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Credit Crunch Caused Investment Slump?
An Empirical Analysis Using Finnish Data

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Abstract

The objective of this paper is to empirically analyze and quantify the effect of changes in the supply of bank credit on private investment. Particular interest is placed on the role of the credit crunch in explaining the collapse in private investment in the early 1990s.

Using a vectorautoregressive econometric model, it is shown that the credit supply plays a statistically significant and economically important role in determining investment. The effect of credit on investment comes through with a lag of about a year and persists for several years. Money supply is a powerful investment predictor in a bivariate relation, but loses its significance completely once credit is included in the model. Hence, in the light of history, it appears that the money supply has had little effect on investment except as relayed through credit and, to a lesser extent, through the interest rate. On the other hand, since strong contemporaneous comovements were found between money and credit, the contemporaneous effect of money on credit may be considerable. In general, the results were found to be consistent with the credit view of the monetary transmission mechanism: monetary policy affects both sides of bank's balance sheets — money supply and credit supply — and credit seems to be the more important predictor for investment.

It is estimated that positive shocks to the credit supply during 1986–1988 raised the peak for private investment in 1990 by about FIM 25 billion annually. On the other hand, the subsequent negative shocks deepened the collapse of investment by approximately FIM 20 billion annually.

Tiivistelmä

Tutkimuksessa analysoidaan empiirisesti pankkien luotontarjonnan muutosten vaikutusta yksityisiin investointeihin. Erityisesti kohdistetaan huomiota luotonannon supistumisen rooliin yksityisten investointien romahduksessa 1990-luvun alkuvuosina.

Tutkimuksessa osoitetaan vektoriautoregressivistä ekonometrista mallia hyväksi käyttäen, että luotontarjonnalla on tilastollisesti merkitsevä ja taloudellisesti tärkeä vaikutus investointeihin. Luotontarjonta vaikuttaa investointeihin noin vuoden viipeellä, ja vaikutus kestää useita vuosia. Rahan määrä ennustaa hyvin investointeja kahden muuttujan mallissa, mutta sen ennustusvoima katoaa käytännössä täysin, kun malliin lisätään luotontarjonta. Historian valossa näyttää siis siltä, että rahan tarjonta vaikuttaa investointeihin lähes yksinomaan luotontarjonnan sekä vähäisemmässä määrin korkojen kautta. Toisaalta pankkiluottojen ja rahan määrän voimakas keskinäinen riippuvuus aikaperiodin sisällä antaa syyn uskoa, että rahan tarjonnan vaikutus luottojen määrään saattaa olla huomattava. Tuloksien voidaan tulkita tukevan luotontarjonnan roolia korostavaa näkemystä rahapolitiikan välittymisestä: rahapolitiikka vaikuttaa pankkien taseiden molempiin puoliin — rahan määrään ja luotontarjontaan — ja näistä kahdesta luotontarjonnalla näyttää olevan suurempi vaikutus investointeihin.

Tulosten perusteella voidaan arvioida, että luotontarjontaan vuosina 1986–1988 kohdistuneet positiiviset shokit lisäsivät yksityisiä investointeja huippuvuonna 1990 noin 25 miljardilla markalla. Vastaavasti luotontarjontaan myöhemmin kohdistuneet negatiiviset shokit syvensivät investointien romahdusta noin 20 miljardilla markalla vuosittain.

Contents

1 Introduction

In the standard Keynesian/monetarist world, monetary policy affects the real economy through the LM-relation. When money supply changes, the interest rate and aggregate demand react so as to restore the equality of money supply and demand. In such a world, the only special role for the banking sector is to hold liquid deposits. On the asset side, a bank is identical to any other agent in the economy: it invests in bonds.

The assumption underlying this traditional view of the transmission mechanism (the "money channel", or "money view") is that the financial system functions smoothly. A debt contract is as easily made between a firm and a household or between two firms as between a bank and a firm. Recent developments in the field of financial microeconomics provide a variety of reason why this may not be so, and why it may be more efficient to use a financial intermediary, such as bank, instead of direct "peer to peer" debt contracting.

Much as a result of these developments, the last decade or so has witnessed the revival of an old and almost forgotten version of the monetary transmission mechanism: the credit channel. The credit channel builds on the realization that for important sectors of the economy, banks are the only source of external financing. Those sectors cannot offset a contraction in the banking sector's ability (or willingness) to lend by issuing bonds. If monetary policy affects banks' credit supply, it also has a direct influence on those sectors' budget constraints and expenditures.

The credit channel and the money channel are not alternatives, neither as theoretical models nor as financial mechanisms. Rather, the two are complementary to each other. In most cases, the credit channel works as an accelerator for the money channel, and thereby amplifies the effects of monetary policy. The most common versions of the credit channel depend on a functioning money channel to have any effect at all.

The term credit channel comprises a number of distinct mechanisms. Gertler (1993) labels the two most important of those the *reserve requirement mechanism* and the *balance sheet mechanism*. The reserve requirement mechanism is — somewhat confusingly — based on the banking sector's balance sheet identities. When bank deposits decrease — because of monetary policy or for some other reason — banks either have to increase borrowing from other sources or reduce lending. If banks react even partly by reducing lending, then those customers who do not have access to direct external funding have to cut their expenditures. This version of the credit channel is often associated with the work of Bernanke and Blinder (1988).

The label "balance sheet mechanism" does not refer to the banking sector's balance sheet but to the balance sheets of the borrowers. For many borrowers, collateral is the most important determinant of the availability and terms of bank loans. When a tightening of monetary policy increases interest rates, it may induce a fall in asset values, thus decreasing the value of collateral and weakening borrowers' balance sheets. Consequently, bank loan availability decreases, which in turn gives a further downward push to asset prices. As collateral values keep falling, the perceived risk increases, and banks again tighten their collateral requirements. As the cycle continues there may be a credit crunch and a flood of bankruptcies .

The question of the relevance of the credit channel is basically an empirical one. A great deal of econometric work has addressed this question. Most decisive is the evidence provided by the cross section studies (see Kashyap and Stein, 1993, for a survey). There is little doubt that the credit channel works as theory suggests. Much more problematic — and from the policy point of view, much more interesting — is how relevant is the credit channel on the aggregate level.

The results of econometric studies using aggregate data are mixed. From the studies using post World War II data, King (1986) finds little evidence of credit having additional predictive power for GNP when measures of money are included. Instead, money was found to be a powerful output predictor. However, Bernanke (1986) shows that once the correlations of the residuals are modeled as contemporaneous interactions of the variables, credit plays an important role in determining output — at least with the particular parametrization used by Bernanke. Another line of literature suggests that disruptions of the lending process can be quite important. For example, the six-point credit restraint program that was in place in the USA for less than four months in 1980 had a remarkable effect on borrowing and expenditure (see Schreft 1990 or Kashyap and Stein 1993 for details).

In this paper we use Finnish aggregate data to examine the comovements of monetary aggregates with private investment. Specifically, we focus on the dependence of private investment on money and credit supply. This exercise does not investigate the working of the credit channel *per se*, since it does not model the dependence of monetary aggregates on monetary policy. The narrower question addressed here is, whether bank credit supply has an effect on investment over and above the traditional money supply and interest rate variables. The causes of movements in the credit supply are outside the scope of this paper and are a possible avenue for future research.

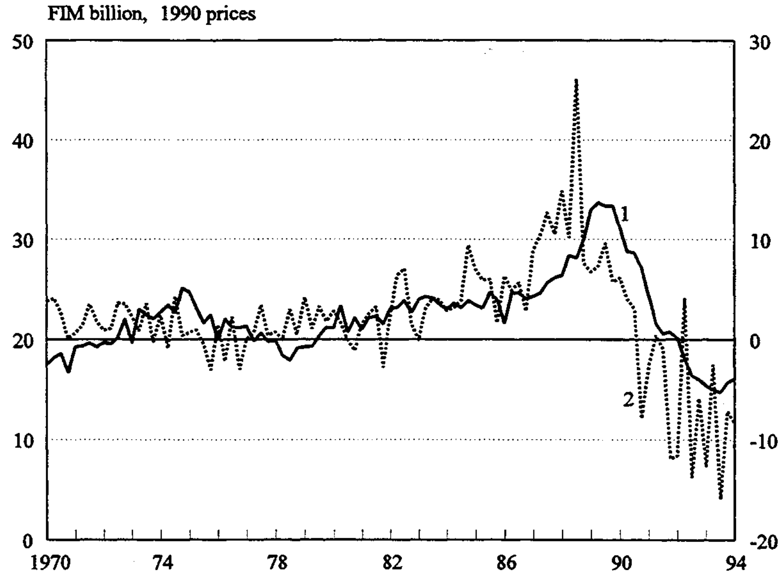
2 Finnish financial development, boom, and bust

The estimation presented later covers the time span from the beginning of the 70s to the present (second quarter of 1994). During this period, much has happened in the Finnish financial system. Roughly the first fifteen years of the estimation period were an era of comprehensive rationing in the financial markets. During most of that period, rationing was effective and real interest rates were often considerably negative. Rationing was gradually removed in the 80s. In all but the last two years of the estimation period, the exchange rate was fixed, although subject to occasional adjustment. For the last two years, the Finnish markka has been floating.

Drastic changes in the Finnish economy have not been limited to institutional changes. Most of the variation in most aggregate time series reflect the two recent major trends in the economy: rapid and accelerating growth during the 80s, a serious overheating of the economy in the last years of the decade, and a collapse in the beginning of the 90s. Although the timing of these trends corresponds to what happened in the world economy, the amplitude of the cycle has been much greater than what other OECD countries experienced.

Likewise, the recent problems of the banking sector have been severe by international standards. The collapse of property prices and heavy credit losses hit the Savings banks hardest, but all major banks have recorded heavy losses in the early years of the 1990s. Public support for the banking sector is estimated to reach 10% of the GNP.

Figure 1 **Private investment and bank loans**



1 Private fixed investment (left axis)
2 Net increase in bank loans (right axis)

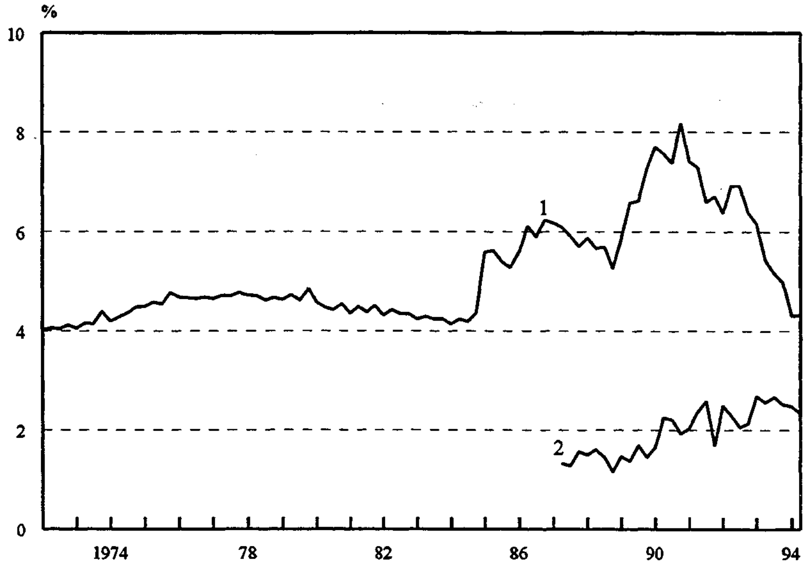
The drastic nature of the changes is well depicted in Figure 1, which graphs private fixed investment and the change in bank loans to the private sector (both in real terms). As can be seen, after peaking at the last turn of the decade, investment is now at a lower level than in the beginning of the 70s, and bank loans have declined four straight years. For an econometrician the question is whether any stable statistical relationship can survive such a stormy period.

There is little doubt that the recent collapse in investment and the decline in bank credit are related phenomena. The question is then which one is driving the other: does the decline in bank credit merely reflect the fall in the demand for credit, or is the slump in investment due to the tightening of bank credit and firms' inability to raise external funds? There is some evidence that the latter effect has been present in recent years. According to surveys and various informal sources, small and middle sized firms have indeed faced significant problems in obtaining bank loans. The biggest roadblock seems to have been insufficient collateral; partly as a reaction to the heavy credit losses, banks' collateral requirements have tightened at the same time as property prices have plummeted. In the virtual absence of non-bank venture capitalist, the scarcity of bank credit has presumably played an important role in reducing investment by small and middle sized firms.

There are some indirect measures of bank credit tightening. One is banks' interest margin. Figure 2 plots two measures of the margin. The first is based on the average rate on new bank loans and the average rate on banks' liabilities. It shows how the margin jumped from around four percentage points to almost six around 1986, and then to seven at the turn of the decade. The first jump was presumably demand driven. However, the wide margins in 1990–1992 were more likely caused by the supply side.

Figure 2

Interest rate margins

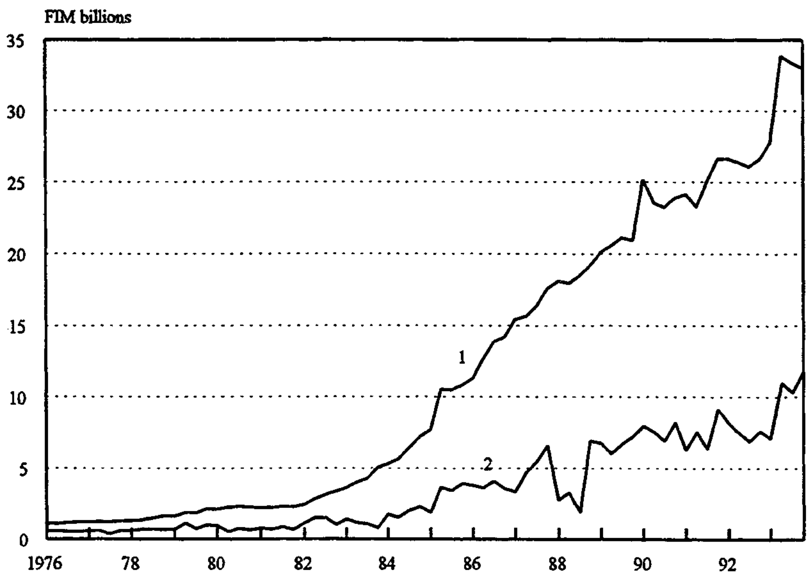


1 Average rate on new bank loans - average rate on banks' liabilities
2 Avg. rate on new loans linked to 3 mth Helibor - 3 mth Helibor

Since the late 80s, banks' assets have been mostly linked to market interest rates, whereas the bulk of liabilities still consists of tax free deposits, on which the rates are regulated. Therefore, this measure of interest margin is likely to reflect as much the discrepancy between market rates and the regulated base rate as banks' willingness to extend credit. The second series in the figure provides a more focused measure. It plots the margin over the three month interbank rate attached to bank loans linked to that rate. The picture is much the same: an upward shift in the margin took place around 1990. However, unlike the first measure, this margin has not shown any tendency to shrink in the last two years.

Figure 3

Corporate bonds



1 Outstanding bonds of domestic firms
2 Outstanding bonds of domestic firms, not held by banks

Another consequence of tighter bank credit should be a fall in bank loans relative to commercial paper. Figure 3 shows that this indeed has been the case. Commercial paper continued to grow for several years after bank loans began to decline. One explanation for this observation is that banks may have converted company loans to commercial paper in order to circumvent BIS capital requirements. This, however, is not a complete explanation. Even after accounting for the increase in banks' holdings, the commercial paper issued by firms still show a definite upward trend. All in all, the evidence seems to speak in favor of a tightening of bank credit around 1990.

3 The data

The purpose of this work is to study the dependence of private fixed investment on money and credit supply. To avoid having to impose a theoretical structure, the form of which would be anything but clear, and to sidestep problems of simultaneity, we approach the problem using the unrestricted VAR methodology. Needless to say, this approach is not without problems of its own. First, it does not model any contemporaneous interactions between variables. If the residual matrix is highly cross-correlated, the residuals cannot be interpreted as genuine shocks to the respective variables. Second, even if a high degree of dynamic interaction between variables is found in the data, this cannot be interpreted as definite evidence of causality unless all relevant variables are included in the regression. Both problems are accounted for shortly.[1]

Four variables are included: private fixed investment (IN), money stock (M2), bank loans to private sector (LOAN), and the interest rate on new bank loans (LRATE). Prior to estimation, several problems had to be tackled. First, since private fixed investment is stated in real terms, the monetary aggregates need to be deflated as well (to avoid expanding the model by including a price index). For this purpose, the monetary aggregates were divided by the consumer price index. This poses a potential problem by introducing a common source of variation in the series. However, the results were checked to be very robust with respect to the handling of inflation. The expected real interest rate on new bank loans was obtained by adjusting the nominal rate for expected next year inflation, the latter obtained from an autoregressive forecast.

Foreign currency denominated loans as a proportion of bank loans to the private sector, which was close to zero in the 70s, peaked at about one quarter in the beginning of the 90s. Hence, the devaluation of the Finnish markka in 1991 and the rapid depreciation following the start of the float in 1992 had a considerable impact on the markka value of the loan stock. Since these changes carry no relation to either the

[1] See Leamer (1985), Eichenbaum (1985) and Bernanke (1986) for a discussion of the problems in and approaches to testing structural hypotheses using vector autoregressions.

supply of or demand for credit, the effects of exchange rate changes were removed from LOAN.[2]

The last problem was one of differencing. The VAR methodology does not assume stationarity of time series. On the contrary, differencing may cause information loss by destroying possible cointegrating relations. However, the series should be of the same order of integration. Table 1 gives the Augmented Dickey-Fuller statistics for level of IN and first differences of M2 and LOAN. Investment is clearly seen to be I(1). For the monetary aggregates, the result is mixed: for the first difference of LOAN, the unit root hypothesis is readily accepted, but for the M2 difference, only barely. In fact, for given number of parameters, the best fit is obtained when LOAN is differenced and M2 is not. However, it makes little sense to assume that the major components of the two sides of banks' balance sheets have different orders of integration. Therefore, both M2 and LOAN were differenced before estimation. The model was estimated also in levels; the changes in the results are reported later.

Table 1 **Augmented Dickey-Fuller tests with 4 lags**

Variable	ADF-statistic
IN	-0.161
LOAN (diff)	-1.076
M2 (diff)	-1.778

Critical values: 5% = -1.944 1% = -2.589

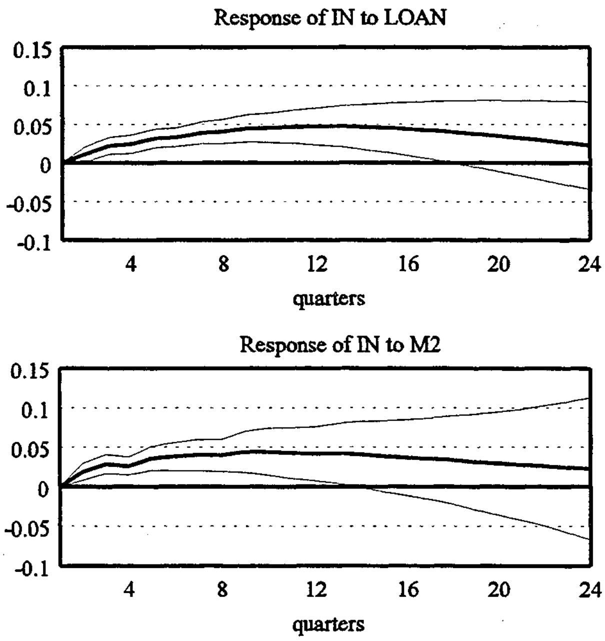
4 Estimation results

4.1 Bivariate relations

First three bivariate VAR(4) models were estimated to test bivariate causality. The results are presented in Table 2. A very strong causal relation appears to exist from both credit and money to investment. The effect from credit is somewhat stronger but both are significant at any common level of significance. Investment does not seem to have any effect on the financial aggregates. Credit seems to be only marginally important in determining money and there is no indication of reverse causality.

[2] This was done using a simple mechanical approach. The change in the markka value of currency loans due to exchange rate changes was approximated by $(\Delta E_t/E_{t-1}) \cdot CLOAN_{t-1}$, where E is the basket exchange rate and CLOAN is currency denominated loans. Although this approach is by no means exact, it captures the major changes (i.e. devaluations), and there is no reason to believe it to be biased.

Figure 4 **Bivariate impulse responses of investment to the monetary aggregates**



Based on the same bivariate VAR models, Figure 2 plots the dynamic response (impulse response) of investment to a positive standard error shock in the financial aggregates with two standard error bounds. The two impulse responses are strikingly similar: in both cases, the shock has a significant and persistentpositive effect on investment. Together with the high correlation (0.54) between the residuals of the financial aggregates, this leads one to conjecture that the impulses in the two have common sources.

4.2 Full model results

The estimated coefficients with corresponding t-values for the full VARX model (with endogenous variables IN, LOAN, and M2, with four lags, and one lagged exogenous variable LRATE) are reported in Table 3. As is typical for a VAR of this size, the individual coefficients tend to have low significance levels. Most of the one-step variation of IN is explained by its own history, although LOAN is also significant at the 10 % level. The one-step variation in LOAN is explained by its own history only, and not very well by that either. Surprisingly, the history of M2 has only a slight effect on its own one period forecast and no effect on the others. Instead, LOAN explains a significant part of the variation in M2.

Table 2 **Granger causality from column variables to row variables**

	Dependent variable		
Explanatory variable	IN	LOAN	M2
IN		1.52 (0.203)	1.62 (0.178)
LOAN	13.24 (0.000)		2.10 (0.088)
M2	11.02 (0.000)	0.93 (0.466)	

F-statistics and corresponding significance levels.

The interest rate variable RLOAN is significant at the system level. In the investment equation it has a small but negative coefficient that is not quite significant at the 5 % level. In the LOAN equation, the interest rate has a positive coefficient. This is not as counterintuitive as may appear, since during credit rationing, increasing the interest rate may well have an expansive effect.

There is no evidence of serious misspesification. The residuals seem to be homoscedastic and exhibit no autocorrelation. The only test that gets a significant value is the Chi-square normality test for the residuals of M2. Since the vector normality test is not significant, we did not consider the problem serious.

The correlation matrix for the residuals reveals a mitigating result: there is practically no correlation in the residuals between investment and the monetary aggregates. Hence, simultaneity does not disturb the interpretation of the results here. On the other hand, the residuals of LOAN and M2 are again correlated with a coefficient of 0.55. Obviously, some of the correlation is due to deflating the nominal series with the same deflator. However, as verified by experiments, even when using nominal values, the residual correlation of money and credit is still well over 0.4. We find this a natural result: shocks to the two sides of banks' balance sheets should be correlated. One may interpret the correlation as an indication of the existence of the credit channel: a shock to bank deposits limits, through the budget constraint, banks' capacity to expand credit. On the other hand, it may be that the shocks to the two are simply caused by the same unmodeled factors. The interpretation of the correlation does have some implications on the results, as is seen later.

Besides the important role of credit, a conspicuous feature in the results is the nonexistent role of money. Money has no one period forecasting power for investment or credit and it performs only a little better in its own equation. One explanation for this observation is that since liquidity affects investment through interest rates and credit supply, which were both included in the model, there is no room left for money to matter. The data provide some support to this interpretation, as shown in the next subsection.

4.3 Dynamic analysis

The results presented above are not very informative as such. Since a VAR model is a reduced form representation of an underlying structural data generating process and the coefficients are highly complicated transformations of the structural parameters, no economic interpretation can be attached to the individual VAR coefficients. Even the F-test for the significance of a variable in an individual equation is not very interesting; first, because it only deals with one-step forecast power, and second, because the effect of one variable on another is transmitted not only through the particular equation, but through the whole system. Much more interesting are the dynamic responses of the system to shocks in different variables, or the impulse response functions. One can think of the impulse response functions as measuring how much the time path of the system changes, when the shock to a certain variable is increased by one standard error.

In order to calculate the impulse responses, one needs to isolate the nature of the shocks that drive the system. In essence, this means that one needs to impose a contemporaneous structure on the model. If the residuals of the model are not cross-correlated, this does not pose a problem; no contemporaneous effects exist and the residuals describe genuine shocks to the particular variable. However, when the residuals are cross-correlated, one faces the same problem of simultaneity as in structural models. The question is, does the correlation reflect a contemporaneous link from one variable to another, or do the shocks merely share common causes.

As mentioned above, the problem in the present estimation is the high correlation between the residuals of money and credit. Whether one assumes the correlation to originate from a contemporaneous effect from money to credit or vice versa, has a significant effect on the outcome. On the other hand, since the residuals of the investment equation are not correlated with the residuals of the financial aggregates, the effects of credit and money on investment (and vice versa) are quite robust with respect to the choice of orthogonalization.

As a reference case, Figure 4 plots the impulse responses calculated from the unorthogonalized covariance matrix, in which the contemporaneous correlations are not modeled. Each impulse response is again plotted with two standard error limits obtained by Monte Carlo simulation. It is seen in Figure 4 that a shock in investment has some persistence — leveling off in about four years — but it has little dynamic effect on the monetary aggregates. Money seems to have a small and statistically insignificant positive impact on investment and little effect on anything else.

A shock in bank loans, on the other hand, has a large and statistically significant positive effect on investment, with a persistence of about seven years. A positive shock increases the loan supply for four or five years, after which a slight backlash may occur. The reaction of investment peaks at about two or three years after the initial shock; at that point, a positive initial shock of one standard error in credit (about 1.5% of the credit aggregate) has increased investment by four per cent.

Next the residuals were orthogonalized using the Choleski decomposition in the order IN, M2, and LOAN. In other words, a recursive structure was imposed on the contemporaneous effects between the variables, such that shocks in investment affect money and credit in the same period, and shocks in money, in turn, affect credit within the period. The choice to put M2 first reflects the mechanism suggested by the reserve requirement version of the credit channel: changes in money, through balance sheet identities, force banks to cut their lending.

Table 3 **Full model estimates using quarterly data 1971:2–1994:2**

	Dependent variable		
	IN	LOAN	M2
IN(-1)	0.3687 (-3.556**)	0.0450 (-1.647)	0.0202 (0.698)
IN(-2)	-0.0579 (-0.518)	-0.0081 (-0.276)	-0.0198 (-0.630)
IN(-3)	0.0956 (0.854)	-0.0170 (-0.577)	0.0170 (0.543)
IN(-4)	0.4331 (4.033**)	-0.0229 (-0.810)	-0.0614 (-2.042*)
LOAN(-1)	0.4198 (0.836)	0.326 (2.462*)	0.1381 (0.982)
LOAN(-2)	0.9192 (1.768)	0.1746 (1.274)	0.2778 (1.908)
LOAN(-3)	0.5813 (1.058)	-0.0179 (-0.124)	0.1910 (1.241)
LOAN(-4)	0.4996 (0.964)	0.1854 (1.358)	-0.1892 (-1.304)
M2(-1)	0.5774 (1.200)	0.0954 (0.752)	0.0240 (0.178)
M2(-2)	0.2884 (0.580)	0.0835 (0.637)	-0.2309 (-1.658)
M2(-3)	-0.1073 (-0.215)	0.0317 (0.241)	-0.0985 (-0.707)
M2(-4)	0.5328 (1.089)	0.1006 (0.780)	0.1150 (0.840)
RLOAN(-1)	-0.4077 (-1.861)	-0.0249 (-0.431)	0.1432 (2.334*)
SEAS(-1)	-0.1933 (-3.103**)	-0.0199 (-1.212)	-0.0728 (-4.174**)
SEAS(-2)	-0.1030 (-1.862)	-0.0018 (-0.124)	-0.0357 (-2.307*)
SEAS(-3)	-0.0661 (-1.024)	0.0064 (0.375)	-0.0602 (-3.333**)
CONST	1.6866 (2.367*)	0.0357 (0.190)	0.4908 (2.460*)
Std. error	0.056	0.015	0.016
Adjusted R^2	0.918	0.578	0.675
AR 1-5, F(5,71)	1.335	0.724	0.347
Normality, $\chi^2(2)$	2.517	5.47	14.0**
ARCH(4), F(4,68)	1.296	0.594	0.078
Xi^2, F(26,49)	0.596	1.003	0.867
F-tests for significance			
IN	38.70**	0.87	2.03
LOAN	2.13	2.88*	2.50*
M2	0.72	0.29	1.39
Vector AR 1-5,		0.927	
Vector normality,		10.75	
Vector Xi^2, F(156,266)		0.757	

t-values in parentheses, * = significant 5 %, ** = significant 1 %.

Figure 4 **Impulse responses of the unorthogonalized model**

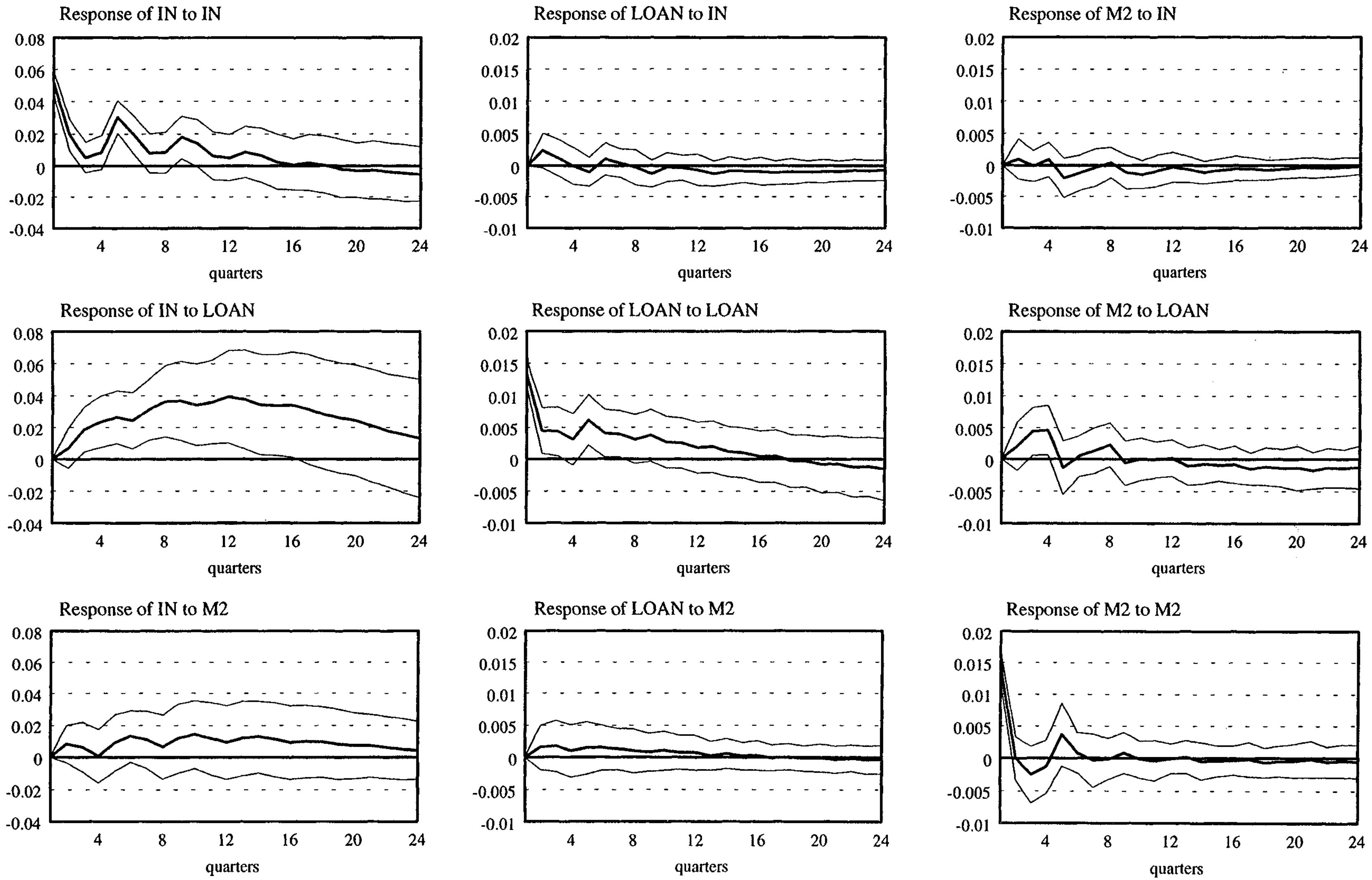
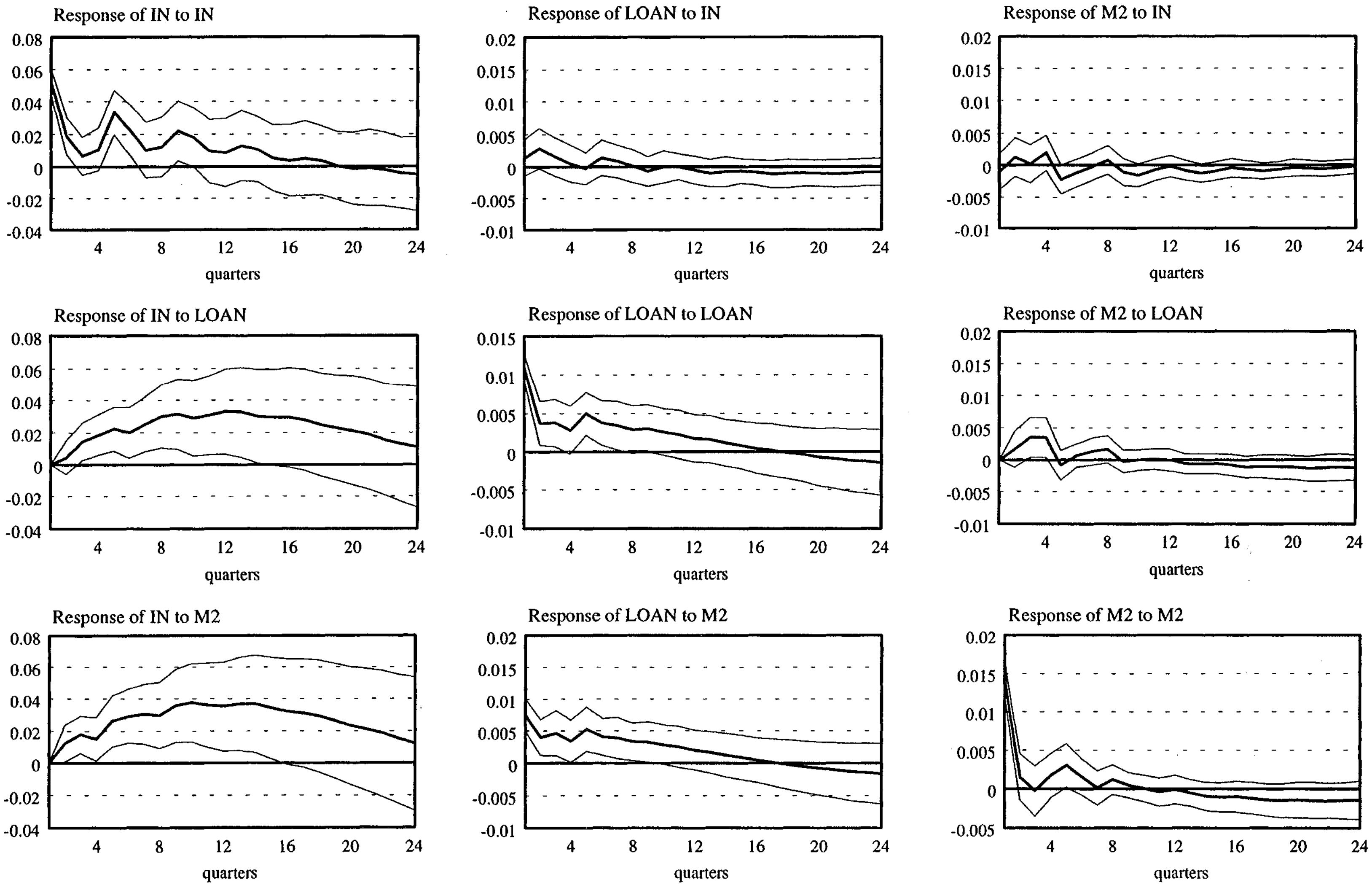


Figure 5 **Impulse responses of the Choleski-orthogonalized system**



The picture changes quite a bit, as depicted in Figure 4. A shock in LOAN still has a large and significant effect on investment, but now money also affects investment. Actually, it can be observed that a shock in money is mostly relayed through the credit supply, which reacts to a shock in money almost exactly as it reacts to its own shock. A noteworthy feature is that credit still maintains its significance after part of its residual variance is attributed to shocks in money. This can be interpreted as an implication of the existence of strong autonomous innovations in the credit supply.

It was hypothesized in the previous section that the insignificant role of money may be explained by the inclusion of its main working channels, namely the interest rate and credit. The data provide at least partial support for this hypotheses. Although the exclusion of the interest rate neither adds to nor diminishes the role of money, dropping credit from the model has a dramatic effect on the relationship between money and investment. As shown in section 4.1, in a bivariate model of money and investment, money has a strong, persistent, and statistically significant effect on investment. The dynamic profile of that effect is very much like what was observed from credit to investment in the complete model, except that here money is strongly significant also in short term forecasts. Once credit is included, this effect disappears completely. We find these results broadly consistent with the hypothesized operation of the credit channel: changes in M2 affect credit supply and thereby investment.

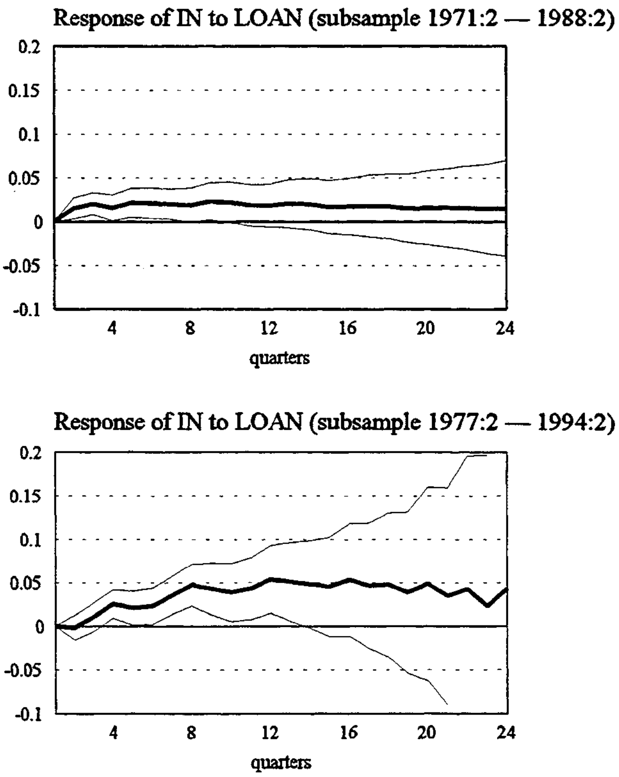
4.4 Sensitivity analysis and structural stability

To test the stability of the system, the model was estimated over two subsamples: 71:2–88:2, and 77:2–94:2. Figure 5 plots the (unorthogonalized) impulse responses of investment to credit in these cases.

Dropping six years from the estimation period severely reduces the degrees of freedom, so it comes as no surprise that the standard errors are somewhat wider. For the latter subsample the picture is very similar to the whole sample. The role of credit in explaining investment is slightly stronger than in the whole sample, but money loses its effect altogether. For the earlier subsample the picture changes a bit more. The effect of credit on investment appears less pronounced than when estimated from the whole sample. The one-step forecast power of credit in the investment equation actually increases: credit is now significant at the 1% level. The reason for the smaller dynamic response of investment is twofold. First, as is clearly visible from Figure 1, the persistence of the credit supply (new bank loans) increases significantly after credit rationing, that is, around 1986. Before that year, credit supply looks like a stationary series. Excluding the last six years significantly reduces the estimated persistence of credit shocks, which is reflected in the less persistent reaction of investment. Second, the standard error shock in credit, which is used as the seed in the simulation, is much smaller in the earlier period (0.0089 versus 0.0121 in the latter subsample). For shocks of equal size, the two dynamic responses would look much more similar, at least in the short and medium run.[3]

Altogether, we may conclude that even though there is evidence of an increase in the persistence of credit shocks, the effect of credit on investment is robust with respect to the estimation period — even surprisingly so, considering the dramatic changes that have taken place in the environment.

Figure 5 **Impulse responses of investment to a shock in credit in the subsamples**



The effect of deflating was examined by running the regression using nominal instead of real variables. This proved to have almost no effect on the results. The most pronounced change was that the residual correlation between investment and credit more than doubled to about 0.25. Finally, the model was estimated with real investment, nominal financial aggregates, and price level as variables. Again, the results were essentially unchanged.

[3] The VAR model was tested for a structural break at 83:2 (the midpoint of the sample) in the coefficients of LOAN. The test value was statistically significant at the five per cent level ($Chi^2[12]$ statistic gets the value 24.7). However, the structural break appears to take place only in the time series process of the financial aggregates. There was no evidence of a change in the dependence of investment on credit.

The picture changes more dramatically when the estimation is done without differencing the monetary aggregates.[4] The estimated model has an exploding cycle with a frequency of about nine years. The amplitude of the cycle roughly doubles with each cycle. Credit maintains — and strengthens — its positive short term effect on investment, but money gets some forecast power as well. The strong cyclical properties of the model take over quickly after a few quarters, so no conclusions can be made about the impulse responses. Since we find this description — exploding cycle — of the time series properties of the variables counterintuitive and implausible, and also because the results were much more sensitive to changes in the estimation period than in the differenced version — in particular to the exclusion of the last five years — the differenced model was maintained.

As mentioned above, the fact that credit supply precedes investment does not necessarily mean that credit supply causes investment. It may be that there is a third variable, or a set of variables, which cause both credit supply and investment, and that credit supply just reacts faster than investment. This problem is inherent to all vector autoregressions: In order to make definite conclusions about causal inference, one would need to control for an infeasibly large set of possible causal variables.

Within the limits of feasibility and data availability, we checked the robustness of the credit-investment relationship with respect to the inclusion of possible background variables. Four regressions were run, with the log of GNP, the number of bankruptcies, and the logs or real housing prices and real stock prices, each included in turn. In the first two cases, the results of the baseline regression remained intact, and the additional variable had a negligible contribution over the original variables. On the other hand, housing prices seem to play a significant role in determining investment. A shock in the price of housing seems to persist about four years and to cause a significant positive effect of similar length on investment. A similar but less pronounced effect was found from stock prices to investment. Most importantly, however, the relations between the three original variables were hardly affected by adding the new variable: in particular, credit supply in each case maintains its persistent and significant effect on investment, with essentially unchanged magnitude. All in al, no evidence was found against interpreting the relationship between credit supply and investment as a causal relationship.

5 Credit crunch and investment slump

The question we ask in this section is the following: To what extent can the recent swings in investment be explained by changes in credit supply? In other words, what would the path of investment have been without shocks to the credit supply. To answer this question, a series of in-sample simulations were run with the VAR model estimated above. In each simulation, the actual value of the exogenous variable (loan rate) was used. The residuals of the VAR model were fed in as shocks to the investment and money equations, but no shocks were fed into the credit equation.

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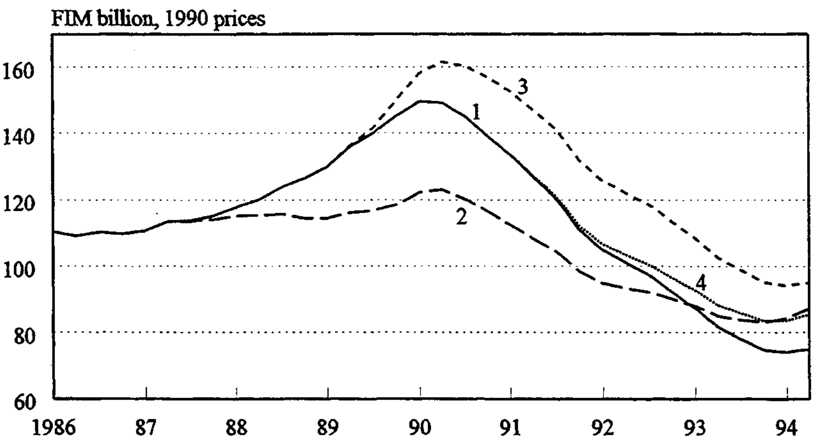
[4] Particularly important question is whether or not to difference LOAN. The impact of differencing M2 is negligible.

There are some caveats with this approach. First, the high residual correlation between credit and money hampers the interpretation of the results. By forcing the shocks in credit to zero while keeping the shocks in money unchanged one clearly disregards an unmodeled structural feature of the process. However, without knowing the true structure, there is no clear avenue for handling this problem. Also, since the autonomous effect of money is quite small, ignoring the correlation should not have a major effect on the result.

Next, even with orthogonal shocks, it would not be perfectly clear how the results should be interpreted. Credit shocks are, of course, not a series of isolated events in the economy. They reflect changes in the situation of the financial market, changes which no doubt also affect the shocks to money and investment. Minimally, one would expect that changing the path of credit supply would also change the path of the loan rate.

Finally, the simulated paths do not pretend to represent feasible paths that might have been attained with another economic policy. Rather, they try to isolate the role of the credit supply by estimating what would have happened in the (most likely quite unrealistic) case that banks had somehow managed to keep their credit supply unchanged regardless of credit losses, capital requirements, and falling property prices. When interpreting the results, one should bear in mind that forcing credit shocks to zero does not mean fixing the quantity of credit. Credit is still very much endogenous in the simulation. However, we assume that shocks to the system affect credit only through the other variables in the system. Of course, in addition to the shocks, credit (as well as other endogenous variables) is also driven by the time series properties of the system, which tends toward its steady state path.

Figure 7 **Private investment; actual and simulated**



1 Actual private investment (four quarter moving sum)
2 Simulation from 1986:3; no shocks to credit
3 Simulation from 1989:1; no shocks to credit
4 Simulation from 1990:3; no shocks to credit

All this said, the results appear to be quite illuminating. Figure 7 plots the actual private fixed investment and the simulated values from three simulations starting with 1986:3, 1989:1, and 1990:3. The starting point of the first simulation is chosen as to predate the boom of the late 80s. Figure 7 shows that without the positive exogenous shocks to the credit supply that took place in period 1986–1988, the investment boom would have been almost nonexistent. Annual investment would have peaked in 1989 at only FIM 118.5 billion instead of the actual FIM 145.1 billion. From 1990 on, investment would have declined but not by quite as much as it actually did.

The second starting point (1989:1) was chosen because it was the point when the series of negative shocks to the credit supply started to appear.[5] If none of the succeeding shocks had arrived, investment would have peaked much higher (at over FIM 160 billion annually). The downturn again would have been steep, but annual investment would have stayed about FIM 20 billion above the actual rate of investment.

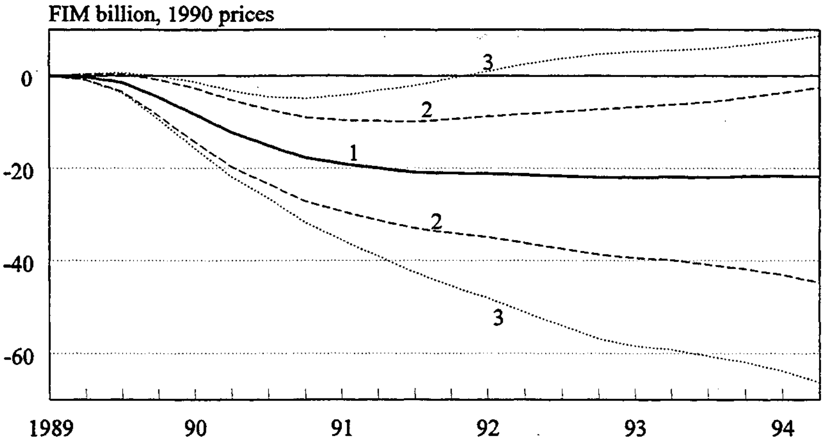
Finally, the last starting point (1990:3) is where the boom ended and the free fall began. Interestingly, it appears that shocks to the credit supply after that date play a minor role in determining investment. Had credit supply stayed at the level it was at the beginning of 1990, annual investment in 1993 would have been higher by less than FIM 9 billion.

The paths simulated for Figure 7 are point estimates. It is not quite straightforward to a choose measure of uncertainty to attach to them. There are two kinds of uncertainties that can be calculated for the simulations. First, there is the uncertainty related to the parameter estimates. If the shocks to the system are known, then this is the only source of uncertainty. In the impulse response simulations presented above, this was the type of uncertainty represented by the confidence intervals. It is the correct measure, because an impulse response measures the effect of a *given* shock on the endogenous variables. However, when one wants to measure the effect of actual shocks that took place during a period of time in history, one faces another source of uncertainty: we do not observe the actual shocks. Instead, we observe the variables, from which the shocks have to be estimated. Hence, to give a full picture of the uncertainties involved in the exercise, we must also take into account the uncertainty connected with the estimation of the shocks.

Figure 8 provides measures of these two kinds of uncertainties for the simulation starting from 1989:1 (that is, for series 3 in Figure 7). It plots the deviation in private investment caused by shocks to the credit supply, together with two sets of approximately 95% confidence intervals (two standard error limits). The solid line is the point estimate of the deviation. It corresponds to the difference between actual private investment and the one simulated in Figure 7, series 3. The narrower limits marked by the dashed lines (marked with number 2) are the confidence interval for the case that the estimated shocks are the true exogenous shocks that hit the credit supply. The confidence interval is relatively wide, but even the upper bound stays well below zero over the whole period. Using these intervals, the most definite effect of the credit crunch on investment took place during the year 1991, when it reduced investment by approximately FIM 20 billion, with the confidence interval extending from FIM 10 billion FIM 30 billion.

[5] The first exogenous shock that hit the market was the credit restraint program imposed on the banks by the Bank of Finland. The program introduced a progressive cash reserve requirement, in which the reserve ratio depended on the rate of credit expansion.

Figure 8 **Cumulative effect of credit shocks on private investment since 1989:1**



1 Simulated deviation from actual
2 Two standard error limits (shocks to credit known)
3 Two standard error limits (shocks to credit estimated)

The wider confidence intervals (dotted line, marked 3) include the uncertainty involved in having to estimate the shocks. To produce these limits parameters were drawn from their distribution, and for each set of parameters, the corresponding estimates of credit shocks were used as the input to the system.[6] The result is noticeably wider confidence intervals. According to these estimates, it appears reasonably certain that during years 1990 and 1991 credit supply constrained investment. However, although it seems likely that the same continued to be true for another year or two, one cannot rule out the possibility that the effect was zero. The closer we come to the end of the estimation period, the less definite the conclusions we can draw.

It is worth noting that the estimated role of credit in the recent investment slump is quite robust to changes in the estimation period. For example, while the time series properties of credit look very different in the subsample 1971:2 – 1988:2, and the impulse response of investment to changes in credit is much smaller (see figure 5), the estimated effect of credit on investment during the last five years is statistically significant and actually even stronger than the effect estimated from the full sample. The reason is that the estimated credit shocks for the simulation period, calculated using the parameter values estimated from the early subperiod, are negative and much greater (in absolute value) than those obtained with the full sample parameters. This more than compensates for the shorter persistence of those shocks.

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[6]More precisely, for each draw of the parameter vetor β, the corresponding residuals were calculated as $u_t = Y_t - X_t\beta$.

6 Conclusions

The results can be interpreted as broadly consistent with the credit view of the transmission of monetary policy. The complete mechanism of the credit channel — from monetary policy through bank balance sheets to investment and consumption — was not tested. Considering the recent regime shifts in monetary policy and several structural changes in the Finnish financial markets, the prospects for such a broad-based approach are not promising. Instead, the analysis concentrated on the last link of the credit channel, namely, the link from credit supply to investment. This link was found to be statistically significant. A positive credit shock has a strong and lasting positive impact on investment. This relation was found to be reasonably stable over time, even with respect to the recent pronounced changes in the Finnish financial markets. It was also found to be invariant with respect to the inclusion of additional variables.

Based on the results, it seems reasonably clear that shocks to monetary aggregates (Granger) cause changes in investment. The question of how these shocks are set off leaves more room for debate. Dynamic analysis provides some indication of credit causing money but no evidence of the reverse causality. However, the contemporaneous correlation between the residuals from the credit and money equations was quite high, so a shock to the money supply may affect the credit supply very quickly. If this is the case, then the results can be interpreted as being consistent with, if not providing direct evidence of, the reserve requirement version of the credit channel: banks react to disturbances in the money supply partly with a sudden cut in lending. This interpretation is, of course, not the only one possible. Perhaps banks react to a tightening of monetary policy by cutting lending, which reduces money demand.

Fundamentally, the question whether money causes credit or vice versa is somewhat contrived: both are endogenous variables that reflect the reactions of the financial system to exogenous variables. It is only natural that the two sides of banks' balance sheets react symmetrically to changes in those exogenous variables. From the monetary policy point of view it would be interesting to know how important monetary policy is as such an exogenous variable. Unfortunately, since the purpose of this paper is to examine the role of money and credit in determining investment, and not to test the whole chain of causality in the monetary transmission mechanism from central bank actions to domestic demand, the analysis offers little scope for such policy conclusions. Still, there is little doubt that factors other than monetary policy have strongly affected credit supply. Most importantly, the plummeting of property prices and the resulting heavy credit losses caused severe bank capital problems. In the last few years the banks have slipped dangerously close to the BIS capital requirement and, without government money, would possibly have breached it. As the perceived riskiness of the economic situation increased and the banking sector's willingness to carry those risks diminished, the result was tight restraints on credit expansion and a sharp rise in collateral requirements.

The central finding of the analysis was that in the light of history, credit matters, and there is no evidence of its importance being on the wane. Hence, if nothing else, the analysis indicates that, at least in Finland, a central banker would be well advised to keep credit in the list of information variables.

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