 1979Q3—1993Q2.

The dependent variable (net investment) was calculated as gross investment per capital stock less the capital depreciation rate. The capital depreciation rate was the one used in the BOF4 model and it is based on national accounts data[9]. The dependent variable is graphed in figures 2 and 3 in Appendix 2.

The calculation of Tobin's q variable was problematic because of the lack of data. The (average) q is in principle defined as

$$q = \frac{\textit{market value of firms} + \textit{net debt}}{\textit{replacement cost of capital stock}} .$$

For more details in the usual/best way of constructing the q variable, see Appendix 1. The q variable used in the estimations of this study were calculated as

$$q = a_0 \times \frac{\textit{stock price index}}{\textit{value of capital stock}} ,$$

where a_0 is a constant which is given a value that sets q to unity on average for the period studied. This way of constructing the q variable would be well founded if

1) the firms listed on the Helsinki Stock Exchange perfectly represented all firms in Finland
2) and if there was no new equity.

Then the q variable would represent the ratio of the value of one average equity to the replacement cost of capital that the equity stands for. For more details, see Appendix 1. The q variable is graphed in figures 4 and 5 in appendix 2.

An additional problem with the q variable for non-manufacturing investment is that this sector is not well represented in the stock market. Banks and other financial institutions have considerably more weight in the price index for stocks of non-manufacturing firms than they have in total non-manufacturing production and investment.

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[8] See publication SP D:73.

[9] In the case of the non-manufacturing sector, the rate of depreciation was calculated as a weighted arithmetic mean of the corresponding depreciation rates for the three industries, services, agriculture and forestry, with the weights being the relative amounts of capital stock for each industry.

The indebtedness variable was calculated as gross debt per capital stock. Gross debt is the long maturity gross debt from the credit statistics[10]. It would possibly be better to use net debt (gross debt minus liquid assets) as the numerator. Unfortunately, quarterly data were not available for liquid assets.

The other problem with the indebtedness variable was that the data for the gross debt were available only for the period from 1979. The estimation of the equations for the period beginning in 1963 was made possible by assuming that the indebtedness of both sectors were constant before 1979 and setting the debt to capital stock ratios at their 1979Q1 levels for the whole prior period. The indebtedness variable is graphed in figures 6 and 7 in Appendix 2.

The proxy for the real rate of interest was calculated as the nominal average interest rate of new bank loans less the yearly change in the fixed investment price index for the sector in question[11].

In 1988 the statistical division of capital between the manufacturing and services sectors changed slightly. It was attempted to take this into account in constructing the variables using BOF4 data. However, in the results there may be some repercussions of this shift in 1988 and in 1989.

6 Estimation results

6.1 The overall results

The flexible accelerator equations worked well for both manufacturing and non-manufacturing investment. The results are shown in tables 1.1 and 2.1 in Appendix 3. All parameter estimates (except one) had the expected signs and all but one were statistically significant. The OLS parameter estimates were quite stable. Graphs of recursive parameters are presented in figures 8 and 12 in appendix 4.

Also the neoclassical type equation specifications seemed quite satisfactory (see tables 1.2 and 2.2 in appendix 3). Not all of the parameter estimates of the real interest rate were of the expected sign and about half of them were statistically insignificant. Other parameter estimates were reasonable and stable (see figures 9 and 13 in appendix 4). According to the Portmanteau test statistics, the residuals for the manufacturing OLS equation may be somewhat autocorrelated.

For non-manufacturing investment, the Tobin's q equations performed surprisingly well. See tables 1.3 and 1.4 in appendix 3. All parameter estimates were significant and of the expected sign. The OLS parameters were quite stable. They are shown in figures 10 and 11 in appendix 4. Equations were estimated both for the periods 1963Q1—1993Q2 and 1979Q3—1993Q2. The latter period was chosen because the indebtedness variable had "real" values only for that period.[12]

[10] Statistics Finland, "Luottokanta" and "Luottovirrat"

[11] In the case of the non-manufacturing sector, the fixed investment price index was calculated as a weighted arithmetic mean of the corresponding indices for the three sectors, with the weights being the relative amounts of investment of each sector.

[12] See section 6.

The q equations did not work as well for manufacturing investment. This is not surprising given the problems in constructing the q variable for this study and the traditional overall poor empirical performance of q investment equations[13]. Nor are earlier results for Finnish manufacturing investment encouraging for the q approach (Takala - Tuomala 1991). The manufacturing sector q equation residuals seemed to be autocorrelated, and the parameter estimates were somewhat unstable.

6.2 Results for the impact of indebtedness

In general the results support the view that indebtedness has had a negative effect on investment in the non-manufacturing sector. In the manufacturing sector, a similar connection was not found. Both these results are well in line with what was expected.

Parameter estimates of the indebtedness variables were negative (as expected) for all the non-manufacturing sector equations and for most of the manufacturing sector equations. However, for the manufacturing sector the parameter estimates were statistically insignificant in all cases, whereas for the non-manufacturing sector most of the estimates were significantly negative[14].

In all recursive OLS estimations for non-manufacturing investment equations the parameter estimates of the indebtedness variable diminished in the last years of the estimation periods. All of them became negative around the year 1990. These results are expected, since indebtedness is generally expected to have an impact on investment only after exceeding some "critical level" and especially in recessions.

In the different investment equations for the manufacturing sector, the long-run[15] parameter estimates of the indebtedness variables had a range from −0.0338 to −0.0158. (The corresponding range for the manufacturing sector was from −0.0172 to +0.0433.) Using these figures, rough estimates of the negative impact of indebtedness on investment for any level of indebtedness can be calculated (and compared with other indebtedness levels). According to these kinds of calculations, private non-manufacturing investment would have been about FIM 2000—4000 million higher in 1993, if the gross debt to capital ratio had been at the year 1980 level. FIM 2000—4000 million corresponds to about 6—15 per cent of total private non-manufacturing gross investment in 1993 and about 4—10 per cent of total private gross investment in the same year.

The results for the relation between indebtedness and investment are clearly intuitively plausible. However, one thing that should be kept in mind when interperting these results is that the indebtedness variable might well have captured the effects of some omitted variables correlated with them. If, for example, the

[13] See eg Chirinko 1993b, 1891.

[14] using standard 95 per cent confidence intervals

[15] RALS estimates are long-run estimates as such. Dynamic equations having lagged dependent variables in the right hand side produce short-run parameter estimates. The long-run parameters of the OLS equations can also be calculated using the parameter estimates for the lagged dependent variables.

drastic change in expectations at the beginning of the latest recession is not seen in other explanatory variables and happens to be somehow correlated with the level of indebtedness, then the parameter estimates of the indebtedness variable could be substantially biased.

7 Concluding remarks

Several empirical investment equations with indebtedness as an additional explanatory variable were estimated using aggregate Finnish data. The results support the view that the indebtedness of non-manufacturing firms has had a negative impact on their investment in Finland. This connection seems to be less important or non-existent in the manufacturing sector, at least at the aggregate level.

Equations reflecting accelerator, neoclassical and Tobin's q investment models were estimated. In all eight of the different estimations for non-manufacturing sector investment, the parameter estimates of the indebtedness variable were negative, and most of them were significantly different from zero. For the manufacturing sector not all corresponding parameter estimates were negative and none was significantly different from zero.

Indebtedness seems to have had a negative impact on non-manufacturing sector investment in recent years, but the size of this impact is difficult or impossible to measure using time series results. However, some rough estimates of the magnitude of the negative effect were calculated. According to these, private non-manufacturing gross investment would have been 6—15 per cent or FIM 2000—4000 million higher in 1993 had the gross debt to capital ratio of firms been at its year 1980 level. The current downward trend in the indebtedness of firms may give more room for investment in the coming years.

Appendix 1 Construction of q variables

$$q = \frac{market\ value\ of\ firms\ +\ net\ debt}{replacement\ cost\ of\ capital\ stock}\ .$$

In the q variable the "market value of firms" is best measured as

$$\frac{dividends\ of\ all\ firms}{dividend\text{-}equity\ ratio}\ ,$$

where "dividends" are dividends paid by all firms and the "dividend-equity ratio" is available for firms listed on the stock exchange. Unfortunately, there are no quarterly Finnish data for dividends paid by the manufacturing and non-manufacturing sectors of the economy. That is why the q variable had to be calculated using the stock price indices.

According to the theory underlying the Tobin's q approach, the use of a stock price index is considerably less well founded than the "correct" construction of the q variable. However, as argued by Robert Barro (1990), changes in stock prices are the dominant source of variation in the q variable. In his own empirical study, Barro explained the rate of change of net investment with the rate of change of the share price. In the previous Finnish study using the Tobin's q approach (Takala — Tuomala 1991), q was constructed using stock price indices as is done here.

As mentioned in section 6, Tobin's q was calculated as

$$q = a_0 \times \frac{stock\ price\ index}{value\ of\ capital\ stock}\ .$$

The alternative would have been to calculate q simply as

$$q = a_1 \times \frac{stock\ price\ index}{investment\ price\ index}\ .$$

However, the latter variable seemed to be non-stationary, having an upward trend.

HEX indices separately for the manufacturing and non-manufacturing sectors were available only from 1987. For the prior period, the series were constructed using UNITAS stock indices.

The UNITAS stock index for the non-manufacturing sector was formed using the UNITAS general index and the UNITAS index for the manufacturing sector. The manufacturing sector index multiplied by its weight in the general index was subtracted from the general index. The formula for the calculation of the index is presented in Hernesniemi 1990 on pages 8—9 and the index weights in Unitas 3/1977 on page 142.

Appendix 2 Graphs of selected variables

Figure 2 **Non-manufacturing sector net investment per capital**

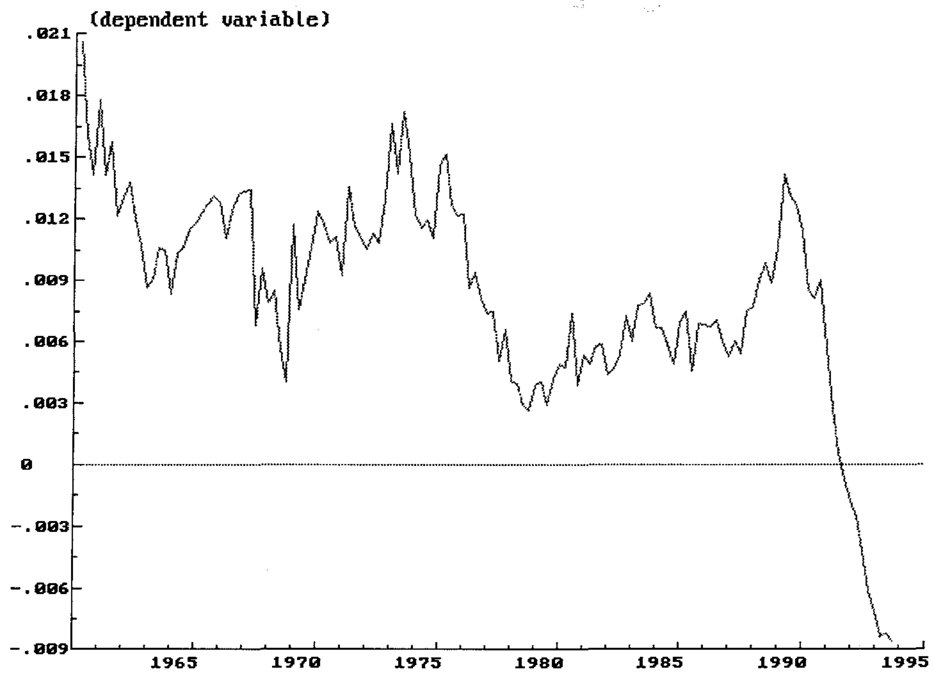


Figure 3 **Manufacturing sector net investment per capital**

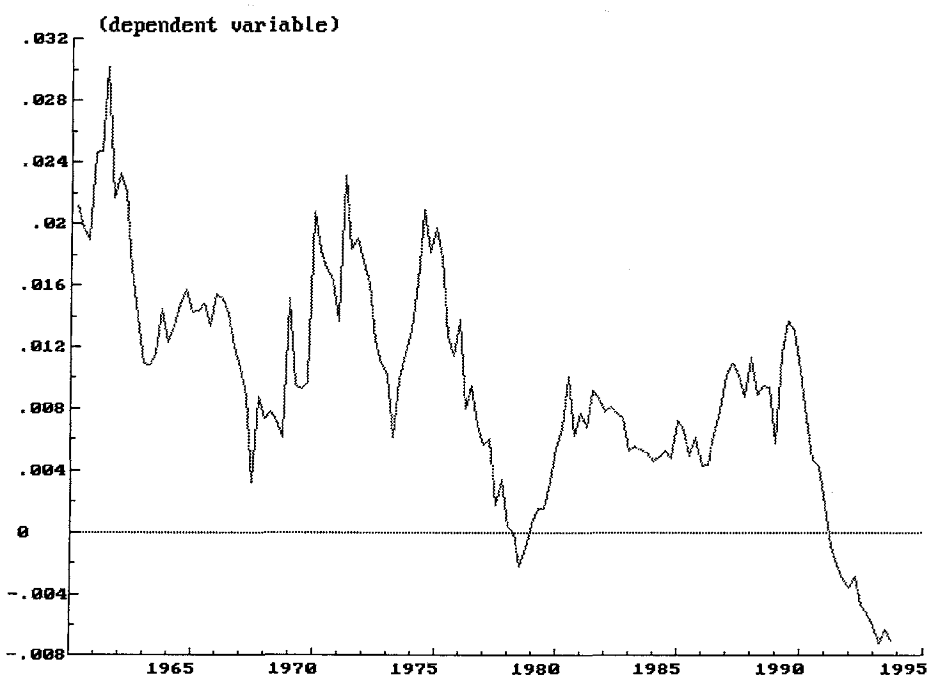


Figure 4 **Non-manufacturing sector q variable**

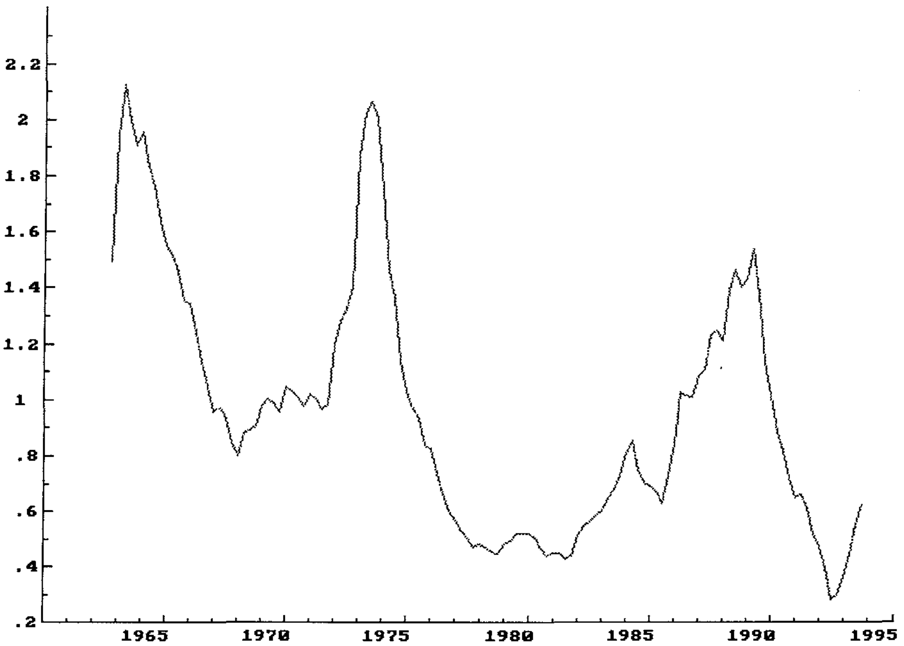


Figure 5 **Manufacturing sector q variable**

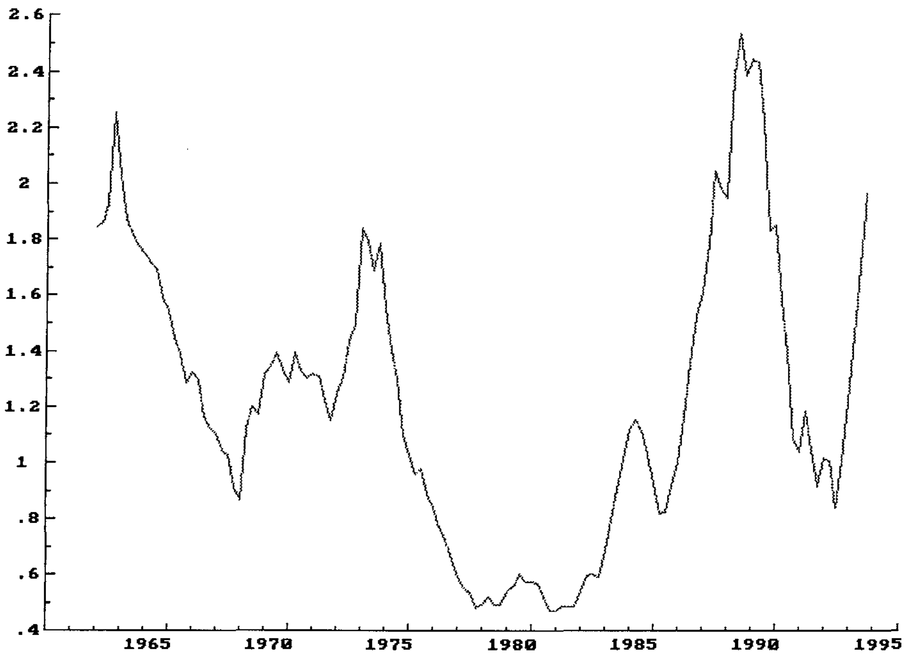
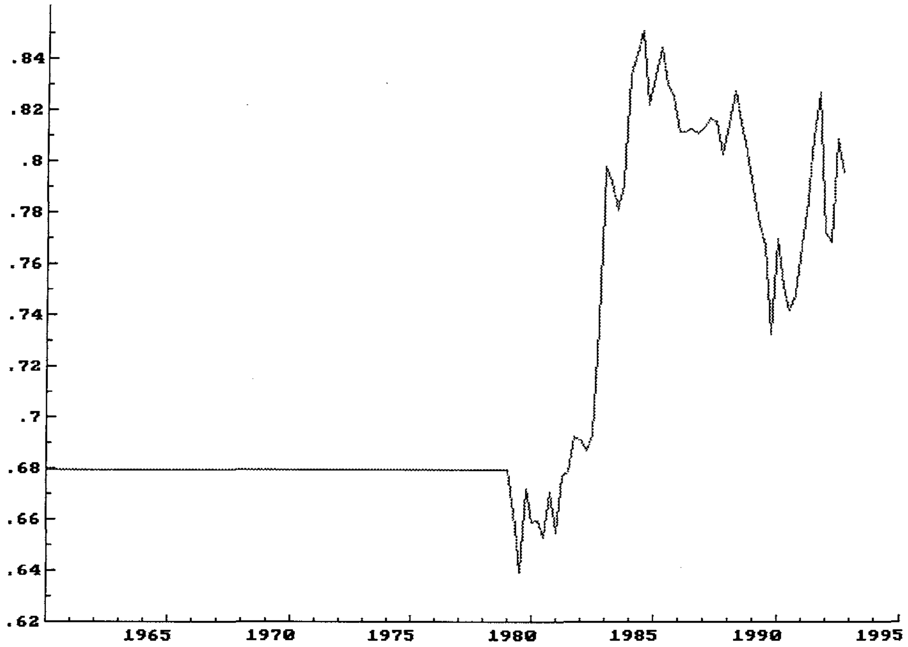


Figure 6 **Non-manufacturing sector indebtedness variable**

Figure 7 **Manufacturing sector indebtedness variable**



Appendix 3 Equations, parameter estimates and test statistics

Symbols

Dependent variable:

$I/K_{-1}-\delta$	Net investment

Explanatory variables:

Q	Tobin's q
D/K	Indebtedness
$\Delta_4 Log(Y)$	One-year difference in log output
RR Real	rate of interest

Other symbols:

ε	residual
u	autoregressive residual
se	standard error
AC(1)	residual autocorrelation with lag 1
q(T)	Portmanteau test statistics of residual autocorrelation (T = number of lags) (95 per cent confidence coefficient critical value in parentheses; if it is less than the actual value, the null hypothesis of no residual autocorrelation is rejected)

Non-manufacturing sector

Table 1.1 **Flexible accelerator equations**

OLS $I/K_{-1}-\delta = c_0 + c_1\ \Delta_4Log(Y) + c_2\ \Delta_4Log(Y)_{-4} + c_3\ \Delta_4Log(Y)_{-8} + c_4\ (D/K)_{-2} + c_5\ (I/K_{-1}-\delta)_{-1} + c_6\ (I/K_{-1}-\delta)_{-2} + \varepsilon$

RALS $I/K_{-1}-\delta = c_0 + c_1\ \Delta_4Log(Y) + c_2\ \Delta_4Log(Y)_{-4} + c_3\ \Delta_4Log(Y)_{-8} + c_4\ (D/K)_{-2} + u$

where $u = c_5u_{-1} + c_6u_{-2} + \varepsilon$

Estimation period: 1963Q1—1993Q2

	OLS		RALS	
constant	0.00080	(0.809)	0.01158	(3.746)
$\Delta_4Log(Y)$	0.01676	(4.709)	0.02083	(3.517)
$\Delta_4Log(Y)_{-4}$	0.00954	(2.632)	0.03507	(5.535)
$\Delta_4Log(Y)_{-8}$	0.00432	(1.203)	0.02985	(5.054)
$(I/K_{-1}-\delta)_{-1}$	0.53492	(6.196)		
$(I/K_{-1}-\delta)_{-2}$	0.35218	(4.052)		
$(D/K)_{-2}$	−.00310	(−1.225)	−.02023	(−2.143)
u_{-1}	0.58447	(6.130)		
u_{-2}	0.19216	(1.978)		
R^2	0.882			
se	0.00163		0.00196	
AC(1)	−0.034		0.047	
q(12)	8.798	(21.0)	9.892	(18.3)

Numbers in parentheses after parameter estimates are t statistics.

Table 1.2 **Neoclassical equations**

OLS $I/K_{-1}-\delta = c_0 + c_1\ \Delta_4Log(Y) + c_2\ \Delta_4Log(Y)_{-4} + c_3\ RR + c_4\ RR_{-4} + c_5\ (D/K)_{-2} + c_6\ (I/K_{-1}-\delta)_{-1} + c_7\ (I/K_{-1}-\delta)_{-2} + \varepsilon$

RALS $I/K_{-1}-\delta = c_0 + c_1\ \Delta_4Log(Y) + c_2\ \Delta_4Log(Y)_{-4} + c_3\ RR + c_4\ RR_{-4} + c_5\ (D/K)_{-2} + u$

where $u = c_6u_{-1} + c_7u_{-2} + \varepsilon$

Estimation period: 1963Q1—1993Q2

	OLS		RALS	
constant	0.00680	(0.608)	0.01645	(3.407)
$\Delta_4Log(Y)$	0.01591	(4.337)	0.01267	(2.507)
$\Delta_4Log(Y)_{-4}$	0.01119	(2.880)	0.01874	(3.725)
RR	0.00292	(0.693)	0.00842	(1.352)
RR_{-4}	−.00690	(−1.591)	−.01749	(−2.837)
$(I/K_{-1}-\delta)_{-1}$	0.52437	(6.041)		
$(I/K_{-1}-\delta)_{-2}$	0.35720	(4.109)		
$(D/K)_{-2}$	−.00188	(−0.529)	−.03309	(−2.395)
u_{-1}	0.63332	(6.864)		
u_{-2}	0.28904	(3.050)		
R^2	0.883			
se	0.00162		0.00170	
AC(1)	−0.009		0.002	
q(12)	8.798	(21.0)	11.46	(18.3)

Numbers in parentheses after parameter estimates are t statistics.

Table 1.3

Tobin's q equations

OLS $I/K_{-1}-\delta = c_0 + c_1\, Q_{-2} + c_2\, (D/K)_{-2} + c_3\, (I/K_{-1}-\delta)_{-1} + c_4\, (I/K_{-1}-\delta)_{-2} + \varepsilon$

RALS $I/K_{-1}-\delta = c_0 + c_1\, Q_{-2} + c_2\, (D/K)_{-2} + u$

where $u = c_3 u_{-1} + c_4 u_{-2} + \varepsilon$

Estimation period: 1963Q1—1993Q2

	OLS		RALS	
constant	0.00287	(2.945)	0.01307	(3.613)
Q_{-2}	0.00120	(2.454)	0.00485	(3.817)
$(I/K_{-1}-\delta)_{-1}$	0.62140	(6.850)		
$(I/K_{-1}-\delta)_{-2}$	0.20172	(2.226)		
$(D/K)_{-2}$	-.00956	(-3.729)	-.03380	(-3.336)
u_{-1}			0.61976	(6.713)
u_{-2}			0.20279	(2.196)
R^2	0.862			
se	0.00174		0.00179	
AC(1)	-0.018		0.005	
q(12)	10.53	(21.0)	9.737	(18.3)

Numbers in parentheses after parameter estimates are t statistics.

Table 1.4

Tobin's q equations

OLS $I/K_{-1}-\delta = c_0 + c_1\, Q_{-2} + c_2\, (D/K)_{-2} + c_3\, (I/K_{-1}-\delta)_{-1} + \varepsilon$

RALS $I/K_{-1}-\delta = c_0 + c_1\, Q_{-2} + c_2\, (D/K)_{-2} + u$

where $u = c_3 u_{-1} + \varepsilon$

Estimation period: 1979Q3—1993Q2

	OLS		RALS	
constant	0.00353	(3.868)	0.00849	(3.010)
Q_{-2}	0.00377	(3.982)	0.01084	(6.516)
$(I/K_{-1}-\delta)_{-1}$	0.72019	(9.205)		
$(D/K)_{-2}$	-.01477	(-5.264)	-.03307	(-4.691)
u_{-1}			0.66350	(5.879)
R^2	0.926			
se	0.00128		0.00159	
AC(1)	-0.251		-0.081	
q(7)	8.395	(14.1)	4.918	(12.6)

Numbers in parentheses after parameter estimates are t statistics.

Manufacturing sector

Table 2.1 **Flexible accelerator equations**

OLS $I/K_{-1}-\delta = c_0 + c_1\,\Delta_4 Log(Y) + c_2\,\Delta_4 Log(Y)_{-4} + c_3\,\Delta_4 Log(Y)_{-8} + c_4\,(D/K)_{-2} + c_5\,(I/K_{-1}-\delta)_{-1} + c_6\,(I/K_{-1}-\delta)_{-2} + \varepsilon$

RALS $I/K_{-1}-\delta = c_0 + c_1\,\Delta_4 Log(Y) + c_2\,\Delta_4 Log(Y)_{-4} + c_3\,\Delta_4 Log(Y)_{-8} + c_4\,(D/K)_{-2} + u$

where $u = c_5 u_{-1} + \varepsilon$

Estimation period: 1963Q1—1993Q2

	OLS		RALS	
constant	-.00304	(-0.968)	0.00941	(0.829)
$\Delta_4 Log(Y)$	0.01576	(3.422)	0.02750	(3.786)
$\Delta_4 Log(Y)_{-4}$	0.01949	(3.919)	0.03853	(4.827)
$\Delta_4 Log(Y)_{-8}$	0.01373	(2.344)	0.01789	(2.384)
$(I/K_{-1}-\delta)_{-1}$	0.56265	(6.280)		
$(I/K_{-1}-\delta)_{-2}$	0.23705	(2.749)		
$(D/K)_{-2}$	0.00376	(0.921)	-.00663	(-0.436)
u_{-1}			0.87613	(17.240)
R^2	0.857			
se	0.00238		0.00246	
AC(1)	0.041		-0.082	
q(12)	17.91	(21.0)	15.04	(19.7)

Numbers in parentheses after parameter estimates are t statistics.

Table 2.2 **Neoclassical equations**

OLS $I/K_{-1}-\delta = c_0 + c_1\,\Delta_4 Log(Y) + c_2\,\Delta_4 Log(Y)_{-4} + c_3\,RR + c_4\,RR_{-4} + c_5\,(D/K)_{-2} + c_6\,(I/K_{-1}-\delta)_{-1} + c_7\,(I/K_{-1}-\delta)_{-2} + \varepsilon$

RALS $I/K_{-1}-\delta = c_0 + c_1\,\Delta_4 Log(Y) + c_2\,\Delta_4 Log(Y)_{-4} + c_3\,RR + c_4\,RR_{-4} + c_5\,(D/K)_{-2} + u$

where $u = c_6 u_{-1} + \varepsilon$

Estimation period: 1963Q1—1993Q2

	OLS		RALS	
constant	-.00479	(-1.324)	0.01115	(1.004)
$\Delta_4 Log(Y)$	0.01405	(2.915)	0.02420	(3.347)
$\Delta_4 Log(Y)_{-4}$	0.01648	(3.232)	0.02808	(4.017)
RR	-.01067	(-2.085)	-.02423	(-2.598)
RR_{-4}	-.00055	(-0.099)	-.01511	(-1.574)
$(I/K_{-1}-\delta)_{-1}$	0.59223	(6.692)		
$(I/K_{-1}-\delta)_{-2}$	0.24474	(2.806)		
$(D/K)_{-2}$	0.00706	(1.408)	-.00663	(-0.441)
u_{-1}			0.87991	(17.096)
R^2	0.856			
se	0.00239		0.00245	
AC(1)	-0.050		-0.036	
q(12)	*22.02*	(> 21.0)	15.55	(19.7)

Numbers in parentheses after parameter estimates are t statistics.

Table 2.3 **Tobin's q equations**

OLS $I/K_{-1}-\delta = c_0 + c_1\, Q_{-2} + c_2\, (D/K)_{-2} + c_3\, (I/K_{-1}-\delta)_{-1} + \varepsilon$

RALS $I/K_{-1}-\delta = c_0 + c_1\, Q_{-2} + c_2\, (D/K)_{-2} + u$

where $u = c_3 u_{-1} + \varepsilon$

Estimation period: 1963Q1—1993Q2

	OLS		RALS	
constant	0.00606	(1.728)	0.01570	(1.266)
Q_{-2}	0.00137	(2.342)	0.00368	(1.934)
$(I/K_{-1}-\delta)_{-1}$	0.83853	(15.791)		
$(D/K)_{-2}$	-.00900	(-1.829)	-.01718	(-1.021)
u_{-1}			0.88613	(17.754)
R^2	0.821			
se	0.00263		0.00265	
AC(1)	-0.123		-0.172	
q(12)	*34.02*	(> 21.0)	*31.8*	(> 19.7)

Numbers in parentheses after parameter estimates are t statistics.

Appendix 4 Recursive OLS estimation parameters

Figure 8 **Non-manufacturing sector accelerator equation**

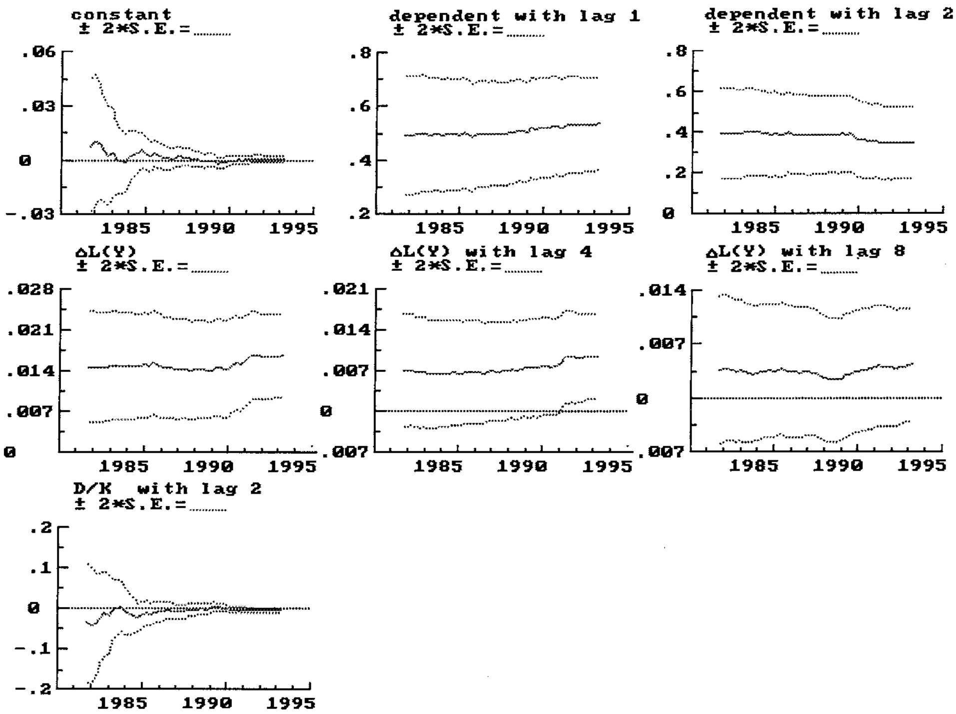


Figure 9 **Non-manufacturing sector neoclassical equation**

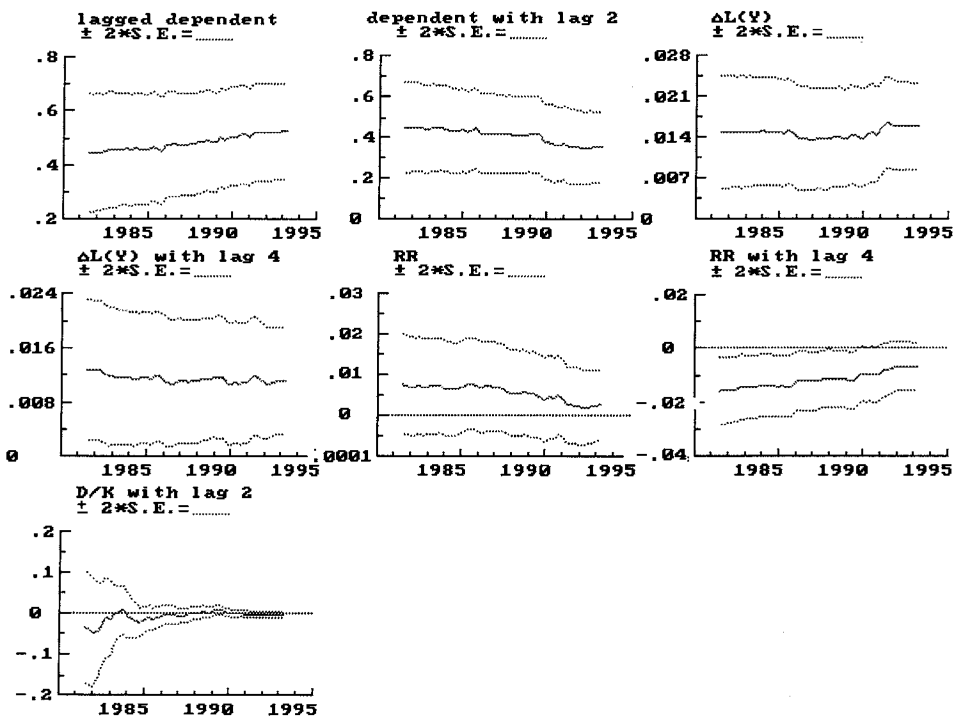


Figure 10 **Non-manufacturing sector q equation 1963Q1–1993Q2**

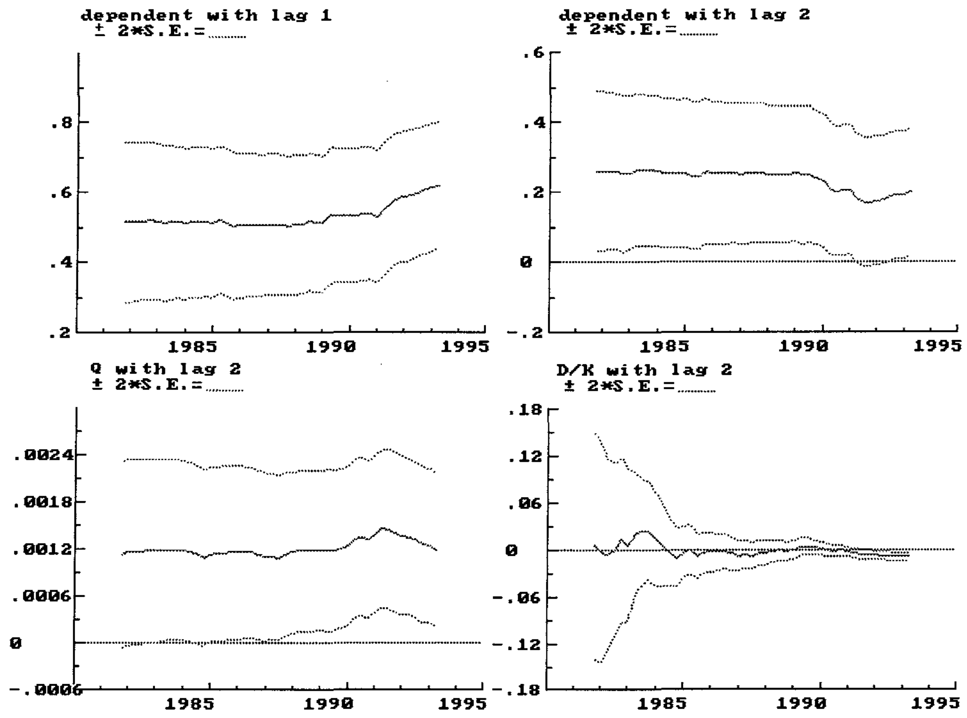


Figure 11 **Non-manufacturing sector q equation 1979Q3–1993Q2**

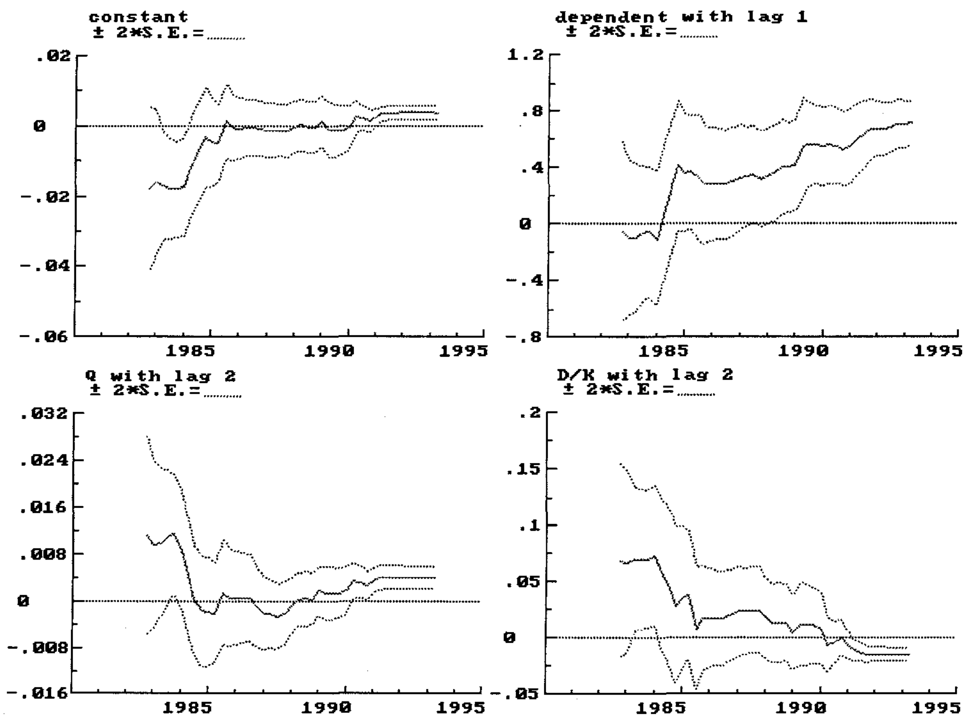


Figure 12 **Manufacturing sector accelerator equation**

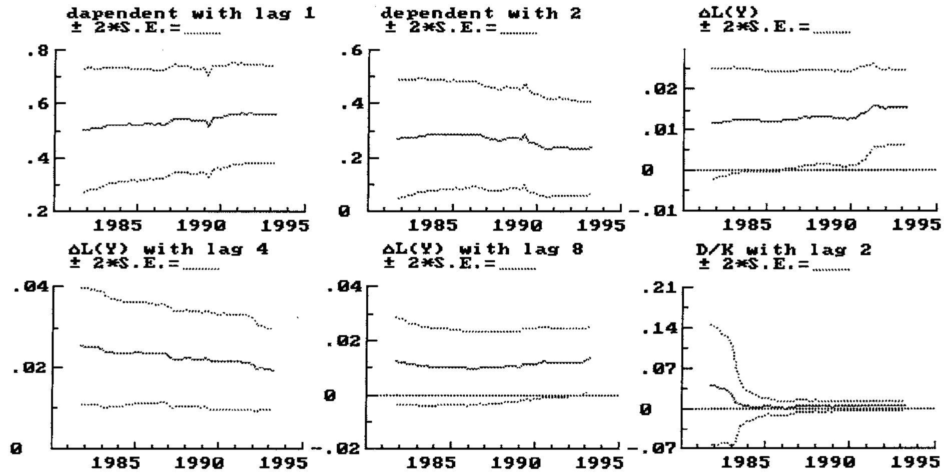


Figure 13 **Manufacturing sector neoclassical equation**

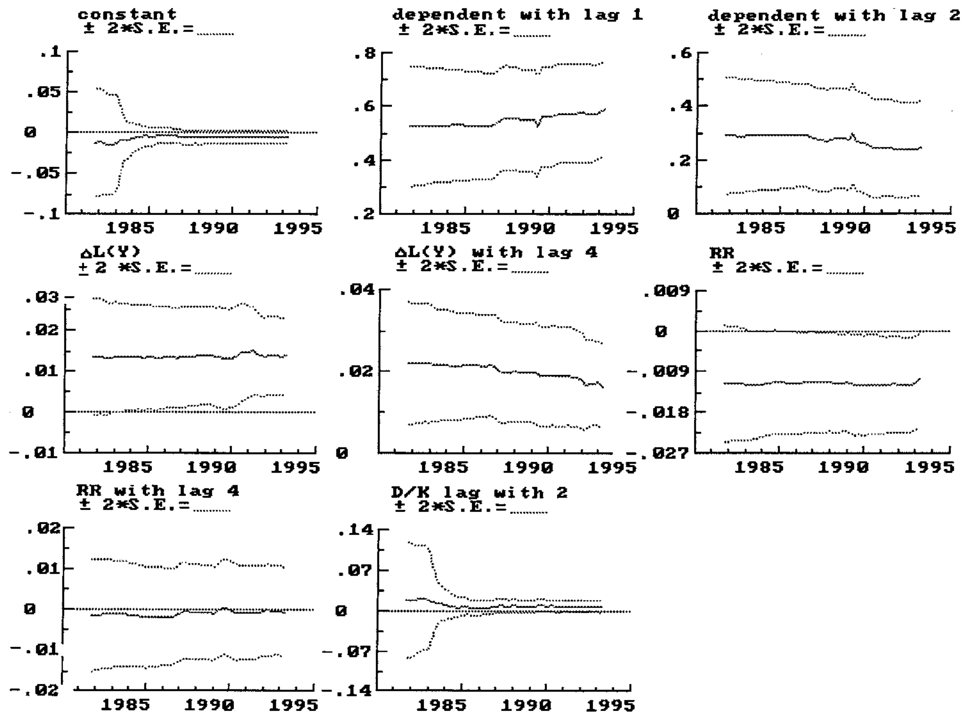
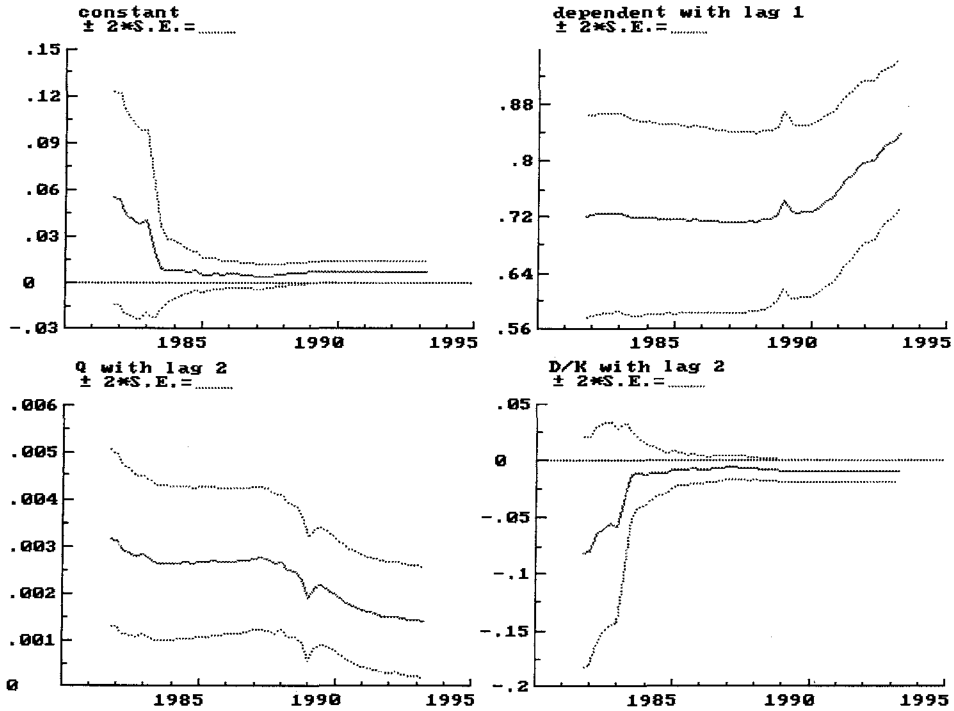


Figure 14 **Manufacturing sector q equation**



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