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(Vállalati beruházások és hitelpiaci tökéletlenségek. VECM-becslés Magyarországra)

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Contents

Abstract

The aim of this paper is to model the interaction between the loan market and real activity, while financial frictions are explicitly taken into account. The econometric methodology used is VECM. Johansen's approach is employed to allow for multiple cointegration. Financial frictions are captured by including balance sheet indicators of firms and banks (cash flow and the VIX index) which move the loan supply curve. For the non-financial corporate sector 3 long-run equilibrium relationships were found, each corresponding to a reduced form investment, a loan demand and a loan supply equation, where loan supply is determined by the cost of borrowing, and the cash flow of firms or the VIX index. In contrast, for manufacturing no evidence was found concerning the significance of financial frictions. Impulse response analysis is used to calculate the real effects of a loan supply shock. Various tax measures and the introduction of inflation targeting were found to have significant impact on investment.

JEL: E22, E44, E51, C32.
Keywords: aggregate investment, financial frictions, cointegration, error correction models.

Összefoglalás

A tanulmány célja a reálgazdaság és a hitelpiac közötti összefüggések modellezése, pénzügyi tökéletlenségek figyelembevételével. Az alkalmazott ökonometriai módszer VECM. Johansen megközelítését használom, mert ez megengedi többszörös kointegrációs kapcsolatok jelenlétét. A pénzügyi tökéletlenségeket olyan vállalati és banki mérlegindikátorok ragadják meg, amelyek a hitelkínálatot befolyásolják. A nem pénzügyi vállalati szektorra kapott becslésekben 3 hosszú távú kapcsolatot találtam. Ezek megfelelnek egy redukált formájú beruházási, egy hitelkeresleti és egy hitelkínálati egyenletnek, ahol a hitelkínálatot a hitelezés költsége, a vállalatok cash flow-ja, illetve a VIX-index határozza meg. Ezzel szemben a feldolgozóiparra az eredmények nem támasztják alá a pénzügyi tökéletlenségek jelenlétét. A hitelkínálati sokkok reálgazdasági hatását impulzusválasz-függvények segítségével számszerűsítettem. Kimutatható, hogy számos adóintézkedés és az inflációs célkövetés bevezetése szignifikáns hatást gyakorolt a beruházásokra.

1 Introduction

Business fixed investment (for short investment) is the most volatile component of GDP and over the long run determines the productive capacity of an economy. That makes investment important for understanding both the business cycle and long-run growth. In this paper I investigate the driving factors of investment and develop models to better understand its long and short-run behaviour. In particular I will model the interaction between loans and investment. To do that it is necessary that financial frictions are explicitly taken into account. This is the first paper which models aggregate investment using Hungarian data, while allowing for financial frictions.

Because of the agency costs caused by various forms of financial frictions, real and financial decisions become interrelated. Investment cannot be modelled in a pure neo-classical framework, but depends on factors such as cash flow or net wealth of firms as well. Two branches of the literature on financial frictions are relied upon. According to the **balance sheet channel,** firms' access to external finance is constrained or more expensive than internal sources of finance, and as a result their net wealth or liquidity impacts their real decisions. Shocks to a firm's balance sheet have an impact on the supply of bank loans, which in turn affects spending decisions. Through this financial accelerator mechanism the impact of monetary policy or other exogenous shocks are amplified. On the other hand, there is a growing theoretical and empirical literature according to which the balance sheet of banks plays a role as well. A deteriorating capital or liquidity position of banks lowers their ability and willingness to lend. The so-called **bank lending channel** effects might also amplify the fluctuations of the real economy. The financial sector itself becomes not only an amplifier, but a source of powerful shocks. The increase in the level of bank intermediation in Hungary and the sub-prime crisis, providing evidence on the relevance of macro-financial inter-linkages, underline the importance of modelling investment with financial frictions.

The econometric approach employed in this paper involves Cointegration Estimation and Vector Error Correction Models (VECM). Economic theory suggests that there exist both short and long-run interactions between the variables of interest, which can be handled by VECM. First, cointegrating or long-run relationships are identified. Given the existence of long-run relationships, VECM provides an efficient estimator for the short-run dynamics. In the context of investment models there is a further motivation for the choice of methodology. One of the disappointing earlier empirical results of investment models was the very low estimates or insignificance of user cost elasticity of aggregate investment. One reason for this is that demand curve shifts, often associated with the business cycle, lower or reverse the relationship between user cost and investment. If shifts in demand are more frequent or important than shifts in supply, then the estimated user cost elasticity will be unintuitive. However, as shocks moving the supply curve (productivity shocks, tax measures) are more persistent, estimation on lower frequency data, i.e. focusing on long-run relationships, could remedy this problem (see Schaller, 2006). In addition, due to adjustment frictions short-run investment dynamics should be modelled. This is one reason why investment is often well described by distributed lags models.[1] Various investment models agree on the steady state determinants of capital, although predict very different short-run dynamics. Therefore it is worthwhile to let the data speak. This can be done by employing VECM, with long-run restrictions implied by theory, but short-run dynamics allowed to be driven by the data.

The estimated model is used to test hypotheses on the relevance of financial frictions. To separate loan demand and supply is an additional aim to be pursued. The real impact of a loan supply shock is investigated via impulse response analysis. Finally the effect on investment of various tax measures and policy regime changes are also looked into.

[1] VECM models always have a reduced form ARDL representation.

The empirical investment literature is often focused on certain subsets of the economy, mainly manufacturing. Here VECM models are estimated for both the entire non-financial corporate sector and manufacturing industry.

The structure of the paper is as follows. First, the theoretical and empirical literature is summarized. Then the dataset and the methodology are outlined. The results of VECM estimations are reported next. Impulse response analysis is conducted and then I conclude.

2 Literature

The benchmark theory of investment is the basic neo-classical model (Jorgenson, 1963). According to this the investment rate depends on the user cost of capital and expectations concerning future output/investment opportunities.[2] Given the production function, profit maximizing firms decide on the optimal level of capital stock by equating marginal product of capital with the user cost of capital. After solving the optimization problem – ignoring adjustment costs and assuming a constant elasticity of substitution (CES) production function – the optimal level of capital is given by:

$$k_t = \alpha + y_t + \sigma * r_t$$

where k is the natural log of desired capital stock at time t, α captures productivity, y is the log of real output, r is the log of user cost of capital and σ is the constant elasticity of substitution between production factors. The special case of $\sigma = 1$ corresponds to the Cobb-Douglas production function.

Given the optimal level of capital, investment is defined by the capital accumulation identity:

$$K_{t+1} = (1-\delta) * K_t + I_t$$

Re-arranging it we get

$$I_t = (K_{t+1} - K_t) + \delta * K_t$$

where I is gross investment, and δ is the depreciation rate. According to this, investment, likewise optimal capital level, depends on output expectations and the user cost of capital. Since its first formalization (Jorgenson, 1963) the neo-classical model has been reformulated allowing for specific features of investment – convex and non-convex adjustment costs, irreversibility, and uncertainty. For example by adding adjustment costs, Hayashi (1982) showed that the neo-classical model corresponds to the Tobin's Q model of investment under certain assumptions (perfect competition, constant return to scale). Adjustment frictions and the irreversible nature of investment together with uncertainty alter both the steady state level of capital and the dynamics of investment – making it sluggish and lumpy. A more recent breakthrough was the introduction of financial frictions into investment models, which typically involves the inclusion of agency costs due to asymmetric information problems. The presence of agency costs has several implications for aggregate investment, in terms of its dynamics and level: they (1) ceteris paribus reduce investment relative to the frictionless case; (2) amplify the impact of output and interest rate on investment through their impact on wealth and default probability; (3) make variables like wealth, average taxes (not only marginal) and idiosyncratic risk relevant for investment; (4) make the financial system a source of potential shocks for investment (see Romer, 2006).[3]

In general, the **empirical performance** of various **investment models** had been rather disappointing when aggregate data is used. Tests on the Q and the neo-classical model for example found non-feasible parameter estimates, implying very large adjustment costs / low elasticity of substitution[4] – for review see, for example, Caballero (1997), Caballero (2000) and Hubbard and Hassett (2002). In contrast, the flexible accelerator model (explaining investment by output and its lagged changes) and 'empirical' models with financial or liquidity variables proved to perform rather well – although at that time these models lacked rigorous theoretical background.

[2] In empirical studies current and lagged output is found to be a highly significant determinant of investment, supporting the simple accelerator model of investment.

[3] One example of a neo-classical investment model with financial frictions can be found in Cuthbertson and Gasparro (1995).

[4] In addition the user cost elasticity of investment is time and state-varying; and larger when the shocks/changes are large.

The empirical literature which tests the relevance and importance of credit market frictions on spending/investment decisions often employs micro data. Such works exploit the cross-sectional heterogeneity of agents – differences in the severity of asymmetric information problems or liquidity and capital constraints. The literature on **investment cash flow sensitivity** and bank lending channel should be mentioned here. Regarding the former, plenty of evidence has been found concerning the relevance of cash flow – see among many others Baum et al. (2006), Chirinko and Schaller (1995) Fazzari et al. (1988) and Hubbard and Hassett (2002). However it is debated whether the investment cash flow sensitivity is due to credit market frictions – see Cooper and Ejarque (2003), Rajan and Zingales (1998) – which could arise because of many other reasons. Cash flow is suspected to capture current and future profitability and therefore can be correlated with future investment opportunities, which is difficult to control in empirical works. Market power and decreasing return to scale can also explain the significance of cash flow. There is no agreement on this in the literature. Nevertheless the excess sensitivity of firms with more severe asymmetric information problems often found in firm-level analysis does prove the relevance of financial frictions.

As to **lending channel,** some examples are found in Kashyap and Stein (1995), Peek et al. (2003), Gambacorta and Rossi (2007), Greenlaw et al. (2009), Driscoll (2003) and Hülsevig et al. (2002). In the wake of the sub-prime crises more evidence has become available about the importance of banks' balance sheet, especially as a longer time series of the senior loan officer survey has become available. The answers in SLO provide good identification tools for supply factors. Moreover, the responses regarding the causes behind loan supply moves help to separate banks' and firms' balance sheet channel. A recent paper employing this methodology on a country panel is Ciccarelli et al. (2010).

One shortcoming of empirical works using micro data is that although identification and test of loan supply factors is easier, they don't inform us about their aggregate importance.

When **aggregate data** are used to model investment the econometric framework is often VAR or VECM. Here credit market imperfections are captured by including various financial indicators (cash flow, net worth, leverage, profit, External Finance Premium estimates, spreads, etc.) as explanatory variables or instruments. See for example: Carruth et al. (1998), Cuthberston et al. (1995), Diron et al. (2003), Ellis and Price (2003), Brigden and Mizen (1999) and Jaeger (2003). They all find evidence concerning the importance of financial frictions on investment. However, results differ as to whether those frictions affect the long-run level of investment or only its short-run dynamics.

Papers modelling the **loan market** with **aggregate** data often found that loan demand depends on income/output and the cost of borrowing. To capture loan supply, financial indicators of either firms' or banks' balance sheet are used – bank profitability or leverage, spreads, cash flow or financial wealth of companies. Some papers manage to separate loan demand and loan supply in a VECM framework. See, for example, Hülsevig et al. (2002), Calza et al. (2001, 2003), Eickmeier et al. (2009), Gambacorta and Rossi (2007), Kaufmann and Valderrama (2007), Peek et al. (2003) and Sorensen et al. (2009).

Few papers study **investment and loan** market interaction on aggregate data. Examples are Ellis and Price (2003), Brigden and Mizen (1999) and Sorensen et al. (2009). They do confirm the relevance of financial frictions. However, investment is often affected indirectly and/or in the short run only.

Turning to existing **Hungarian results,** Kátay and Wolf (2004) find evidence concerning the significance on investment of user cost and cash flow. They use cash flow as a control variable, but do not aim to test explicitly the importance of financial frictions. The paper of Ádám Reiff (2010) shows that aggregate profitability shocks have a moderate effect on aggregate investment, but the presence of non-convex cost enlarges the response. Horváth et al. (2006) investigated the bank lending channel. Based on their bank panel evidence they cannot rule out supply effects in the Hungarian banking sector.

3 Methodology – VECM

When economic theory suggests – as in the case of investment models – that there exists an equilibrium relationship between integrated variables, cointegration and error correction model provide an efficient estimator to describe short-run dynamics. Beyond these pure econometric reasons cointegration techniques and ECM are especially useful in modelling investment. As Hubbard and Hassett (2002) argues, a number of fundamental variables affecting investment move together over the business cycle. This causes simultaneity problems. Shifts in the investment function (often associated with the business cycle) imply a positive relationship between the user cost and investment, while interest rate shocks cause negative correlation between the two. If the first dominates, user cost elasticity will be small, and accelerator effect (impact of output on investment) large. This problem could be circumvented by focusing on the long-run relationship instead. In addition, ECM allows a rich dynamic representation of the data, which often turns out to be very useful given the sluggish nature of capital stock adjustment and investment.

Given evidence about the long-run equilibrium relationship between integrated variables, the short-run dynamics is captured by the lags of the differenced variables and an equilibrium correcting term. As a result, the following econometric model is estimated:

$$\Delta X_t = \alpha_0 + \Pi \times X_{t-1} + \sum_i c_i \times \Delta X_{t-i} + \varepsilon_t$$

where $\Pi = \alpha \times \beta$,

β: are the cointegrating vectors, $\beta \times X_{t-1}$ captures the long-run relationships (cointegration equations)

α: contains the loading parameters, they give the speed of adjustment to the long-run relationship

X: are endogenous variables

In this paper Johansen's methodology is followed, as this allows for multiple cointegration. There is no need to pre-test unit root, as cointegration test results inform us about the (co)integration properties: if zero cointegrating relationship is found, X are I(1), but not cointegrated. If Π is full rank, then the model corresponds to a stationary VAR. The first step is to estimate unconditional VAR models to decide about the lag length, based on the autocorrelation of error terms. The decision concerning lag length is a crucial input of the cointegration test. Given the lag length of VAR, cointegration tests are run in the second step. In the third step full VECM is estimated. Restrictions on the long-run beta parameters and weak exogeneity are tested. Diagnostic tests are evaluated (autocorrelation, normality of residuals, stationarity of CE residuals, stability of CI test result) and the stability of the long-run parameter estimates is also examined. Then the estimated parameters are interpreted. Robustness of the results is checked by alternative cost variables and loan stock definition (long or total loans). Finally, impulse response analysis is conducted.

As an alternative, dynamic OLS is also used to estimate long-run relationship. Dynamic OLS estimates the link between level variables, but adding leads and lags of the differenced regressor. This can remedy the problem of static OLS, which tends to produce a biased estimate for the investment equation because of the adjustment frictions typical in investment (see Stock and Watson, 1993). Small sample bias is also reduced if leads and lags of the differenced explanatory variables are included in the model.

4 Data

Real, seasonally adjusted data, expressed in natural logarithm are used in the analysis – except the cost variables, which are expressed in percentage points. The time period covered is 1997 Q1–2008 Q4.

Investment is defined as real business fixed investment. Manufacturing and the non-financial corporate sector (excluding fiscal industries, the financial sector and real estate) are analyzed.

Gross value added is at 2000 prices. The data is derived from the production of GDP table, and always corresponds to the definition of investment (manufacturing, non-financial corporate sector).

Real loans. Loans for investment purpose cannot be distinguished in our dataset, only the original maturity is known. Firms are expected to take long-term loans to finance investment. However, there are times and type of firms (typically smaller, new firms) to whom banks are reluctant to provide long-term finance. Therefore short loans can act as substitutes for long loans. Some papers did find a substitution effect between short and long loans (see Anderson and Carverhill, 2007). Therefore both total and long loans are experimented with. Total loans are preferred, as we want to investigate loan supply shocks.

In Hungary around two-thirds of the corporate loan stock is denominated in foreign currency, and more than 40% of this stock is raised abroad. Since the industrial composition of loans is available only for domestically raised loans, this is used in the estimation. This is acceptable if the loan stock raised abroad and from domestic banks show a similar pattern – which is confirmed at aggregate level: the total loans (foreign and domestic) strongly co-move with the domestic loans stock (see Chart 7-2 in the Appendix).

To get real loan stock, the GDP deflator is employed.

Cost of investment: ideally real user cost of capital is used. As no estimate for user cost of capital is available for Hungary, it is replaced by the **cost of borrowing** variable. Two variants are used.

– Cl: based on actual borrowing costs reported by Hungarian banks. First I take the loan stock weighted average of the HUF and Euro borrowing cost.[5] To get effective cost for foreign currency loans one needs to control for the change in foreign exchange rate. However as long as nominal loans are used as weights, this impact is already included.

– rir: based on long-run (5-year) benchmark HUF and Euro yields instead of actual borrowing rates.

The nominal borrowing cost is deflated in the following way: Given a period of high inflation in Hungary, the current inflation rate was not a good proxy of inflation expectations on the longer horizon. Therefore, in the first part of the estimation period the average of observed cpi inflation over the subsequent 5 years is used as deflator. With the introduction of inflation targeting (2001 Q2), the forecast of the MNB is assumed to be accepted by market agents. Beyond the forecasting period, expectation is approximated by the actual inflation target.

[5] Unfortunately borrowing costs for Euro loans are available only from 2004, therefore the series was extended by using 5y Euro benchmark yield plus an average margin (observed in 2005–2008) on Euro loans.

Balance sheet effects might be captured by aggregate measures of financial conditions of firms. To do that **cash flow** (gross operational surplus) is calculated in the following way: total employment compensation of a given industry is deducted from its value added. In Hungary foreign ownership of firms is significant and in recent years Hungarian firms have expanded their activity abroad as well. Therefore to calculate internal sources available for financing, the net outflow of dividends is also deducted from cash flow.

There are opposing views on the direction of the impact of cash flow on the loan decision. As to the demand side, according to the pecking order theory firms prefer financing from internal retained earnings, which is followed by external debt, while raising new equity comes last. Therefore larger cash flow may imply lower loan demand. On the other hand, to the extent that cash flow acts as a good indicator of future profitability and investment prospects, a positive correlation is expected between cash flow and loan demand. As such, increasing cash flow may raise loan demand. The sign of the net effect of the two is ambiguous. As to the supply side, given financial frictions, banks are more willing to give loans when cash flow is larger (the loan supply curve shifts to the right).

As to investment, irrespective of what cash flow captures, a positive correlation between the two is expected.

Lending channel (or banks' balance sheet) effects are usually captured by profitability, liquidity or capital position of the banking sector, lending standards and interest margin. Unfortunately in Hungary the half-yearly Senior Loan Officer survey was launched only in 2003, and thus the time series available is short. Capital adequacy ratios of Hungarian banks were well above the regulatory minimum in the period under investigation, and they were not likely to act as an efficient constraint to lending. Therefore the VIX index is used to indicate the movements in risk appetite. As Hungary have been relying heavily on external funds – in the first half of the 90s through FDI, later primarily through the banking sector – the risk appetite of international investors is likely to influence the availability or price of external funds and as such the supply of loans.[6] The presence of foreign bank holding groups reinforces this link. Nevertheless VIX effects real activity not only through its impact on banks' financing cost but also through the cost of capital of non-financial firms.

[6] A corrected margin between banks' lending and 'borrowing' rate was also used to capture the impact of banks' balance sheet on loan supply. However, estimation with the margin variable did not yield consistent and robust models.

5 Estimation results

To test the presence of financial frictions two indicators (cash flow and the VIX index) were experimented with. First, models which control for firms' balance sheet effects are reported.

5.1 ESTIMATION RESULTS – CASH FLOW MODELS

5.1.1 Unconditional VAR and cointegration test

In the unconditional VAR estimation 2 lags are needed to have uncorrelated errors.[7] The rank test indicates the presence of 3 cointegrating relationships between investment, GDP, borrowing cost and cash flow. As to the deterministic trend, a constant in both VAR and the cointegrating relationship was assumed.

5.1.2 Long-run relationship

After applying and testing theoretically reasonable normalizations and zero restrictions on the long-run beta parameters, the parameters reported in Table 5-2 describes the long-run relationships. The first renders a reduced form investment equation, where investment depends on output and the borrowing cost – which replaces the user cost of capital here. The parameter of output is allowed to be restricted to −1, which is evidence of constant return to scale.

The cost of borrowing parameter has the expected sign. The user cost sensitivity corresponds to the elasticity of substitution in the production function. The highest estimate of user cost elasticity for open economies is around −1.6 (for Canada see Schaller, 2006). As the cost variable used here is expressed in percentage point, 1 unit change in value corresponds to a change of about 30%. Therefore a −1.6 elasticity would imply a beta parameter of −0.48 in our model. This should be lowered, as several components of the user cost of capital are ignored here (e.g. depreciation, taxes). According to a rough estimate a 1% change in real interest rate translates into about 0.25% change in the user cost,[8] implying a −0.12 parameter. Thus our estimate is rather larger than expected but not out of range. Nevertheless the parameter estimate, although has the correct sign, is not robust to restrictions on other (alpha and beta) parameters or alternative model specifications.

Table 5-1
Result of the CI test (Rank test)

Trend assumption: Linear deterministic trend

Lags interval (in first differences): 1 to 1

No. of CE(s)	Statistic	Critical Value	Prob.**
None *	81.05	65.82	0.005
At most 1 *	50.85	44.49	0.026
At most 2 *	29.29	27.07	0.057
At most 3	13.33	13.43	0.103

[7] The error terms are not skewed but have excess kurtosis – however, this deviation from normality is less a problem regarding the robustness of cointegration tests (see Ellis and Price, 2003).

[8] Taking the average of our real interest rate variable (3.5), assuming a depreciation rate of 6% and a constant risk premium of 6%, we get a 4:1 multiplier between the real interest rate and the user cost.

Table 5-2
Long-run parameters
(standard errors in brackets)

	CointEq1	CointEq2	CointEq3
Inv(−1)	1	0	0
Loan(−1)	0	1	1
GDP(−1)	−1	−0.908 (0.066)	0
CI(−1)	0.194 (0.042)	0.138 (0.032)	0.105 (0.025)
Cash flow(−1)	0	0	−0.743 (0.067)

The cash flow term is not significant in the investment equation. However, investment depends on cash flow indirectly, through the loan market.[9] In addition, deviations from the long-run loan equilibrium impact the short-term dynamics of investment (see Table 5-3).

The second cointegrating equation can be interpreted as a loan demand relationship, where loan demand depends on income/output and borrowing cost. The third cointegrating equation links loans to the borrowing cost and cash flow. The significant positive parameter of cash flow can be interpreted such that the larger the cash flow, the more willing banks are to provide loans. In this sense, the third CE is a kind of loan supply equation and describes the firms' balance sheet/financial accelerator effect. Nevertheless we cannot exclude that the cash flow term could also depict future profitability and related investment and loan demand. As such, the parameter rather captures the net demand/supply effect. The sign of the borrowing cost in the supply equation is not intuitive. One reason could be the dominance of demand shocks during the estimation period.

The estimated system thus defines two behavioural equations: loan demand and loan supply. The third one is a reduced form investment equation. Given that the real borrowing cost is a stationary variable, this claims that the investment ratio is constant in the long run. Adding investment to the system allows us to investigate the dynamic relationship between investment and the loan market.

5.1.3 Short-run dynamics

In the cash flow model the loading parameters suggest the existence of equilibrium-correcting mechanisms.

Table 5-3
Short-run dynamics
(standard errors in brackets)

	d(Inv)	d(Loan)	d(GDP)	d(CI)	d(Cash flow)
CointEq1	−0.299 (0.123)	0.154 (0.099)	0.015 (0.028)	−3.356 (1.255)	0.128 (0.097)
CointEq2	0.705 (0.240)	−0.022 (0.194)	−0.007 (0.055)	1.612 (2.449)	−0.403 (0.190)
CointEq3	−0.500 (0.188)	−0.350 (0.152)	−0.073 (0.043)	0.503 (1.924)	0.145 (0.149)

[9] If solely investment is modelled but not loans, cash flow becomes significant in the long-run relationship.

The loan stock adjusts to revert back to its own equilibrium. In the case of the investment equation investment does the job of equilibrium correction. In the d(investment) equation the loadings of the two loan equations (CE2 and CE3) are also significant. Excess borrowing causes investment to slow down/increase, depending on whether that is due to excess supply or demand. Some of the other significant loadings are also sensible. For example, the loading of the first CE is negative in the d(cost) equation. Larger investment implies that optimal capital is larger than actual (K*>K). However increasing capital will lower the MPC and thus the cost of capital.

Weak exogeneity is rejected for all the variables. Therefore none of the variables are dropped from the conditional VECM estimation.

5.1.4 Deviations from the long-run equilibrium

The error terms of the long-run equations were investigated to see whether there were any significant or long-lasting deviations resulting in over/underinvestment or debt overhang. We also wanted to see whether those deviations are in line with our previous knowledge about investment and loan developments.

There were large but short-lived deviations from loan demand equilibrium during the period of frequent monetary policy shocks in the turbulent time of 2002–2003 (attack on the HUF at the strong end of the intervention band at the end of 2002, widening of the band in June 2003 and the impact of the Argentine crisis). Due to the deteriorating fundamentals (falling GDP and cash flow, increased risk premium and borrowing cost) and the sluggish adjustment of loans stock at the very end of 2008, the loan stock got well above the long-run equilibrium level defined by our model.

As for investment, the model suggests signs of underinvestment around 2006. The puzzling decline in investment in 2006 relative to development in output was documented in Gál (2007). This coincided with a large dividend outflow (reflected in the development of cash flow as well). At that time the weak fundamentals of the Hungarian economy, external imbalances, fiscal deficit and indebtedness increased the likelihood of a fiscal consolidation. The adjustment programme was announced only at the end of 2006, but the worsening expectations and increased uncertainty might have had a strong impact on both the investment and dividend decisions of companies beforehand.

In a simple exercise I tested whether various policy and tax changes have any impact on investment. The question to be answered was whether changes in the tax system or monetary policy regime affect the deviation of investment from its long-run equilibrium. To do that the residuals of the 1st cointegration equation were regressed on the following dummy variables:

Chart 5-1
Error terms of the cointegrating equations

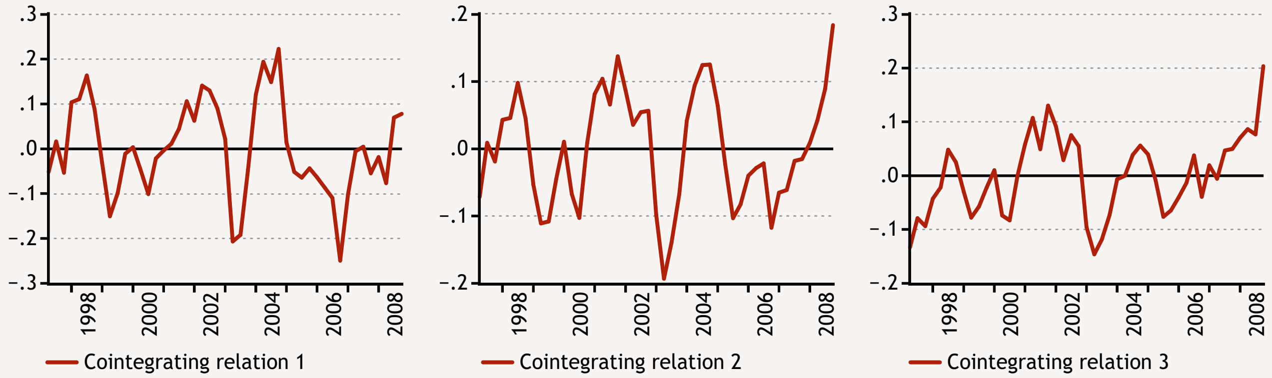


Table 5-4
Investment's deviation from long-run equilibrium level regressed on tax dummies

Variable	Manufacturing	Non-financial Corporate Sector
D_CIT	0.503***	0.399***
D_ITC1	0.086	−0.017
D_ITC2	−0.148**	−0.291***
D_PIT	−0.388***	−0.343***
D_2006	0.0827	0.050
D_IT	0.113**	0.126**

*Significance levels are indicated as follows: p=1%:***; p=5%:**; p=10%:**

D_IT: inflation targeting regime
D_ITC: various investment tax credit regimes
D_CIT: lower corporate income tax regime
D_2006: fiscal adjustment from 2006, including various tax measures
D_PIT: change in personal income taxation and the introduction of capital gain tax

The results are very similar for the non-financial corporate sector and manufacturing – both are reported here – and are all in line with suggestions of economic theory (see Hubbard and Hassett, 2002). The lowering of the corporate income tax rate increased investment. The introduction of inflation targeting had a smaller but positive impact on investment. On the other hand, the introduction of a more stringent investment tax credit regime (d_itc2), changes in personal income taxation and the introduction of capital gain tax have lowered investment.

5.1.5 Diagnostics

Looking at the error term of each cointegrating equation, the stationarity of the first two are supported, but that of the third one is questioned (see Chart 5-1). These results are confirmed by unit root tests as well. Based on KPSS test the stationarity of the long-run residuals is rejected only for the third CE and only at a 10% level. ADF and PP tests confirm this result.

Table 5-5
Results of the residual serial correlation LM test and the AR root test

Included observations: 47			Modulus
Lags	Probability		1
1	0.82		1
2	0.81		0.897
3	0.30		0.780
4	0.86		0.800
5	0.49		0.375
6	0.65		0.375
7	0.48		0.207
8	0.51		0.152
			0.152

The models are well specified in the sense that there is no serial correlation in the error terms and normality cannot be rejected. According to the AR root tests,[10] the estimated VECM is stable.

The stability of long-run parameters is investigated by looking at the recursive dynamic OLS estimates. As an alternative estimation method they provide a robustness check as well. Because of the relatively short sample only 2 leads and lags are used. The long-run parameter of cash flow in the loan equation is declining over time, which could be a sign of easing liquidity constraints. There is other evidence of this.[11] The instability of the parameter estimate might explain the rejection of stationarity of errors in the 3rd cointegrating equation (see above). In contrast, the sensitivity of loans to GDP is fairly stable with a narrowing confidence band, and is very close to the VECM parameter estimate. The parameter of borrowing cost is much smaller than the VECM estimate, and its confidence band remains wide.

Chart 5-2
Recursive dynamic OLS estimates of the parameters in the loan equation(s)

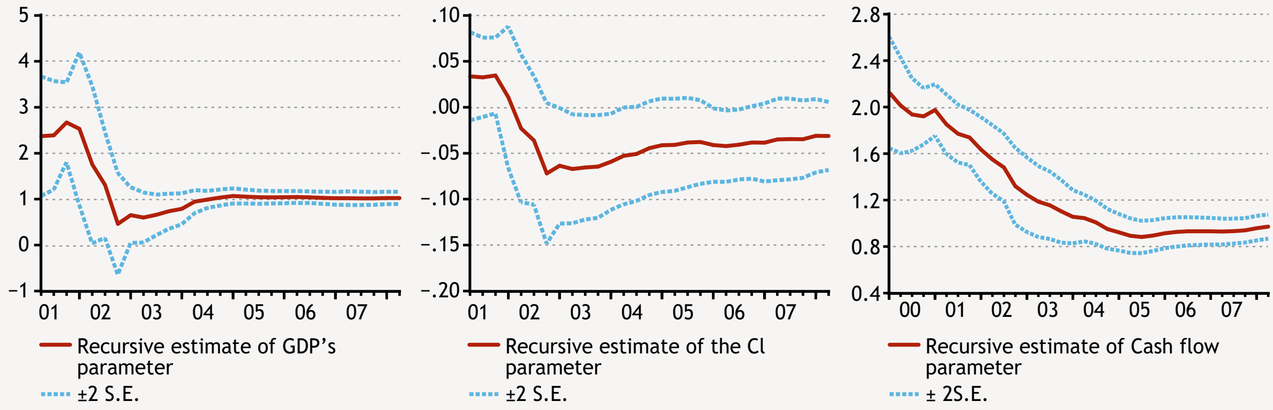
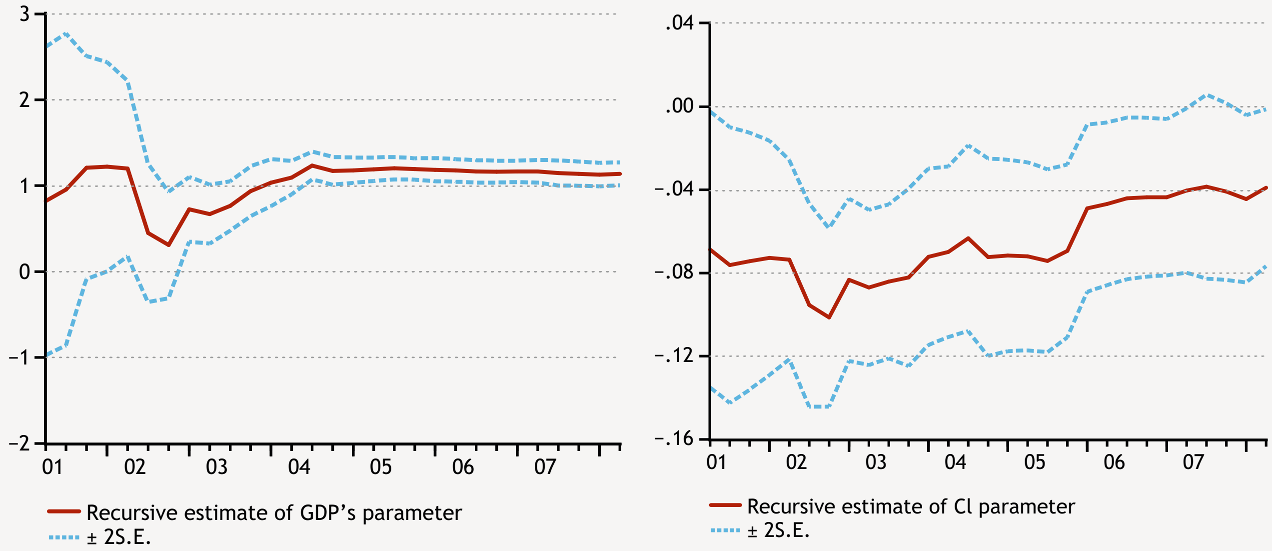


Chart 5-3
Recursive dynamic OLS estimate of the investment equation



[10] Stability is confirmed, if k−r modulus equals 1, and the rest lies within the unit circle – where k and r are the number of endogenous variables and cointegrating relationships respectively.

[11] During that period the share of long-term loans in the Hungarian banks' corporate loan portfolio increased from 34% to 53%. Moreover SMEs got easier access to bank loans – the number of SMEs having bank loan more than doubled in the 2000s. See MNB (2010), Box 3-3.

The dynamic OLS results for the investment equation reveal that the sensitivity to the cost variable is slightly declining over time, although its confidence band remains high. With easing credit constraints one would expect the interest rate sensitivity to rise, which is not observed in the data. The sensitivity to GDP is rather stable. The parameter estimates are close to those found in the VECM model for output, but smaller in the case of borrowing cost. As mentioned earlier, the elasticity of substitution estimates were also sensitive to various VECM model specifications and normalizations.

5.1.6 Robustness of the results

Robustness of the VECM estimation results was further checked by estimating the cash flow model with an alternative cost variable (bond yields instead of lending rates) and with long loans instead of total loans. The results are similar (some of them are reported in the Appendix), both in a quantitative and qualitative sense. In all cases 3 cointegrating relationships are found, loan supply and demand can be separated, and the long-run parameter estimates are intuitive. Evidence on liquidity constraint is found, as cash flow determines loan supply in the long run.

For manufacturing results are less robust. Intuitive models and cointegration are found only for long but not for total loans. In the case of manufacturing, in contrast to the non-financial corporate sector, output and cash flow cannot be included in the model at the same time. The presence of one makes the other insignificant. As a result, no indication of balance sheet effects is found. This might imply that balance sheet effects are less severe in manufacturing, for example due to access to foreign mother companies' funds or loans from banks abroad. However, it could also be a result of data problems (some of the variables like borrowing cost are not sector-specific, in addition the use of domestic-loans-only could distort the analysis).

The inability to establish significant balance sheet effect means that it is not possible to separate loan demand and supply either. Nevertheless a 2 equation VECM with no financial frictions was estimated for manufacturing – results are reported in the Appendix.

5.1.7 Impulse response analysis

To investigate the potential impact of a loan supply shock, impulse response analysis is conducted. Cholesky decomposition with the following ordering is employed: Investment, GDP, Cash flow, Loan, Borrowing cost.

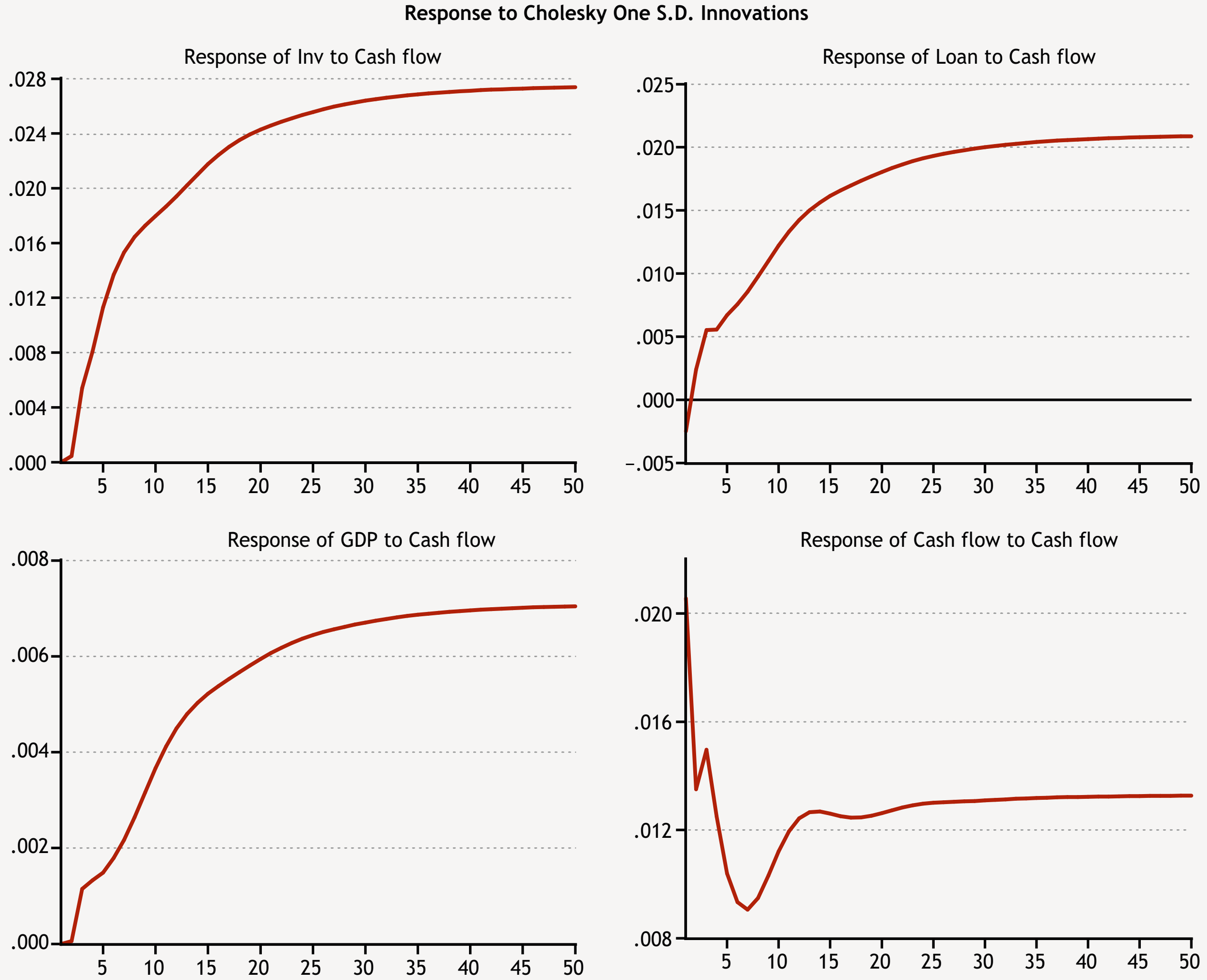
One of the challenges here is whether we can identify a pure loan supply shock. The shock to cash flow is interpreted as a loan supply shock; however, we know that cash flow can be a contaminated variable – it captures balance sheet effects but also could act as an indicator of future profitability. It may therefore reflect both supply and demand of loans.

Impulse responses to 1 standard deviation shock to the cash flow are reported. It takes the shocks about 4-5 years to die out and their impact to reach the maxima. As expected, a positive shock to cash flow increases loan stock, output and investment.

We interpret the cash flow shock as a loan supply shock. The multiplier between loan and GDP is calculated based on their IRFs. This multiplier measures the impact of a loan squeeze on GDP. Based on the above reported Cholesky IRFs, at medium horizon (3-5 years) the multiplier is around 0.2-0.3, i.e. a 10% change in corporate loan supply corresponds to 2-3% change in non-financial corporate sector GDP.[12] This is larger than that found by other studies, such as Cihak and Brooks (2009). They estimated a 0.1 multiplier for EU countries on a two-year horizon. However, their calculation is based on total (including household) loans and GDP. The difference can also be attributed to differences in methodology (to what extent we are able to identify loan supply shock), in the importance of financial frictions and bank intermediation.

[12] Depending on the ordering of the variables, the multiplier varies in a wider range.

Chart 5-4
Effect of a loan supply shock



5.2 ESTIMATION RESULTS – MODEL WITH VIX

To capture the lending channel, VIX as an indicator of risk appetite and as such, an important loan supply factor is added to the model.

Table 5-6
Result of the CI test (Rank test)

Trend assumption: Linear deterministic trend

Lags interval (in first differences): 1 to 2

No. of CE(s)	Statistic	Critical Value	Prob.**
None *	81.43	65.82	0.005
At most 1 *	46.20	44.49	0.071
At most 2	19.31	27.07	0.470
At most 3	4.51	13.43	0.859

Two cointegrating relationships are found by the trace test. As we expect to have 3 equilibrium relationships between the variables, 3 cointegrating relationships were imposed instead. A model with 2 CE is estimated as well (details can be found in the Appendix). Regarding the impact of a loan supply shock, the two models yield very similar results.

When 3 cointegration equations are assumed, the first one is interpreted as a reduced-form investment equation. The elasticity of substitution estimate is much smaller than in the alternative, cash flow model. That just confirms the uncertainty already observed regarding the stability of this parameter. The second and third long-run equations correspond to a loan demand and supply equation, where the cost of borrowing has negative/positive impact respectively. The VIX appears in the supply equation with a negative sign, implying that a worsening risk sentiment lowers the supply of loans. Changes in investors' risk appetite has a significant impact on the loan stock; 1 unit increase in the index in the long run (about 5% change) implies a 2.5% decrease in the loan stock.

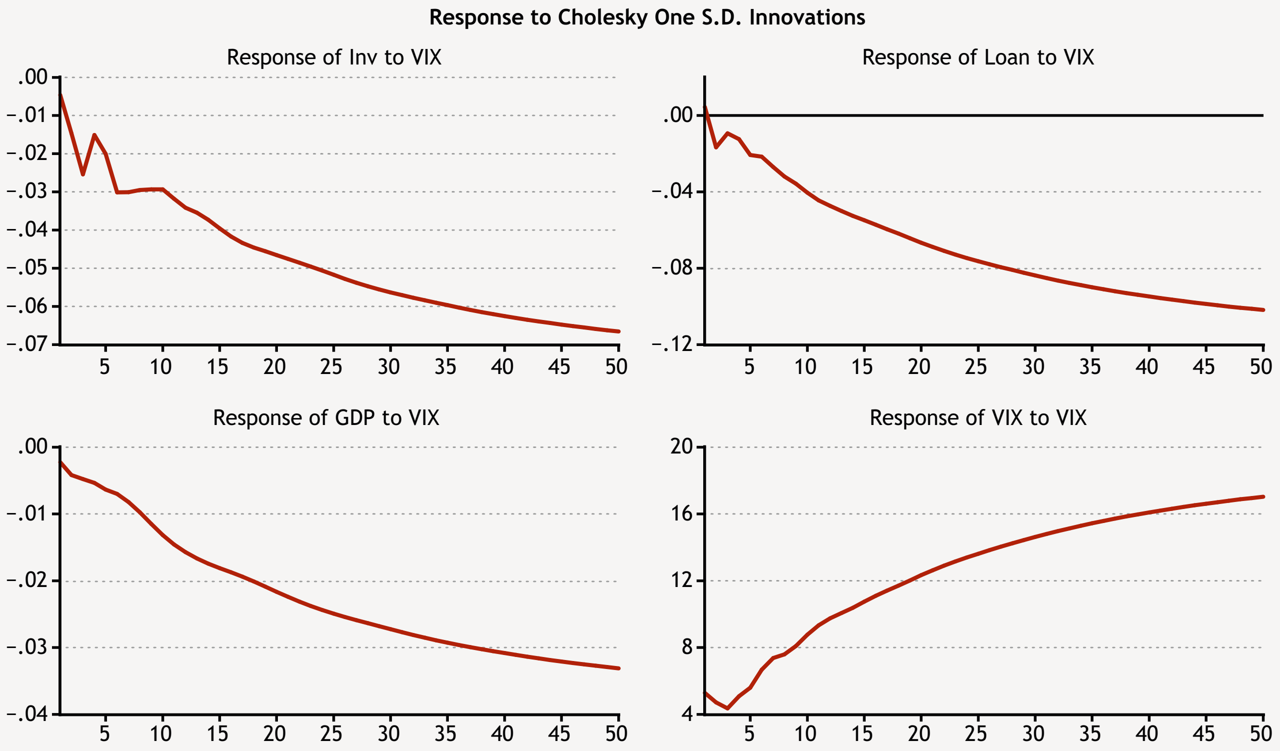
The weak exogeneity of VIX cannot be ruled out, therefore its loadings are restricted to zero.

The model is stable and has nice diagnostics (not reported). The impulse responses to a one standard deviation shock in VIX are displayed in Chart 5-5. The ordering used is: VIX, Investment, GDP, Loan, Borrowing cost. On a 3-5 year horizon the multiplier between GDP and the loan stock is about 1 to 3, implying that a 10% decrease in the loan stock due to a supply shock lowers GDP by about 3.3%. The result is somewhat larger than in the cash flow model; however, sensitivity to the ordering of the variables impedes comparison.

Table 5-7
VECM estimation result

Sample (adjusted): 1997 Q3–2008 Q4					
Standard errors in brackets					
Chi-square(2): 5.222		Probability: 0.265			
Cointegrating Eq:	**CointEq1**	**CointEq2**	**CointEq2**		
Inv(−1)	1	0	0		
Loan(−1)	0	1	1		
GDP(−1)	−1	−0.800 (0.103)	0		
CL(−1)	0.032 (0.018)	0.073 (0.032)	−0.323 (0.071)		
VIX(−1)	0	0	0.026 (0.006)		
Error Correction:	**D(Inv)**	**D(Loan)**	**D(GDP)**	**D(CL)**	**D(VIX)**
CointEq1	−0.545 (0.153)	0.211 (0.138)	0.054 (0.039)	−4.637 (1.566)	0
CointEq2	0.060 (0.120)	−0.284 (0.108)	−0.088 (0.031)	1.071 (1.224)	0
CointEq3	−0.061 (0.029)	−0.284 (0.026)	−0.003 (0.007)	1.394 (0.295)	0
R-squared	0.530	0.405	0.331	0.595	0.501
Adj. R-squared	0.340	0.163	−0.059	0.431	0.300

Chart 5-5
Impulse response analysis – supply shock



6 Conclusion

The aim of this paper was to model the short and long-run behaviour of aggregate investment in a VECM framework. In particular, I wanted to test the significance of financial frictions and to separate the demand and supply for loans. Calculations were made for the non-financial corporate sector and for manufacturing industry.

For the non-financial corporate sector a VECM with 3 cointegrating relationships was estimated, each of those could be interpreted as an investment, a loan demand and a loan supply equation. In the long run investment depends on the cost of borrowing (here replacing the user cost of capital) and output. Loan demand is driven by the cost of borrowing and income. Loan supply is determined by cash flow, evidencing the balance sheet effect on the loan market. Financial frictions affect investment through the loan market; in addition there is short-term interaction between 'disequilibrium' on the loan market and investment. For manufacturing no evidence was found concerning balance sheet effects and a VECM with 2 cointegrating equations was estimated. This failure to establish balance sheet effects could be simply due to data problems. However, manufacturing is likely to be less exposed to frictions because of manufacturing firms' access to alternative sources of finance – through their foreign parent and bank relationships.

Estimation results are robust to alternative model specifications (cost variables and loan categories) for the non-financial corporate sector, but less so for manufacturing industry. The long-run parameter estimates are intuitive, although the elasticity of substitution estimate is less robust. Recursive parameter estimates show that the long-run parameters are fairly stable, except that of the cash flow term. The declining influence of cash flow could be a sign of easing liquidity constraints.

Looking at the deviation of investment and loan from its long-run level (implied by the model) some interesting findings emerged. In 2006 investment fell below its long-run equilibrium. The most likely underlying reason is the increased uncertainty because of the anticipated fiscal consolidation. The deviation of investment from its long-run equilibrium was regressed on various tax and policy regime dummies. According to the results investment levels benefited from the introduction of inflation targeting and lower corporate income taxes. While a more stringent investment tax credit regime, in effect after 2002, and the introduction of capital gain tax lowered investment.

The significance of the cash flow variable is taken as evidence of financial frictions; however, one should add that this variable is contaminated and is suspect to capture some loan demand effects as well.

According to the impulse responses, a loan supply shock – captured by innovation to the cash flow – lowers output. There is some uncertainty regarding the magnitude of this effect.

As to the lending channel effect, captured by the VIX index, the estimated model confirms the importance of banks' balance sheet channel. The increase in the VIX reflecting decreasing risk appetite lowers the supply of loans, and through that has consequences for real activity. The multiplier between GDP and loan is of similar magnitude as in the case of the cash flow model.

There are many potential avenues of development. One is taking non-linearity and potential regime changes into account. However, given the relatively short time series available, these improvements may be pursued in a different setting, for example when country panel data are used.

Appendix

Chart 7-1
Variables used in the estimation

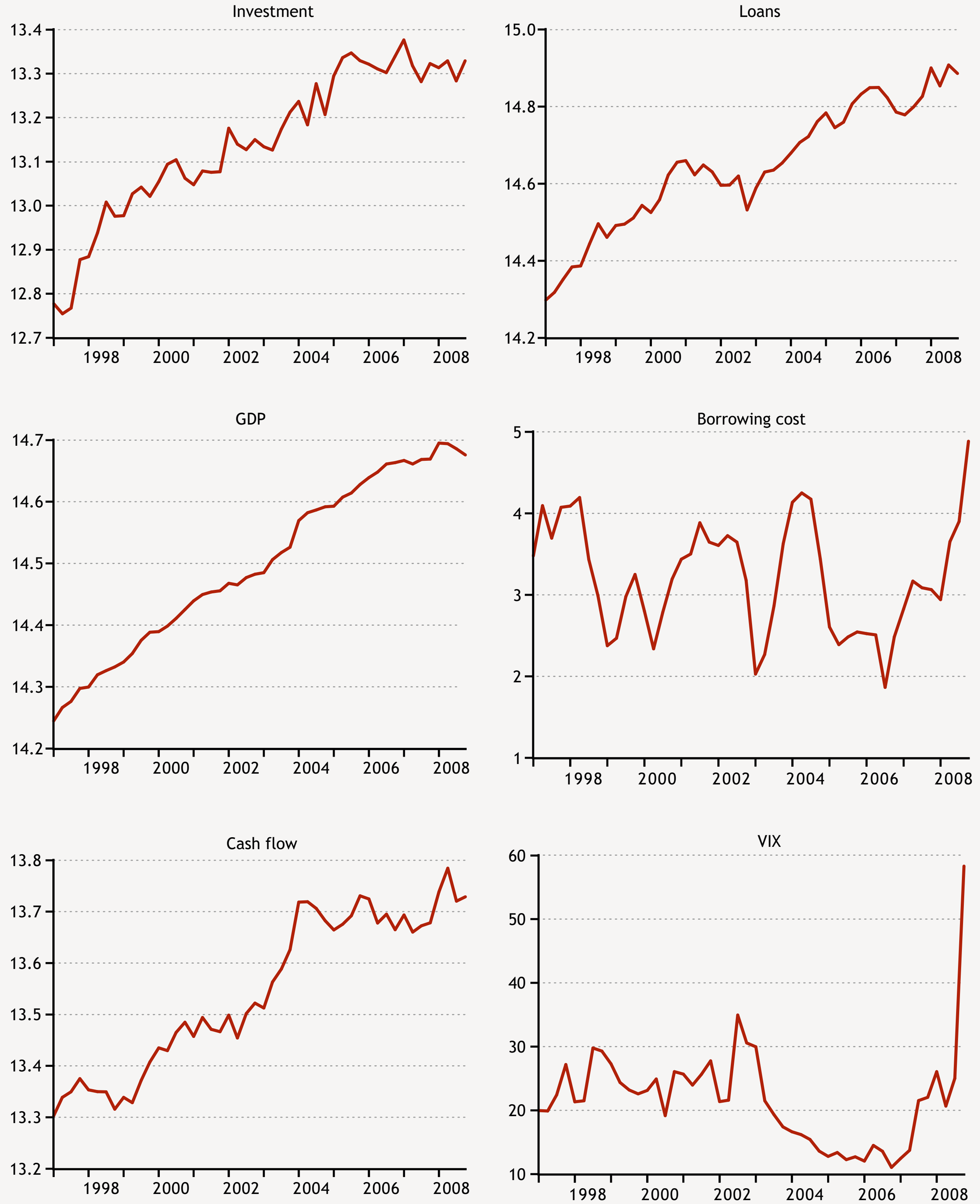


Chart 7-2
Domestic bank loans and the total stock of loans (yoy log changes)

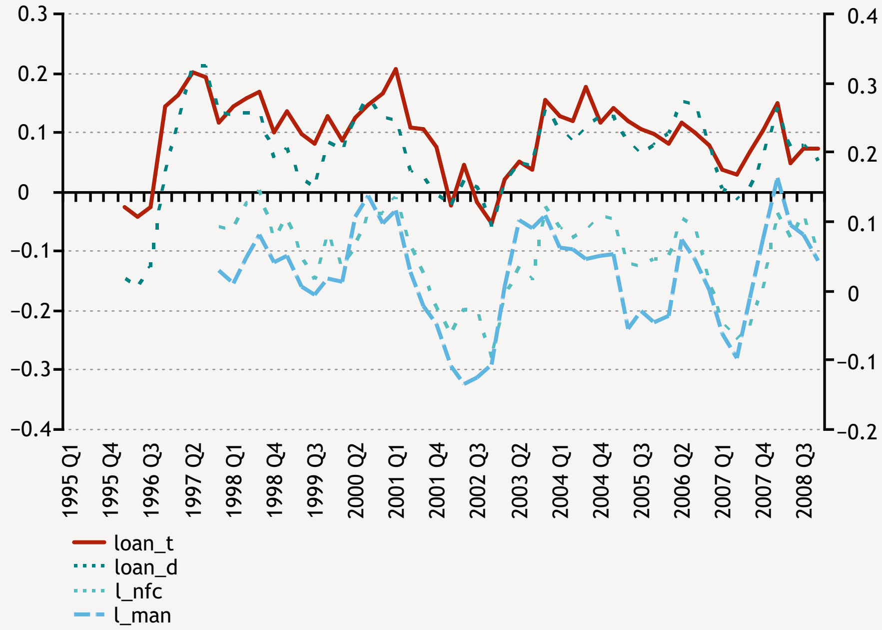


Table 7-1
Long and short-run parameters of the model with an alternative cost variable (yields)

Cointegrating Eq:	**CointEq1**	**CointEq2**	**CointEq3**		
Inv(−1)	1	0	0		
Loan(−1)	0	1	1		
GDP(−1)	−2.073 (0.281)	−1.610 (0.182)	0		
RIR(−1)	0.281 (0.056)	0.178 (0.037)	0		
Cash flow(−1)	0	0	−0.793 (0.084)		
Error Correction:	**D(Inv)**	**D(Loan)**	**D(GDP)**	**D(RIR)**	**D(Cash flow)**
CointEq1	−0.400 (0.124)	0.114 (0.105)	0.039 (0.031)	−3.260 (1.360)	0.185 (0.104)
CointEq2	0.558 (0.183)	−0.239 (0.155)	−0.072 (0.046)	2.237 (2.001)	−0.373 (0.153)
CointEq3	−0.4374 (0.120)	−0.181 (0.102)	−0.012 (0.030)	−1.422 (1.320)	0.134 (0.101)
R-squared	0.394	0.330	0.206	0.4513	0.257
Adj. R-squared	0.263	0.185	0.034	0.333	0.096

Table 7-2
Long and short-run parameters of the model with long loans

Included observations: 47					
Standard errors in brackets					
Cointegrating Eq:	**CointEq1**	**CointEq2**	**CointEq3**		
Inv(−1)	1	−1.284 (0.084)	0		
Long Loans(−1)	0	1	1		
GDP(−1)	−1	0	0		
Cl(−1)	0.032 (0.009)	0	0		
Cash flow(−1)	0	0	−1.006 (0.098)		
Error Correction:	**D(Inv)**	**D(LongL)**	**D(GDP)**	**D(CL)**	**D(Cash flow)**
CointEq1	−0.353 (0.175)	0.349 (0.252)	0.010 (0.052)	−7.784 (2.072)	−0.271 (0.168)
CointEq2	0.270 (0.123)	−0.136 (0.177)	−0.017 (0.036)	−2.442 (1.458)	−0.250 (0.119)
CointEq3	−0.112 (0.090)	−0.221 (0.129)	−0.005 (0.026)	3.445 (1.062)	0.180 (0.086)
R-squared	0.479	0.395	0.095	0.411	0.161
Adj. R-squared	0.369	0.267	−0.095	0.286	−0.016

VECM RESULTS FOR MANUFACTURING

Table 7-3
Result of CI test (Rank test)

Trend assumption: Linear deterministic trend			
Lags interval (in first differences): 1 to 1			
No. of CE(s)	**Trace Statistic**	**0.05 Critical Value**	**Prob.****
None *	60.136	47.856	0.002
At most 1 *	32.593	29.797	0.023
At most 2	13.294	15.495	0.104
At most 3 *	4.0315	3.841	0.045

Chart 7-3
Deviations from the long run equilibrium (CE errors)

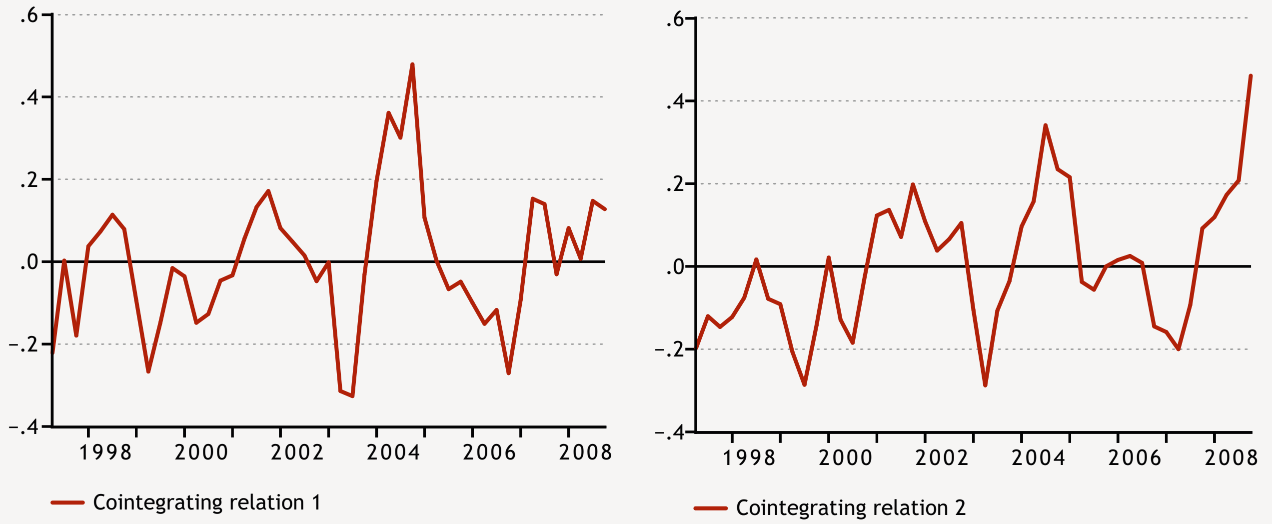


Table 7-4
VECM estimation results for manufacturing

Cointegrating Eq:	CointEq1	CointEq2		
Inv(−1)	1	−0.542 (0.115)		
Long Loan(−1)	0	1		
GDP(−1)	−0.444 (0.176)	0		
CI(−1)	0.176 (0.035)	0.186 (0.035)		
Error Correction:	**D(Inv)**	**D(Long Loan)**	**D(GDP)**	**D(CI)**
CointEq1	−0.338 (0.119)	0.202 (0.088)	0.017 (0.016)	−1.620 (0.628)
CointEq2	0.313 (0.159)	−0.336 (0.117)	−0.065 (0.022)	0.046 (0.837)
R-squared	0.327	0.215	0.630	0.302
Adj. R-squared	0.226	0.100	0.574	0.197

Chart 7-4
Parameter stability of the long-run loan equation

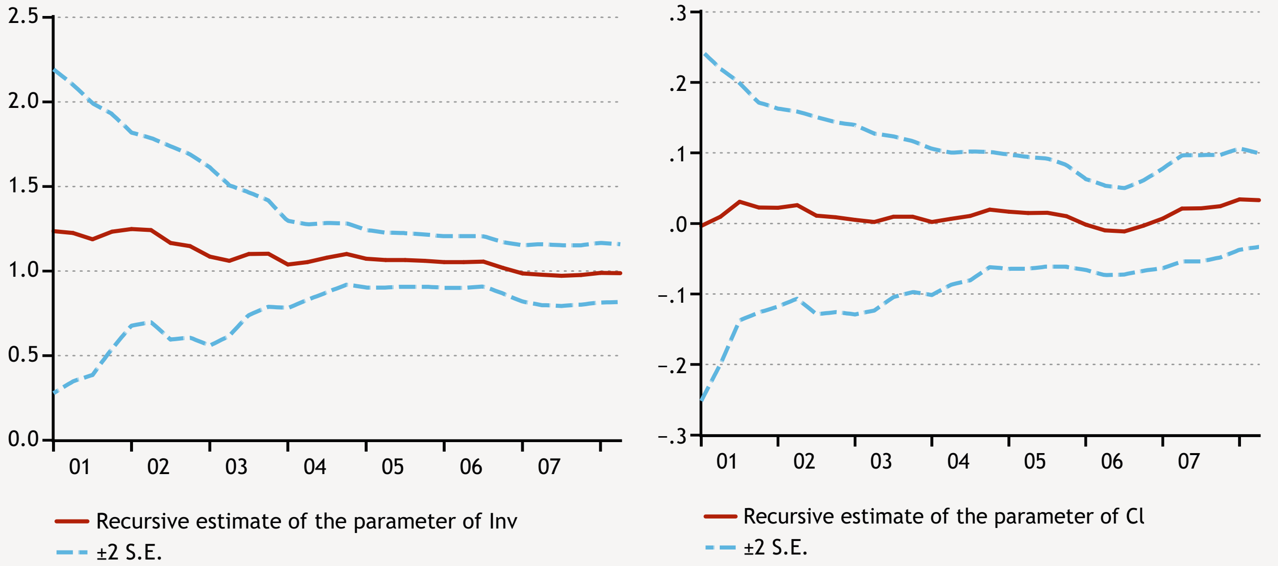


Chart 7-5
Parameter stability of the long-run investment equation

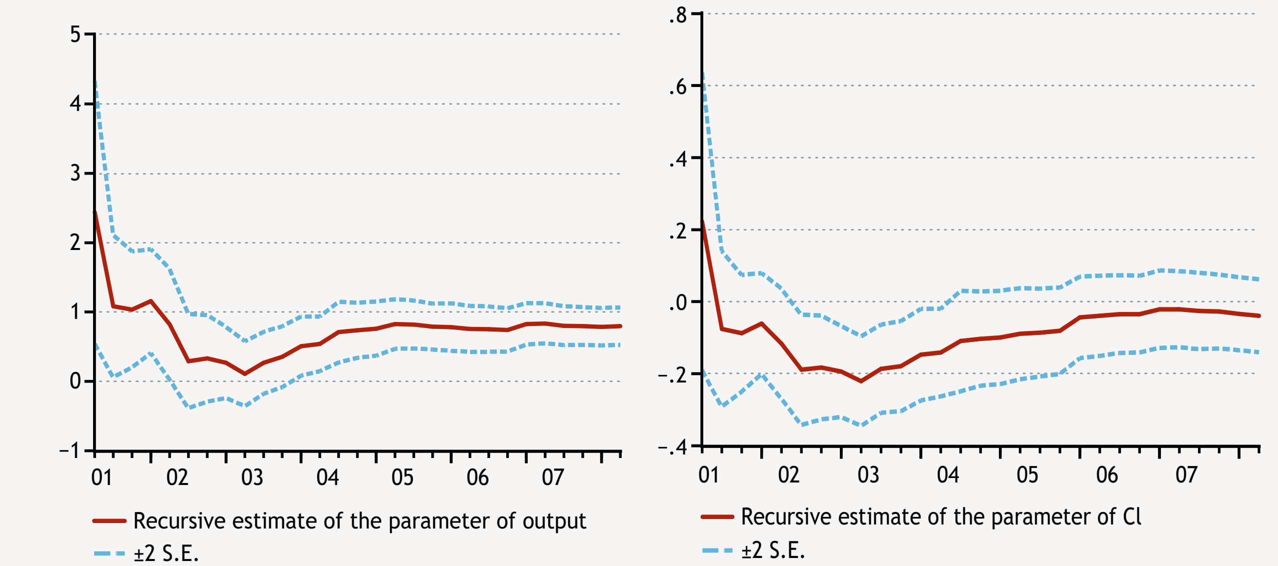


Table 7-5
VECM estimation results for the VIX model, when 2 CE are assumed

Sample (adjusted): 1997 Q3–2008 Q4					
Standard errors in brackets					
Chi-square(2): 3.664		Probability: 0.161			
Cointegrating Eq:	**CointEq1**	**CointEq2**			
Inv(−1)	1	0			
Loan(−1)	0	1			
GDP(−1)	−1	−0.414 (0.156)			
CL(−1)	0.029 (0.017)	−0.090 (0.030)			
VIX(−1)	0	0.012 (0.003)			
Error Correction:	**D(Inv)**	**D(Loan)**	**D(GDP)**	**D(CL)**	**D(VIX)**
CointEq1	−0.552 (0.155)	0.132 (0.133)	0.004 (0.039)	−4.738 (1.479)	0 (0)
CointEq2	−0.118 (0.072)	−0.117 (0.063)	−0.019 (0.018)	3.129 (0.690)	0 (0)
R-squared	0.526	0.332	0.126	0.571	0.457

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