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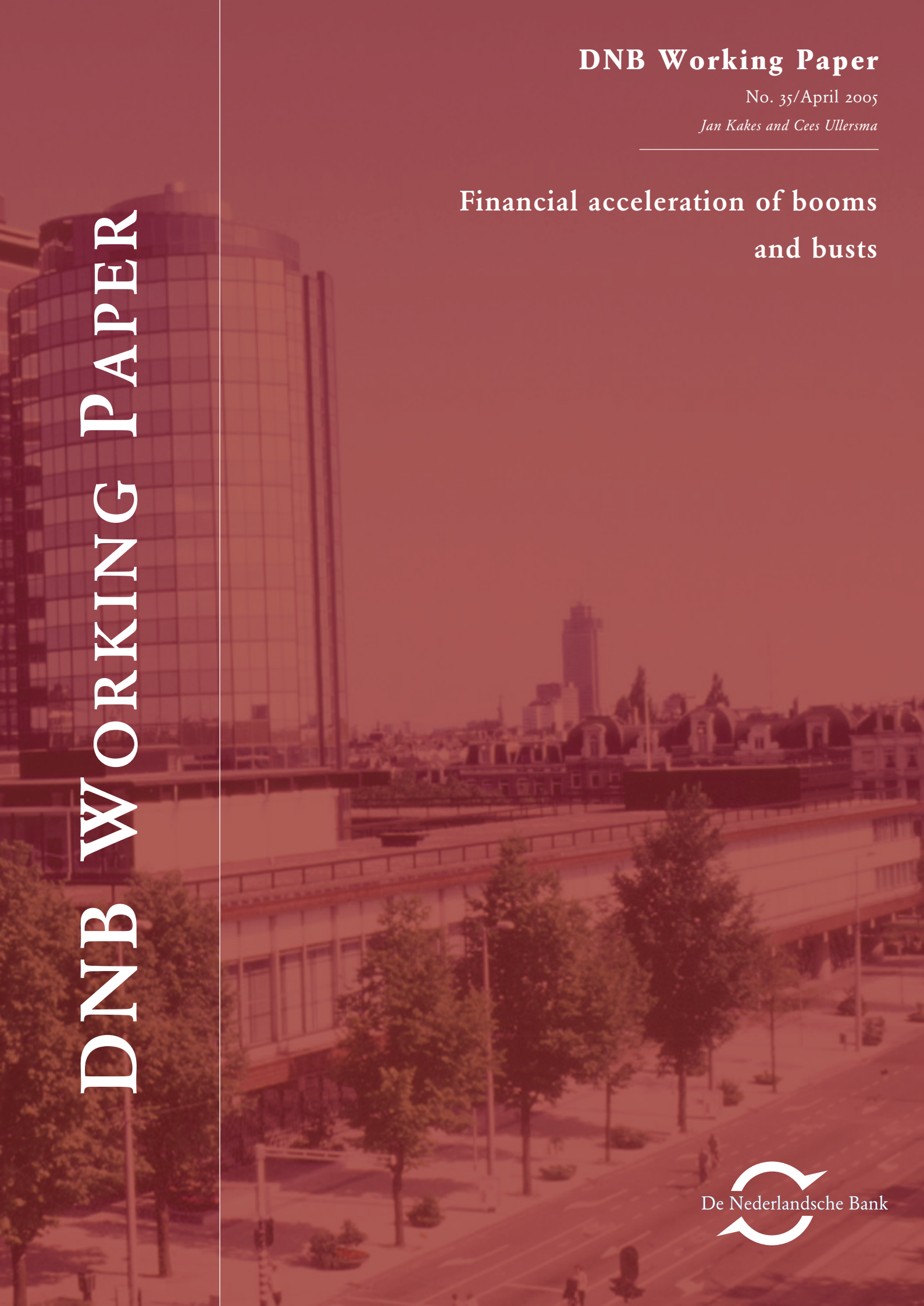

De Nederlandsche Bank

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Jan Kakes and Cees Ullersma *

* Views expressed are those of the individual authors and do not neccessarily reflect official positions of De Nederlandsche Bank.

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De Nederlandsche Bank NV
P.O. Box 98
1000 AB AMSTERDAM
The Netherlands

Financial acceleration of booms and busts

Jan Kakes* and Cees Ullersma*†

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Abstract

For a panel of 20 industrialized countries from 1970 through 2002, we analyze the role of financial variables in economic cycles. We focus on equity busts, which are considered a proxy for downward revisions of economic prospects. Our empirical findings provide support for financial accelerator effects around asset price busts. The financial accelerator mechanism appears to have become stronger over time. The typical bust is followed by a reduction in nominal policy interest rates, sometimes to levels close to the zero lower bound.

JEL codes: E44, E32
Key words: asset price busts, financial accelerator

*De Nederlandsche Bank, P.O. Box 98, 1000 AB Amsterdam, The Netherlands, voice: +31-20-524-2332, fax: +31-20-524-2506, e-mail: c.a.ullersma@dnb.nl. This article does not necessarily represent the position of De Nederlandsche Bank. Martin Admiraal and René Bierdrager provided expert research assistance. The authors thank Allard Bruinshoofd, Paul Cavelaars, Bryan Chapple, Inge van den Doel, John Duca, Leo de Haan, Iman van Lelyveld, Marga Peeters, Job Swank, and participants of the 79th Annual Conference of the Western Economic Association in Vancouver on June 26-29 2004 and of the CCBS/Bank of England Research workshop on asset prices and monetary policy in London on November 1-3 2004 for constructive comments.

†Erasmus University Rotterdam.

1 Introduction

Over the past couple of years, many countries have gone through equity busts. Stock price corrections are often associated with sharp falls in economic activity and financial instability. Nonetheless, the importance of equity and other financial variables has long been ignored in the mainstream macro-economic literature.[1] Under the Modigliani-Miller propositions, financial factors are irrelevant for firms' investment behaviour. Recently, the so-called 'credit channel' or 'financial accelerator' theory has drawn attention to financial frictions. This new literature, which is based on sound micro foundations, attaches a key role to credit and asset prices in the transmission mechanism (e.g. Bernanke et al. (1999)).

A key question is whether the role of financial factors in propagating and amplifying economic shocks can also be observed in practice. Given the surge in financial markets in the past decades, this issue has become increasingly relevant. In particular, studies based on micro-data have established that financial constraints indeed play a role in explaining the behaviour of individual firms and consumers (see Hubbard (1998) for a survey). So far, evidence based on macro-economic data has been less conclusive, largely on account of identification problems. Although less rigorous, macro-based studies are important to get insight into the quantitative importance of financial accelerator effects at the aggregate level. In this paper, we provide new evidence on the financial accelerator based on macro-data. We focus on periods around equity busts, which represent strong downward revisions in economic prospects and losses in financial wealth.

Section 2 presents a model that illustrates the effects of a financial accelerator. Hypotheses are formulated on the basis of this model. After a brief outline of the methodology for testing these hypotheses in Section 3, Section 4 discusses the empirical results. Section 5 concludes. We find empirical support for financial accelerator effects around asset price busts, with the typical bust followed by a reduction in nominal policy interest rates. These results are strongest for the second half of our sample, indicating that the importance of the financial accelerator has increased over time.

[1] Exceptions are Kindleberger (1978) and Minsky (1982), who present early examples of macro-economic theories in which financial frictions play a prominent role. They stress the instability of the interaction between credit, equity prices and economic activity. Others have focused on financial wealth accumulation, in particular the relationship between asset prices and consumption (e.g. Poterba, 2000).

2 Model

We present a stylized model to illustrate the difference between an economy with and without a financial accelerator mechanism. This model elaborates on Bordo and Jeanne (2002) and fits into the New Keynesian framework. Private agents optimize intertemporally. The labour market is perfectly competitive, but nominal wages are predetermined, leading to a non-vertical short-term Phillips curve. The central bank influences the real interest rate by setting the nominal policy rate. If there is a financial accelerator, this provides a separate credit channel for monetary policy, as in Bernanke et al. (1999).

Credit market imperfections can be mitigated by aligning the borrower's incentives with those of the lender, for instance if the borrower risks substantial financial losses. In that case, credit will be extended at a higher cost, if at all, to borrowers with low collateral value. Since collateral consists of productive capital, its price is determined by the expected long-run productivity level.

We distinguish three periods. In period 0, a 'low risk' assessment by both borrowers and lenders may initiate an investment and credit boom. Depending on the fundamentals – the long-run productivity level, which is unknown at this stage – this may lead to a build-up of financial and real imbalances (compare Asea and Blomberg, 1998, and Borio and Lowe, 2002). In period 1, the productivity level is revealed. If productivity is lower than anticipated in period 0, economic prospects need to be revised, which is reflected by an equity bust. In the financial accelerator case, falling equity prices reduce the collateral basis for new borrowing, which may trigger a credit crunch that leads to a fall in real activity. Period 2 is the aftermath of the crisis, in which the central bank may decide to counter a credit crunch by reducing the policy interest rate. Period 3 is the long-run steady state.

The aggregate demand and supply equations are:

$$y_t = -\sigma r_t, \tag{1}$$

$$y_t = \alpha p_t + \varepsilon_t, \tag{2}$$

where y_t is the percentage deviation of log output from its steady-state level at time t, p_t is the percentage deviation of the log of the price level from its steady-state level, and r_t is the real interest rate. Eq. 1 (the IS curve) can be derived from the Euler equation for consumption. Eq. 2 (the Phillips

curve) follows from nominal rigidities. ε_t is a financial shock linked to the possibility of a credit crunch:

$$\varepsilon_0 = 0 \tag{3}$$
$$\varepsilon_1 = \varepsilon_2 = 0 \quad \text{if no credit crunch} \tag{4}$$
$$\varepsilon_1 = \varepsilon_2 = -\nu \quad \text{if credit crunch} \tag{5}$$
$$\varepsilon_3 = 0 \tag{6}$$

A credit crunch can only occur when economic outcomes based on unjustified expectations materialize in periods 1 and 2. Whether or not there is a credit crunch depends on the corporate sector's debt burden and collateral value. Firms issue (real) debt D in period 0 and have to repay $(1 + r_1) D$ in period 1, where r_1 is preset in period 0. A fraction (ϕ) of firms need working capital (γ) in period 1. These firms have access to working capital only if the real value of their collateral exceeds or equals their lending obligations. Otherwise, these firms cannot produce, leading to a credit crunch (negative supply shock $-\nu = \log(1 - \phi)$) if:

$$Q_1 < (1 + r_1) D + \gamma, \tag{7}$$

where Q_1 is the collateral value in period 1 (unknown in period 0). We define μ as the probability that the economy falls into a credit crunch:

$$\mu = \Pr\left[Q_1 < (1 + r_1) D + \gamma\right]. \tag{8}$$

It is assumed that negative values for the net value of the firm excluding working capital do not occur ($Q_1 - (1 + r_1) D \geq 0$), which implies that $\mu = 0$ in the case without working capital ($\gamma = 0$). However, the borrower will only comply with his lending obligations if he is producing. There is an implicit insurance scheme to assure that firms start new periods with equal net worth. Because of the risk of non-complicance with lending obligations, the lending rate includes a premium in addition to the monetary policy interest rate (i), known as the External Finance Premium ($EFP; \frac{\partial EFP}{\partial \mu} > 0$):

$$r_t = i_t + EFP_t, \tag{9}$$

where, assuming risk neutrality among lenders:

$$EFP_t = \frac{\mu\phi}{1 - \mu\phi} i_t. \tag{10}$$

It follows from eq. 10 that the effect of a change in i on r is exacerbated if $\mu, \phi > 0$, which is the financial accelerator case. It can be shown that the debt burden $(1 + r)D$ is decreasing with r, because a rise in r_t has a strong negative impact on credit demand D. Therefore, an interest rate hike in period 0 reduces the risk of a credit crunch in period 1 $\left(\frac{\partial \mu}{\partial r_t} < 0\right)$.

In period 1, the long-run productivity of the asset (R) is revealed, which determines the price of the asset in period 1 ($Q_1 = R$). The value of the collateral (Q_1) can take two values: a high 'New Economy' level (Q_H) and a low 'Old Economy' level (Q_L). The perceived probability of the 'New Economy' P_{NE} in period 0 is a measure of economic agents' optimism. The perceived probability (in period 0) of the 'Old Economy' is $P_{OE} = 1 - P_{NE}$. When P_{NE} is high, but Q_1 turns out to be equal to Q_L, there is overoptimism, implying EFP and r to be below levels consistent with economic fundamentals. In ths way, financial conditions exacerbate business fluctuations. Through this financial accelerator mechanism D and Q_0 are lifted, increasing the probability of a sharp drop in $Q\,(Q_1 \ll Q_0)$.

If there is an 'Old Economy' outcome Q_L, this may lead to a credit crunch. Taking into account that

$$E_0\,(Q_1) = P_{NE} Q_H + (1 - P_{NE})\,Q_L = (1 + r_1)\,(K + D)\,, \qquad (11)$$

where K is the level of firms' equity at $t = 0$, the condition for a credit crunch can also be written as:

$$K\,(1 + r_1) < \gamma + P_{NE}\,(Q_H - Q_L)\,. \qquad (12)$$

Altogether, a credit crunch is more likely if (1) the probability of a 'New Economy' is perceived as high, stimulating credit demand; (2) the equity price differential between the 'New Economy' and 'Old Economy' case is large, implying more scope for a correction; or (3) r_1 is low, stimulating credit demand in period 0.

Period 2 is the post-bust period. In the case of a credit crunch, the central bank has a strong incentive to boost both aggregate demand and supply by reducing i_t (Ullersma, 2004). As to demand, the reduction in i_t will counterbalance the upward pressure on r_t from the increase in EFP. As to supply, a reduction in i_t - given the level of D - will alleviate the collateral constraint embedded in eqs. 7 and 12. Note that if there is no financial accelerator mechanism, then there is no incentive to reduce i_t since $\gamma = \mu = EFP_t = \varepsilon_t = 0$.

Several hypotheses can be derived from this section.

1. If there is a financial accelerator, the external finance premium rises more than without a financial accelerator when there is an equity bust ($Q_1 = Q_L$), since $\frac{\partial EFP}{\partial \mu} > 0$ and μ increases only in the financial accelerator case.

2. If there is a financial accelerator, high credit growth (D) and real activity (y) at $t = 0$ raise the probability of an equity bust ($t = 1$) more than in a situation without a financial accelerator, since the build-up of financial imbalances (EFP_1 and r_1 below fundamental values) increases the probability of a downward correction in Q.

3. If there is a financial accelerator, an equity bust ($Q_1 = Q_L$) will be followed by more expansionary monetary conditions than without a financial accelerator, in order to relax the collateral constraint and counteract the rise in the external finance premium.

4. If there is a financial accelerator, an equity bust in period 1 ($Q_1 = Q_L$) has a stronger negative impact on real activity ($y_{1,2}$) than in a situation without a financial accelerator because of the external finance premium. For the same reason, an equity bust would raise the probability of housing busts and banking crises.

3 Methodology and data

So far the macro-economic evidence for financial accelerator effects is limited. Gertler and Lown (1999) and Mody and Taylor (2003) present some macro evidence for the United States, using the bond spread as a proxy for the external finance premium. In an earlier paper, Bernanke (1983) presents evidence that financial factors explain the severity of the Great Depression. Another strand of literature based on aggregate data, initiated by Bernanke and Blinder (1992), investigates the importance of credit market imperfections in the transmission of monetary policy.

We investigate the four hypotheses in the previous Section using a probit model. In particular, we look at the explanatory power of several macro-economic variables around equity busts, which reflect downward revisions in the long-term economic growth perspective.[2] We consider a panel of 20 in-

[2] A graphical analysis of the behaviour of key macro-economic variables around asset price busts and banking crises can be found in Kakes and Ullersma (2003).

dustrialized countries[3] over the period 1970 - 2002, which includes sufficient equity busts to investigate general patterns. Particularities of individual cases are not the focus of this paper. All results are pooled estimations of all countries, using annual observations.

Our definition of equity busts follows Bordo and Jeanne (2002). A bust is defined as a period in which the real average asset price change over a 12-quarter window is smaller than a threshold. This threshold is the average growth rate of asset prices in all countries over the entire sample ($\overline{g}$), minus x times its standard deviation v:

$$\sum_{l=1}^{12} \frac{g_{i,t-l}}{12} \leq \overline{g} - xv \tag{13}$$

Bordo and Jeanne also choose a three-year window, which is sufficient to filter out short-term volatility. The parameter x is calibrated such that the main bust episodes are selected, without including too many observations. For this purpose, x is set at 0.8. The main boom-bust periods are plausible when compared to other sources. In particular, most boom-bust patterns for individual countries closely match the results of Bordo and Jeanne, despite some differences between their data set and ours. Furthermore, the IMF (2003) finds similar patterns using a very different methodology (Figure 1).[4] Following our procedure, 35 stock market busts have occured over the period we consider (see Appendix B). Busts are concentrated in particular subperiods, reflecting the strong correlation of international stock markets.

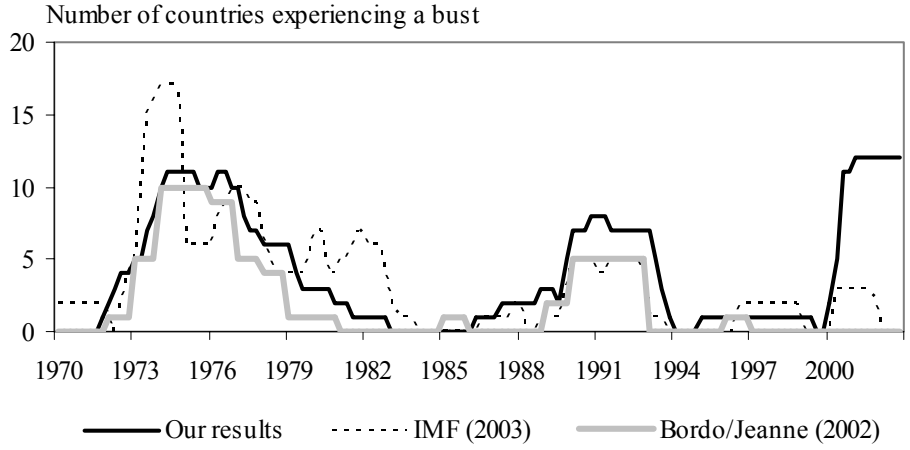
We examine both real and financial indicators in relation to equity busts: industrial production, gross domestic product, private investment (capital formation), inflation, short-term and long-term interest rates, money, credit, asset prices (equity and residential property), and the external finance premium.[5] For the latter, we use the interest rate spread of private debt over government debt, a standard measure of the private sector's risk premium. While the private debt interest rate series are not as accurate and consistent across countries as one would like (see Appendix A), our results show

[3] The countries concerned are Australia, Austria, Belgium, Canada, Denmark, Finland, France, Germany, Italy, Japan, Korea, the Netherlands, New Zealand, Norway, Portugal, Spain, Sweden, Switzerland, the United Kingdom, and the United States.

[4] Bordo and Jeanne (2002) and IMF (2003) do not include the most recent equity busts. In addition, they consider slightly different groups of countries. Bordo and Jeanne do not include Austria, Belgium, Korea, New Zealand, Portugal and Switzerland; the IMF does not include Korea and Portugal.

[5] Most data are taken from the IFS, see Appendix A for an overview.

Figure 1 Equity busts



that the spread does have important characteristics of the external finance premium.

Table C1 in Appendix C displays cross-correlations of all variables we included in our analysis, at an annual frequency. Most of these are very plausible. Nominal interest rates are positively correlated with each other and with inflation, and negatively related to real activity (industrial production, GDP, investment), money and credit growth, and asset prices. Positive correlations also exist between real activity measures, and between money and credit. The interest rate spread is negatively related to real activity, again in line with what one would expect.

4 Empirical results

4.1 Explaining equity busts

Table 1 presents the results of probit estimations with only one explanatory variable. Each entry in the table represents a separate equation, in which the equity bust dummy is explained by a constant and one particular lag of a variable. Including lags up to 8 years, we can investigate to what extent equity busts are related to developments several years earlier.[6] This

[6] This approach follows Estrella and Mishkin (1998), who investigate leading indicator properties of several financial variables in order to predict recessions in the United States.

accords with the idea that imbalances build up over a long period prior to a correction. As the estimated coefficients of probit models are difficult to interpret directly, the table reports the marginal impact of the regressors. This so-called 'slope derivative' is evaluated at the sample means of the data and can be interpreted as the increase in the probability of an equity bust due to a one-unit change in the explanatory variable. The results in Table 1 are useful to address the first two hypotheses that were formulated in Section 2.

According to our *first hypothesis*, a financial accelerator should manifest itself by an increase in the external finance premium prior to a stock market bust. This is supported by the results in Table 1. Our proxy for the external finance premium – the interest rate spread – is significant, particularly just before the equity bust starts. Apparently, stock price corrections are preceded by growing uncertainty regarding economic prospects.

The results in Table 1 are also in line with our *second hypothesis*, that higher real activity and credit growth raise the probability of an equity bust. The explanatory power of industrial production, gross domestic product and investment is strongest three to six years prior to the equity bust. The same holds for money and credit growth. Altogether, these results suggest that easy financial conditions in combination with high production and investment growth contribute significantly to the boom-bust cycle in equity prices. In this context, it is also interesting to observe that higher inflation significantly raises the probability of an equity bust up to three years in advance. Inflation is a sign of overheating and likely to drive up nominal interest rates, which also appears from the strong correlation between inflation and the short-term interest rate. Indeed, the results for both interest rates suggest that these are important triggers of stock price corrections. The short-term interest rate is also significant with 4-7 year lags, but with a negative sign. This suggests that stock market exuberance may be the result of long cumulative processes initiated by loose monetary conditions.

Finally, asset prices have significant explanatory power. For stock prices themselves, this is an obvious result as it reflects the boom-bust cycle. For house prices, the explanatory power is likely to be related to the investment boom prior to the stock price correction, also given the correlation between house prices and investment, money and credit growth.

Table 1 Probit analysis for individual regressors

Variable	*Lag*								
	0	1	2	3	4	5	6	7	8
	*Estimated slope coefficients**								
Short-term interest	1.03^a	0.70^b	–	–	-0.96^a	-0.73^b	-0.73^c	-0.66^c	–
Long-term interest	0.94^a	0.69^c	–	–	–	–	–	–	–
Inflation	1.60^a	1.56^a	1.24^a	0.60^c	–	–	-0.82^b	-0.75^b	-0.59^c
Industrial production	-0.59^b	–	0.65^b	0.92^a	1.06^a	1.07^a	1.39^a	1.18^a	0.95^a
Gross domestic product	–	–	1.73^a	1.73^a	1.89^a	1.53^a	1.29^b	0.96^c	–
Investment	–	0.64^a	1.04^a	1.31^a	1.15^a	1.04^a	0.82^a	0.36^c	–
M3 growth	–	–	0.51^c	1.06^a	1.34^a	1.08^a	0.82^a	–	–
Credit growth	–	–	–	0.57^b	0.56^b	–	–	–	–
Spread	2.13^c	3.24^b	–	–	–	–	–	–	-3.78^b
Stock prices	-0.72^a	-0.37^a	-0.18^a	–	0.25^a	0.30^a	0.22^a	0.26^a	0.17^b
House prices	–	0.71^a	1.19^a	1.18^a	0.78^a	–	–	-0.41^c	-0.57^a

*Explanation: the subscripts a, b and c denote, respectively, statistical significance at the 1%, 5% and 10% level. Slope derivatives, which report the marginal impact at the sample means, are multiplied by 100 to convert them into percentage points.

Our next step is to analyse the external finance premium in a probit model with several regressors (Table 2). We consider a baseline equation including three key macroeconomic variables – inflation, industrial production and the long-term interest rate – which is extended by the interest rate spread. For each regressor, we include both a short-term lag (zero or one year) and a long-term lag (four years or more). In line with Estrella and Mishkin (1998), the choice of lag lengths is guided by the results in Table 1. This way, we capture that variables tend to have explanatory power for several lags – often with different signs – while at the same time restricting the number of lags in order to avoid multicollinearity. Table 2 also includes the 'pseudo R^2' as a goodness of fit measure.[7] Most variables show a pattern similar to the individual equations in Table 1. Furthermore, for all statis-

[7] The pseudo R^2 can be directly derived from the regression, which is estimated by maximum likelihood, and is defined as

$$1 - \left(\frac{\log L_u}{\log L_c}\right)^{-(2/n)\log L_c}$$

where L_u is the estimated likelihood of the equations presented in Table 2 (i.e. 'unconstrained'). L_c is the likelihood under the constraint that all coefficients except the intercept are zero, i.e. the dependent variable is explained by only a constant. n is the number of observations. The pseudo R^2 will always be between zero (no fit) and one (perfect fit). See Estrella and Mishkin (1998) for a further discussion.

tically significant coefficients, short-term and long-term lags have opposite signs.

The approach in Table 2 is also useful to investigate the *third hypothesis* in Section 2, i.e. whether equity busts are followed by more expansionary monetary policy in the case of a financial accelerator. To explore this, we split our observations into two parts: those that are followed by a monetary expansion – i.e. decreasing short-term interest rate – in the subsequent year, and those followed by a monetary contraction. We re-estimate the equation with the spread for both subsamples. Interestingly, the spread is only significant for the observations followed by expansionary monetary policy. This finding supports the idea that an equity bust is followed by a lower nominal policy interest rate when the external finance premium has risen. This is in line with Ullersma's (2004) hypothesis that a downward revision of long-term prospects which is exacerbated by financial factors causes downward pressure on the nominal policy interest rate.

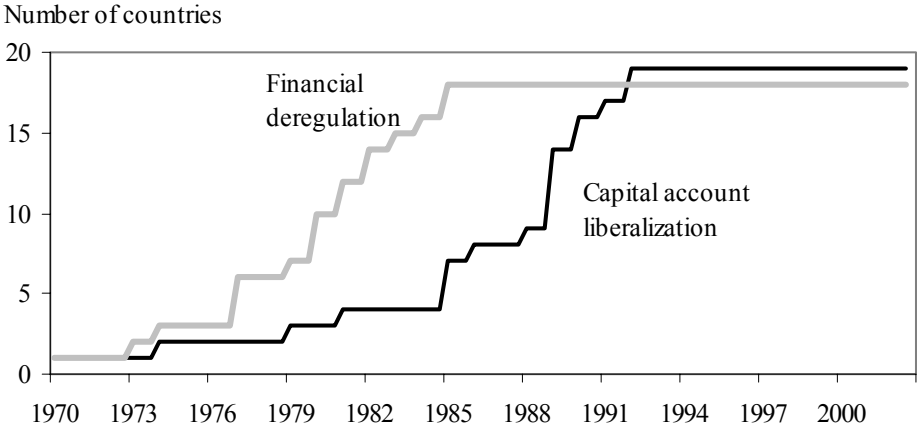
Table 2 Extended probit analysis

Variable	*Estimated slope coefficients**				
Constant	-31.8^a	-26.6^a	-22.8^a	-23.5^a	-27.9^a
Inflation (t)	1.26^b	1.13^c	–	1.87^b	–
Inflation (t-6)	-2.27^a	-3.38^a	-3.27^a	-3.22^a	-3.41^a
Industrial production (t)	–	–	–	–	–
Industrial production (t-4)	1.01^a	1.03^a	2.04^a	–	1.07^a
L-t interest rate (t)	2.19^b	3.06^a	3.50^a	–	3.45^a
L-t interest rate (t-4)	–	-1.65^c	-2.42^b	–	-1.47^c
Spread (t-1)		4.98^a			6.09^a
Spread (t-5)		-5.20^a			-6.28^a
Mon. expansion spread (t-1)**			5.36^b		
Mon. expansion spread (t-5)**			-7.38^a		
Mon. contraction spread (t-1)**				–	
Mon. contraction spread (t-5)**				–	
Spread (t-1) * financial deepening					0.85^b
Spread (t-5) * financial deepening					–
# observations	573	461	258	203	443
pseudo R^2	0.1059	0.1940	0.2543	0.1867	0.2040

*See Table 1.

**Only includes observations that are followed, respectively, by a monetary expansion or a monetary contraction (measured by the short-term interest rate).

Figure 2 Deregulation and liberalization



Source: Bakker and Chapple (2002)

We also investigate to what extent the relationship between equity busts and other variables has changed over time. Presumably, the role of financial variables has increased on account of financial deepening. To investigate this, we add $\log\left(\frac{credit}{GDP}\right)$ as a proxy for financial development, multiplied by the external finance premium. The one-period lag of this interaction term is statistically significant, implying a positive relationship between financial development and the short-run impact of the external finance premium.

We repeat the analysis for two subperiods: 1970-1986 and 1987-2002. This splits our sample into two equal parts, which also roughly corresponds to a distinction between pre and post financial liberalization (see Figure 2).[8] The results are presented in Appendix C. Table C2 presents the estimation results for individual regressors. In the most recent period, financial variables such as credit growth and the external finance premium have become more important leading indicators for equity busts. This also follows from the more extended analysis in Table C3, in which the spread is investigated for monetary expansions and contractions. For both subperiods the spread is only significant for observations followed by a monetary expansion, but this effect is more significant (both statistically and in terms of the slope coefficient) for the most recent sample. Altogether, these results point at a

[8] Financial liberalization encompasses both deregulation of domestic financial markets and lifting capital account restrictions, see Bakker and Chapple (2002).

growing role of financial variables over time.

Finally, we analyse the connection between equity busts, property busts and banking crises, also for both subperiods.[9] According to the *fourth hypothesis* in Section 2, the financial accelerator strengthens the impact of equity busts on other types of crises. The results in Table 3 show that an equity bust raises the probability of a property bust a few years later. The strongest effect is with a 2-3 year lag, which is in line with previous empirical studies (Sutton (2002)). Table C4b in Appendix C shows that only the results for the recent subsample are robust after controlling for the long-term interest rate and other macro-economic variables. Equity busts also increase the probability of a banking crisis, although this is only a significant result for the most recent subsample. This must be seen against the backdrop of a very limited number of banking crises in the earlier period. Nonetheless, taking into account the growing importance of the financial accelerator over time, evidence for a stronger connection between equity busts and other crises is in line with the fourth hypothesis.

Table 3 Sequence of crises: equity bust as regressor

*Estimated slope coefficients**

Lags of equity bust			Extended probit analysis		
Lag	Property bust	Banking crisis	Variable	Property bust	Banking crisis
0	–	7.6^a	Constant	-41.2^a	-23.7^a
1	10.5^a	8.7^a	Inflation (t)	–	-1.57^a
2	15.3^a	8.4^a	Inflation (t-6)	–	–
3	16.2^a	–	Industrial production (t)	-0.86^a	-0.43^b
4	12.4^a	–	Industrial production (t-4)	–	–
5	8.8^b	–	L-t interest rate (t)	3.20^a	–
6	–	-6.4^c	L-t interest rate (t-4)	–	0.78^b
7	–	-8.8^b	Stock market bust (t-2)	–	6.92^a
8	–	-9.1^b	Stock market bust (t-3)	–	–

*See Table 1.

[9] Property busts are constructed the same way as equity busts, with a threshold value of $x = 1.0$. Episodes of property busts and banking crises are summarized in Appendix B.

4.2 Robustness

We performed several robustness checks:

- In the results shown in the tables we use a threshold value $x = 0.8$ to determine equity bust episodes. Although this gives plausible equity bust episodes which broadly correspond with other studies, it is important to check the robustness of our results to a change in x. Using $x = 1.0$ already leads to a substantial reduction in crisis observations (by about half), but the main results and conclusions remain intact. When larger thresholds are used, too many crisis observations are thrown away to be able to perform analyses.

- We repeated the analysis with the equity busts episodes derived by Bordo and Jeanne (2002) and IMF (2003). As shown in Figure 1, both patterns of aggregated equity busts are similar to our indicator, although some countries and most of the recent bust episodes are missing. With some exceptions, the results of these two alternative indicators are similar, and do not lead to different conclusions. In many cases the results are even more pronounced. At the same time, our proxy for the external finance premium – the credit spread – performs worse than in the estimations with our own indicator. Presumably, this is because the recent equity busts – which largely determine the results of the second subsample – are missing for the two alternative indicators.

- As an alternative proxy for the external finance premium, we considered the level of stock price volatility perceived by market participants. More specifically, we used the conditional variance of stock prices, generated by a GARCH process. This measure of uncertainty is a key determinant of the risk premium required by investors to hold shares instead of deposits, and therefore indicative of the external finance premium. At the same time, a serious drawback of this measure is that it is directly derived from the same variable (equity prices) that is used to generate the equity bust dummy. In most equations, however, including stock price volatility instead of the interest rate spread leads to the same conclusions.

- We re-estimated the extended analysis (Tables 2 and C3) with alternative baseline equations, including gross domestic product and the short-term interest rate instead of industrial production and the long-term interest rate, and including the oil price. In addition, we experi-

mented with different lag structures. Neither of these alternatives had much impact on our results.

- We analysed smaller subsamples, in particular the periods 1970-1980 and 1990-2002. In general, this leads to stronger differences between periods. Recursive estimations also confirm our finding that financial variables have become more important over time.

5 Concluding remarks

Although some of the hypotheses are difficult to test, our results for the external finance premium, the build-up of financial imbalances before an equity bust, and the sequence of financial crises are in line with a financial accelerator mechanism during boom-bust periods. The financial accelerator seems to have become more important over time, probably due to the rapid development of financial markets. Comparing stock market performance in the 1970s and in recent years, Davis (2003) draws a similar conclusion. More specifically, he concludes that the 1970 busts were characterized by a sharp deterioration of fundamentals, while the recent equity busts reflect the correction of overvaluation (i.e. a correction of an incorrect *perception* of fundamentals).

The outcomes for the external finance premium and interest rates around equity busts support Ullersma's (2004) model, which expects downward pressure on policy interest rates after a downscaling of long-term growth prospects that is exacerbated by financial accelerator effects. Expansionary monetary policy in reaction to busts has been the typical reaction in the recent period, but not in the 1970s and early 1980s.

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Appendix A Data

Most data are taken from the IMF's International Financial Statistics (IFS), extended by various other (mostly national) sources. Table A1 gives an overview of data availability for each country in our sample.

- *Real activity and prices.* We include real Gross Domestic Product, Industrial Production and Investment (Gross Capital Formation) as measures for real activity. Inflation is based on the consumer price index.

- *Money and credit markets.* The short-term interest rate is a (mostly three-month or overnight) market interest rate, and the long-term interest rate is in most cases the ten-year government bond yield. The interest rate spread proxy for the external finance premium is the difference between the interest rates of long-term private debt and government bonds. For most countries, private-sector interest rates are based on corporate bonds, taken from Globalfindata. Obviously, several characteristics, such as the average maturity, are likely to differ between corporate bonds and government bonds and across countries. Therefore, this measure for the risk premium may also capture a yield curve effect. However, because the direction of this effect varies across countries, its aggregate impact on our results is probably limited. Furthermore, the yield curve itself (measured by difference between long-term and short-term interest rates) has no significant explanatory power in most of our estimations. The alternative proxy for the external finance premium, the conditional volatility of stock prices, is calculated with a GARCH(1,1) model. M3 and credit data from the IFS are extended by data from many other sources.

- *Asset markets and financial crises.* Most stock prices are taken from the IFS, while house prices are based on various national sources and mostly taken from the BIS Datase. An episode is considered a banking crisis if it qualifies as such according to either Bordo et al. (2001) or Mehrez and Kaufmann (1999).

TABLE A1 Data availability

	GDP	IP	I	π	r_S	r_L	r_{spread}	$M3$	CR	S	H
Australia	65-02	65-02	65-02	65-02	68-02	65-02	83-02	65-02	65-02	65-02	70-02
Austria	65-02	65-02	88-02	65-02	65-02	70-02	65-02	65-02	65-02	65-02	87-99
Belgium	80-02	65-02	80-02	65-02	65-02	65-02	65-02	69-98	65-02	65-02	70-02
Canada	65-02	65-02	65-02	65-02	65-02	65-02	65-02	68-02	65-02	65-02	70-02
Denmark	70-00	68-02	88-02	65-02	71-02	65-02	71-02	68-02	65-02	65-02	70-02
Finland	75-02	65-02	75-02	65-02	78-02	78-02	–	75-99	65-02	65-02	70-02
France	70-02	65-02	78-02	65-02	65-02	65-02	65-02	65-98	65-02	65-02	70-02
Germany	65-02	65-02	91-02	65-02	65-02	65-02	65-02	65-02	65-02	65-02	71-99
Italy	65-02	65-02	70-02	65-02	71-02	65-02	71-02	80-02	70-98	65-02	72-01
Japan	65-02	65-02	80-02	65-02	65-02	65-02	65-02	65-02	65-02	65-02	70-01
Korea	70-02	70-02	70-02	70-02	76-02	73-02	76-02	65-02	65-02	78-01	–
Netherlands	65-02	65-02	77-02	65-02	65-02	65-02	70-98	65-98	65-02	65-02	70-02
New Zealand	70-01	77-02	70-02	65-02	73-02	65-02	–	71-02	65-02	65-00	70-02
Norway	65-02	65-02	78-02	65-02	71-02	65-02	83-02	65-02	65-02	65-00	70-02
Portugal	77-02	68-02	86-02	65-02	82-02	65-02	–	80-02	65-02	88-02	88-02
Spain	65-02	65-02	80-02	65-02	74-02	78-02	74-02	65-02	65-98	70-00	75-02
Sweden	70-02	65-02	70-02	65-02	65-02	65-02	65-02	65-02	70-00	65-02	70-01
Switzerland	65-02	65-02	70-02	65-02	65-02	65-02	65-02	72-02	65-02	65-02	70-02
United Kingdom	65-02	65-02	65-02	65-02	65-02	65-02	65-02	82-02	65-02	65-02	68-02
United States	65-02	65-02	65-02	65-02	65-02	65-02	70-02	65-02	65-02	65-02	70-02

$GDP =$ real gross domestic product
$IP =$ industrial production
$I =$ investment
$\pi =$ inflation
$r_S =$ short-term interest rate
$r_L =$ long-term interest rate
$r_{spread} =$ spread
$M3 =$ M3 growth
$CR =$ credit growth
$S =$ stock prices
$H =$ house prices

Appendix B Asset busts and banking crises

	Equity busts	Property busts	Banking crises
Australia	1972Q2-1977Q1	1981Q1-1986Q1	1989-1990
Austria	1990Q4-1992Q3	-	-
Belgium	1974Q1-1977Q3	1979Q3-1985Q4	-
Canada	2001Q1-	1981Q3-1985Q1	1983-1985
Denmark	1977Q4-1980Q3	1978Q4-1983Q3 1986Q4-1991Q2	1987-1991
Finland	1973Q4-1979Q2 1988Q4-1993Q1 2002Q2-2001Q1	1974Q2.1979Q2 1989Q2-1995Q2	1991-1993
France	1974Q2-1977Q2 2000Q3-	1982Q4-1986Q4	1994
Germany	2000Q1-	1973Q3-1977Q3	1977-1979
Italy	1973Q1-1979Q1 1990Q1-1993Q2 2000Q3-	1981Q4-1987Q2 1994Q1-1997Q4	1990-1994
Japan	1989Q4-1993Q3 2000Q3-	1973Q4-1978Q1	1991-1997

(continued)

Korea	1976Q2-1982Q4 1989Q4-1993Q2 1995Q1-1999Q2	-	1985-1986 1997-1998
Netherlands	2000Q1-	1978Q1-1984Q4	-
New Zealand	1973Q3-1977Q4 1987Q2-1991Q2	1975Q1-1981Q1	1987-1990
Norway	1974Q1-1979Q1	1987Q2-1993Q4	1987-1993
Portugal	1986Q2-1989Q2 1989Q4-1993Q3 2000Q2-	1992Q2-1995Q2	1986-1989
Spain	1973Q3-1981Q2	1978Q3-1983Q2	1977
Sweden	1990Q1-1993Q1 2000Q2-	1979Q1-1984Q4 1990Q2-1995Q3	1990-1993
Switzerland	1972Q1-1976Q3 2000Q3-	1973Q2-1977Q4 1989Q4-1994Q4	-
United Kingdom	1971Q4-1977Q1 2000Q3-	1973Q3-1977Q3 1989Q3-1993Q4	-
United States	1972Q3-1975Q2 2000Q3-	-	1984-1991

Appendix C

TABLE C1 Cross-correlations

	r_S	r_L	π	IP	GDP	I	$M3$	CR	r_{spread}	S	H
r_S	1.00										
r_L	0.82	1.00									
π	0.78	0.55	1.00								
IP	-0.22	-0.19	-0.34	1.00							
GDP	-0.24	-0.12	-0.38	0.89	1.00						
I	-0.24	-0.23	-0.31	0.80	0.80	1.00					
$M3$	-0.34	-0.30	-0.51	0.33	0.45	0.51	1.00				
CR	-0.36	-0.30	-0.58	0.60	0.69	0.72	0.88	1.00			
r_{spread}	-0.07	0.01	-0.09	-0.68	-0.61	-0.57	0.18	-0.68	1.00		
S	-0.26	-0.13	-0.52	0.21	0.32	0.12	0.22	0.21	-0.12	1.00	
H	-0.44	-0.52	-0.51	0.45	0.54	0.58	0.74	0.45	-0.12	0.16	1.00

TABLE C2 Probit analysis for individual regressors: subperiods

Variable	*Lag*								
	0	1	2	3	4	5	6	7	8
	*Estimated slope coefficients 1970-1986**								
Short-term interest	1.07^{b}	–	–	–	-1.22^{b}	-1.00^{b}	-1.31^{b}	-1.39^{a}	-0.93^{a}
Long-term interest	1.08^{b}	–	–	–	–	–	–	-1.17^{c}	-1.43^{b}
Inflation	2.29^{a}	2.19^{a}	1.77^{a}	0.88^{b}	–	-0.87^{c}	-1.64^{a}	-1.73^{a}	-1.92^{a}
Industrial production	–	–	–	0.73^{b}	1.02^{a}	1.04^{a}	1.32^{a}	1.24^{a}	1.22^{a}
Gross domestic product	–	–	1.34^{b}	1.11^{c}	1.55^{a}	1.37^{b}	1.11^{c}	–	–
Investment	–	0.48^{c}	0.64^{b}	1.34^{a}	1.44^{a}	1.35^{a}	0.92^{a}	0.71^{b}	0.66^{b}
M3 growth	–	–	–	0.58^{c}	1.15^{a}	1.11^{a}	1.17^{a}	0.95^{b}	0.85^{b}
Credit growth	-0.68^{b}	–	–	–	–	–	–	–	–
Spread	–	–	–	–	–	–	–	–	–
Stock prices	-0.58^{a}	-0.44^{a}	-0.40^{a}	-0.22^{b}	0.09	0.32^{a}	0.31^{a}	0.34^{a}	0.26^{b}
House prices	–	0.64^{b}	1.08^{a}	1.09^{a}	0.85^{a}	0.08	-0.06	-0.12	-0.03
	*Estimated slope coefficients 1987-2002**								
Short-term interest	1.52^{a}	1.20^{b}	–	–	–	–	–	–	–
Long-term interest	1.66^{b}	1.35^{b}	–	–	–	–	–	–	–
Inflation	4.52^{a}	3.86^{a}	2.46^{a}	–	–	–	–	–	–
Industrial production	-1.74^{a}	–	0.97^{c}	1.41^{a}	1.25^{b}	1.25^{b}	1.69^{a}	1.29^{a}	–
Gross domestic product	-2.75^{a}	–	2.60^{a}	3.28^{a}	2.76^{a}	2.00^{b}	1.83^{b}	–	–
Investment	–	0.85^{a}	1.64^{a}	1.27^{a}	0.81^{b}	0.70^{b}	0.73^{b}	–	-0.54^{c}
M3 growth	–	0.95^{b}	1.21^{b}	1.73^{a}	1.50^{a}	1.03^{b}	0.53	–	–
Credit growth	–	0.88^{b}	1.09^{a}	0.99^{b}	0.75^{c}	–	–	–	–
Spread	3.74^{c}	4.29^{b}	–	–	–	-4.30^{c}	-3.43	-3.97^{c}	-7.20^{a}
Stock prices	-0.88^{a}	-0.33^{a}	–	0.37^{a}	0.39^{a}	0.31^{a}	–	0.22^{b}	–
House prices	–	0.82^{a}	1.34^{a}	1.28^{a}	0.68^{b}	–	–	–	-0.69^{b}

*See Table 1.

TABLE C3a Extended probit analysis, 1970-1986

Variable	*Estimated slope coefficients**			
Constant	-33.7^a	-27.7^a	-24.8^a	-8.34^b
Inflation (t)	1.95^a	1.54^a	1.05^b	0.96^b
Inflation (t-6)	-2.96^a	-2.00^a	-1.90^a	-0.81^b
Industrial production (t)	0.76^b	0.62^b	0.59^b	–
Industrial production (t-4)	0.59^c	0.41^c	0.87^b	–
L-t interest rate (t)	–	–	–	–
L-t interest rate (t-4)	–	–	–	–
Spread (t-1)		3.47^b		
Spread (t-5)		-3.55^b		
Mon. expansion spread (t-1)**			2.64^c	
Mon. expansion spread (t-5)**			–	
Mon. contraction spread (t-1)**				–
Mon. contraction spread (t-5)**				–
# observations	257	198	112	86
pseudo R^2	0.2512	0.3756	0.51	0.35

*See Table 1.**See Table 2

TABLE C3b Extended probit analysis, 1987-2002

Variable	*Estimated slope coefficients**			
Constant	-31.3^a	-15.1^b	–	-44.1^a
Inflation (t)	8.79^a	–	-2.26^c	–
Inflation (t-6)	–	-2.38^c	–	–
Industrial production (t)	-2.23^a	–	–	–
Industrial production (t-4)	–	1.16^c	0.78^c	–
L-t interest rate (t)	–	4.53^a	4.04^a	–
L-t interest rate (t-4)	-6.04^a	-4.80^a	-4.57^a	–
Spread (t-1)		6.86^b		
Spread (t-5)		–		
Mon. expansion spread (t-1)**			6.84^a	
Mon. expansion spread (t-5)**			-5.74^a	
Mon. contraction spread (t-1)**				–
Mon. contraction spread (t-5)**				–
# observations	316	263	146	117
pseudo R^2	0.1836	0.1879	0.3112	0.1763

*See Table 1.**See Table 2.

TABLE C4a Sequence of crises
Probit analysis with equity bust as a regressor

	Lag								
	0	1	2	3	4	5	6	7	8
	*Estimated slope coefficients**								
Property bust									
1970-2002	–	10.5^a	15.3^a	16.2^a	12.4^a	8.8^b	–	–	–
1970-1986	–	15.8^a	16.0^a	12.4^b	–	–	–	–	–
1987-2002	–	–	11.9^a	15.3^a	13.2^b	–	–	–	–
Banking crisis									
1970-2002	7.6^a	8.7^a	8.4^a	–	–	–	-6.4^c	-8.8^b	-9.1^b
1970-1986	–	–	–	–	–	–	–	–	–
1987-2002	16.5^a	23.2^a	27.8^a	17.8^a	–	–	–	–	–

*See Table 1.

TABLE C4b Sequence of crises
Extended probit analysis including equity bust as a regressor

Variable	*Estimated slope coefficients**					
	Property bust			Banking crisis		
	70-02	70-86	87-02	70-02	70-86	87-02
Constant	-41.2^a	-30.9^a	-53.1^a	-23.7^a	-0.45^a	-53.3^a
Inflation (t)	–	-2.01^b	–	-1.57^a	-0.04^c	–
Inflation (t-6)	–	–	-1.47^c	–	–	–
Industrial production (t)	-0.86^a	-1.46^a	–	-0.43^b	0.02^b	-1.38^a
Industrial production (t-4)	–	–	–	–	–	–
L-t interest rate (t)	3.20^a	4.40^a	–	–	–	–
L-t interest rate (t-4)	–	–	–	0.78^b	–	–
Stock market bust (t-2)				6.92^a	–	21.6^a
Stock market bust (t-3)	–	–	12.7^b			
# observations	560	244	316	557	257	300
pseudo R^2	0.0881	0.0951	0.0892	0.0851	0.1555	0.1611

*See Table 1.

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