Jarmo Pesola

Banking fragility and distress: An econometric study of macroeconomic determinants

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Banking fragility and distress: An econometric study of macroeconomic determinants

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Abstract

The macroeconomic determinants of banking sector distresses in the Nordic countries, Belgium, Germany, Greece, Spain and the UK are analysed using an econometric model estimated on panel data from partly the early 1980s to 2002. The dependent variable is the ratio of banks' loan losses to lending. In addition to the lagged dependent variable, the explanatory variables include a surprise change in incomes and real interest rates, both variables as a separate cross-product term with lagged aggregate indebtedness. The underlying macroeconomic account that this paper puts forward is that loan losses are basically generated by strong adverse aggregate shocks under high exposure of banks to such shocks. The underlying innovations to income and real interest rates are constructed using published macro-economic forecast for these variables.

According to the results, high customer indebtedness combined with adverse macroeconomic surprise shocks to income and real interest rates contributed to the distress in banking sector. Loan losses also display strong autoregressive behaviour which might indicate a feedback effect from loan losses back to macroeconomic level in deep recessions. The results can be used in macro stress-testing the banking sector.

Key words: financial fragility, shock, loan loss, banking crisis

JEL classification numbers: G21, E44

Pankkien haavoittuvuus ja ahdinko: Makrotaloudellisten tekijöiden ekonometrinen tutkimus

Suomen Pankin tutkimus
Keskustelualoitteita 13/2005

Jarmo Pesola
Rahapolitiikka- ja tutkimusosasto

Tiivistelmä

Tutkimuksessa on analysoitu ekonometrisen mallin avulla pankkisektorin ahdinkoon vaikuttavia makrotaloudellisia tekijöitä. Malli on estimoitu paneeliaineistolla, joka kattaa Pohjoismaat, Belgian, Saksan, Kreikan, Espanjan ja Yhdistyneen kuningaskunnan ja ajanjakson osittain aina 1980-luvun alkuvuosista vuoteen 2002. Selitettävänä tekijänä on pankkien luottotappioiden suhde luottokantaan. Selittävinä muuttujina on viivästetyn selitettävän muuttujan lisäksi käytetty kahta ristitermiä. Niistä toinen on muodostettu yhdistämällä tuloyllätykset ja toinen yhdistämällä korkoyllätykset viivästettyyn aggregaattitason velkaantuneisuusmuuttujaan. Tutkimuksessa esitetyn makrotaloudellisen hypoteesikehikon mukaan luottotappiot aiheutuvat voimakkaista epäedullisista makrotaloudellisista sokeista pankkien ollessa vaikeasti altistuneita tällaisten sokkien vaikutuksille. Analyysin perustana olevat tulo- ja reaalikorkoinnovaatiot on muodostettu näistä muuttujista julkaistujen ennusteiden avulla.

Tutkimustulosten mukaan asiakkaiden raskas velkaantuneisuus yhdistettynä tulo- ja reaalikorkomuuttujaan kohdistuvaan yllättävään makrotaloudelliseen sokkiin lisäsi pankkisektorin ahdinkoa. Luottotappiot käyttäytyvät selkeän autoregressiivisesti, mikä mahdollisesti johtuu luottotappioiden takaisinkytkentävaikutuksesta makrotasolle syvissä taantumavaiheissa. Tutkimustuloksia voidaan käyttää pankkisektorin makrostressitestaukseen.

Avainsanat: rahoitusjärjestelmän haavoittuvuus, sokki, luottotappio, pankkikriisi

JEL-luokittelu: G21, E44

Contents

1 Introduction

There are two different purposes and, consequently, two broad lines of approach in banking crisis studies. One line is the attempt to simply find a set of early warning indicators by observing leading indicators which could reliably signal of the threats ahead.[1] Another line is the attempt to find an explanation to the events by theoretical reasoning and econometric testing. This study belongs to the latter group.

Increasing our understanding of the macroeconomic factors causing banking crises is one of the goals of this study. We also attempt to gain knowledge of the factors underlying fragility or, for that matter, robustness of the banking sector. This area of research is important from the point of view of the macroprudential analysis conducted by central banks in order to prevent adverse developments to result in a potential systemic event in banking sector, to banking crisis in an extreme case. The results of the study can be used in assessing the resilience of the banking sector in the context of macroprudential analysis, eg in stress testing the banking sector. The results might also be helpful in designing regulatory procedures.

This empirical study has an aggregative approach. Only the comprehensive banking sector is analysed in the countries included in the study sample – the Nordic and five other European countries. No individual banks are studied. The dependent variable in the econometric analysis is banking sectors' aggregate loan losses.

The Nordic Countries is an 'ideal' pool of countries because of their homogeneity. Their size, except for Iceland, and structures of society and economy are mutually fairly similar. Hence, their economies are likely to function in a more or less similar manner. The EU-15 countries, as a somewhat less homogenous but an increasingly integrated group would be suitable for analysis, too. In addition to crisis countries, the pool of countries includes some crisis-free cases as well. The availability of aggregate level banking sector loan loss data has limited the number of countries included in the panel.

Banking crisis or distress is a very rare event in a single country. There can typically be several decades of tranquil time between systemic events (Eichengreen and Bordo 2003/Goodhart, BoF-CASS presentation September 2, 2004). For example, about 60 years has elapsed between the crises in the 1990s and the1930s in Finland (Pesola 2000; Autio, Ikonen and Elonen 1991). There were a few more banking crises between 1865 and the 1930s (Herrala 1999). In Norway, there have been three banking crises in the 20th century: just in the beginning of the century, in the 1920s and 1988–1993 (Gerdrup 2004).

[1] Kaminsky and Reinhart (1999) and Borio and Lowe (2002) are, among others, examples of these.

Such a long time span is difficult to put in a coherent quantitative framework because of, among other things, numerous major structural changes (eg in the industrial structure, regulation) as well as changes in technology. Consequently, it is reasonable to concentrate on, roughly, the two last decades and use pooled country data in econometric study (Pesola 2001; Valckx 2003; Bikker and Metzemakers 2004).

The structure of paper is following. First, the results of some most crucial related studies are presented in section 2. Second, some descriptive stylized facts in the Nordic countries are highlighted in section 3. Third, the theoretical framework of study is set in section 4. There the concept credit distress cycle is introduced and the idea of loan losses as a product of financial fragility and negative macroeconomic shock is presented. Fourth, model specification and econometric analysis are presented in section 5. Finally, in conclusions we can sum up that a parsimonious model using a combination of fragility and surprising macroeconomic shock gives a satisfactory explanation to banks' loan losses. Moreover, there seems to be an element of inertia in loan losses, which is caught by applying a lagged loan losses as explanatory variable.

2 Related studies

Mexican and Asian crises in the 1990s prompted several studies which link macroeconomic variables to the financial health of banking sector (see IMF 2000). There have also been some empirical studies about the macroeconomic causes of the Nordic banking crises, which took place in the early 1990 (Pesola, 2001; Hansen 2003; Englund and Vihriälä 2003 and Sandal 2004). Also Fröyland and Larsen's (2002) study on the loan losses of Norwegian banks is relevant in this context.

Many of the empirical world wide crisis studies are done in the IMF. Typically, the wide country samples are rather heterogeneous. Hence, the dependent variable is usually some discrete one-off crisis data. Probit/logit estimation technique is mostly used as the large samples allow statistically sufficient variation in the binomial data for testing purposes.

Regarding the dependent variable, there have been two main alternative lines in empirical studies. The one is to exploit the data generated in numerous banking crisis studies, which mostly gives a strict binomial dichotomy in time series: crisis vs. non-crisis (eg Lindgren, Garcia and Saal 1996, ECB Monthly Bulletin, July 2004 etc). The other one uses ordinary statistical time series such as banks' nonperforming lending, loan losses, firm bankruptcies etc (Pesola 2001) or some proxies for those ones eg loan loss provisions.

The (micro)theoretical foundation of this study is closely related to the credit default approach, which, in turn, is originally based on Merton's (1974) option theoretic approach. A number of macro-economic credit risk studies have been published recently where default rates are modelled according to this approach. Fröyland and Larsen's (2002); Drehman's (2005) and Virolainen's (2004), to mention few, are examples of such studies. Drehmann finds that some macroeconomic variables have a systematic effect on credit risk and that this effect is non-linear and non-symmetric. Virolainen estimates a macroeconomic credit risk model for the Finnish corporate sector by using industry specific quarterly corporate bankruptcy data.

Another theoretical idea underlying the present study is that of debt deflation. The idea was originally launched by Fisher (1932). Kiyotaki and Moore (1997) developed a dynamic credit cycle model. In a theoretical study utilizing the debt deflation model in the banking sector, von Peter (2004) shows that a shock can set the asset prices of the non-bank corporation sector in such a decline that, in an extreme case, can cause loss of banks' capital. This feeds back into the economy through banks' reduced lending ability which can further drive asset prices down.

According to the findings of Koopman, Lucas and Klaassen (2002), who analyse US business failure rates from the viewpoint of portfolio credit risk analysis, a short (10 years) and long (40 years) cycle affects business failures. They also conclude that the contribution of cyclical factors varies over time.

Regarding the explanatory variables, almost all of the studies find that the GDP and interest rates are among the most important factors in explaining loan losses. Interestingly, Drehman also uses innovations of GDP and interest rates to explain variations in loan losses, so in this respect his study comes close to the present one. However, he constructs innovations in these variable using a different approach, as he uses autoregressive models to generate forecasts of the relevant variables. The importance of GDP and interest rates can also be seen in the recent studies inspired by the new Basel Accord and IAS regulation on banks' loan loss provisioning behaviour. Examples of such studies are Valckx (2003) and Bikker and Metzemakers (2004) both or which use a panel estimation framework similar to ours to study loan losses.[2]

A further group of important explanatory variables are banks' lending and asset prices. The contribution of these variables have been investigated by Fröyland and Larsen. Also, Englund and Vihriälä (2003) argue that in Finland and Sweden the fundamental financial liberalization contributed to a credit boom which preceeded the crises.

[2] Further loan loss provision studies: Hoggarth and Whitley (2003) study the provisions made against credit losses by the major UK commercial banks in aggregate. Delgado and Saurina (2004) study how macroeconomic variables affect both non-performing loans and loan loss provisions of Spanish banks. A different approach is in the study of Hasan and Wall (2003) where loan loss allowances are explained among others by non-performing loans and net charge offs.

Borio and Lowe (2002) seek early warning indicators for financial distress in 34 countries. They find that sustained rapid credit growth with large increases in asset prices appears to increase the probability of financial instability. By using the signal analysis, developed by Kaminsky and Reinhart (1999), they conclude that combining threshold values of credit gap around 4 percentage points and of asset price gap[3] of 40 percent gives the lowest noise to signal ratio[4]. Borio and Lowe's noise to signal ratio will be more than halved (from .13 to .06) when signalling horizon increases from one to three years.

Hansen's (2003) similar study in the Nordic countries indicates a very high predictive power of lending and house prices for firm bankruptcies. Davis and Zhu (2004) get a particular strong links of credit to commercial property in the countries that experienced banking crises linked to property losses.

3 Backround empirical evidence on banking crises in Finland and Norway

We look at the outset some stylized facts about the last Finnish and Norwegian banking crises in the early 1990s. Both of these countries have rather well developed set of monthly and quarterly data set and the both crises have been studied intensively.[5] We also look at the development of lending and asset prices in the Nordic countries. In the end of chapter, we discuss the concepts of loan loss, nonperforming loan and loan loss provision in order to motivate our choice of loan losses to dependent variable.

3.1 Stylized facts

The dynamics in development of the Finnish banking crisis can be seen in the timing of peaks in the crucial time series (Figure 1). Monthly time series of changes (d) in lending and nonperforming loans (NPL) stocks, number of bankruptcies and amount of loan losses are smoothed with Hodrick and Prescott filter. The peak in the change of banks' lending seems to be at the end of 1988, whereas the peak in loan losses is at the end of 1993 about five years later

[3] Those gaps are deviations from respective rolling Hodrick and Prescott trends.
[4] The noise to signal ratio is the ratio of size of Type II errors (percentage of non-crisis periods in which a crisis is incorrectly signalled) to one minus the size of Type I errors (the percentage of crises that are not correctly predicted).
[5] There are many separate studies about the recent Finnish banking crisis, for instance, Nyberg and Vihriälä (1994), Vihriälä (1997) , Pesola (2000) etc. The Norwegian recent crisis has, among others, been thoroughly analysed in Moe, Solheim and Vale (2004).

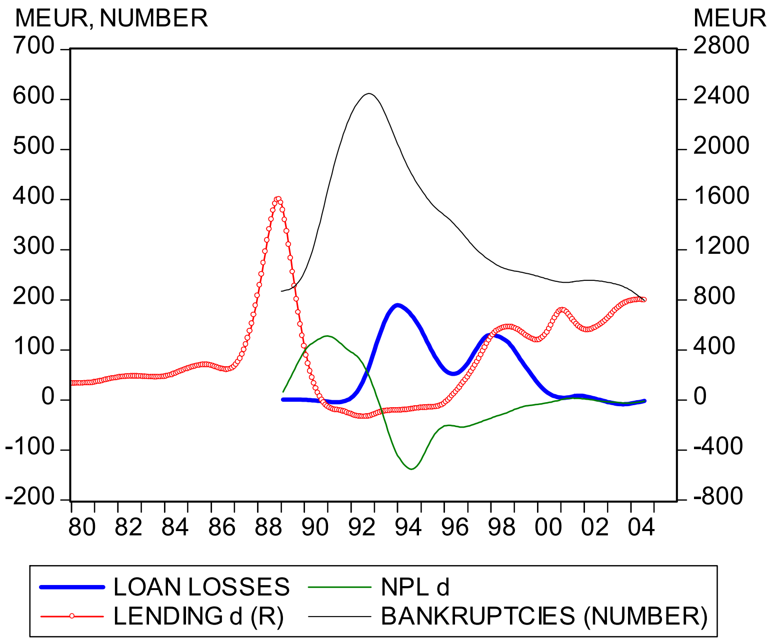
(Figure 1). There is certainly a kind of gestation period between lending boom and loan losses. Meanwhile, the peak in nonperforming loans can be found at the end of 1990 and the peak in firm bankruptcies at the beginning of 1993. Obviously, there is a clear chronological sequence in the order of the peaks: 1) lending boom, 2) increase in NPLs, 3) increase in bankruptcies and 4) increase in banks' loan losses. In addition, we can see in chart 5 that an asset price boom coincided with lending boom in Finland as well as in other Nordic countries. That fits in the picture laid down by Borio and Lowe.

In principle, loan loss provisions should be made about the same time as the NPLs develop. However, the accounting practices and goals influence the behaviour of provisioning, as Valckx and Bikker – Metzemaker point out. This can be seen in the Finnish case where during the crisis years the level of provisions was very low (Figure 2). Yet, the amount of loan losses was rapidly increasing in the run up to the crisis. Possibly, the banks were taken by surprise at the severity of economic shock. As seen from the accounting point of view, there was no point to make any further provisions in profit and loss (P&L) account as the realised loan losses already caused heavily negative profits. The same phenomenon is reflected in Figure 1 where the nonperforming loans started to diminish when loan losses began to grow. The NPLs were transformed into loan losses.

Hence, a macroeconomic shock initially worsens the loan quality. This raises the amount of non-performing loans and loan loss provisions. For example in Figure 1, the lag between the peaks of NPLs and realised loan losses is some three years. Similar kind of time difference should prevail between the loan loss provisions and realised loan losses.

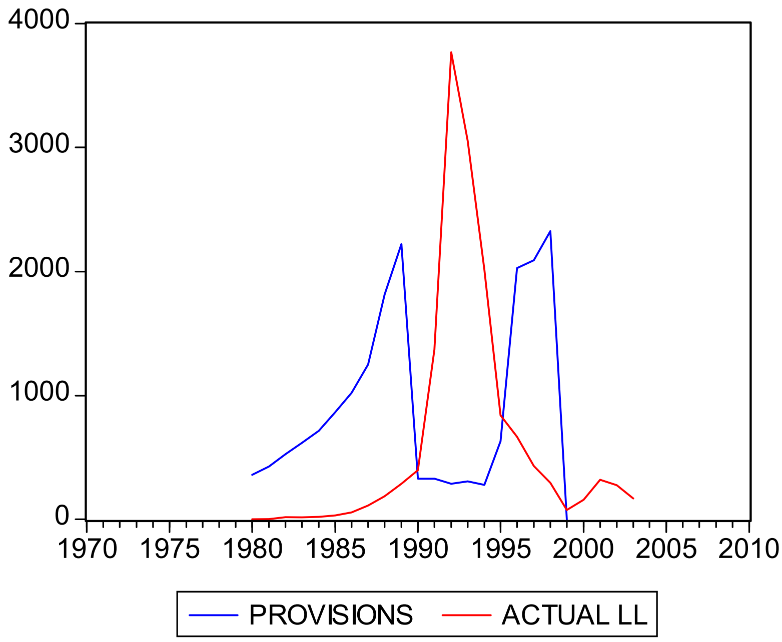
The worst years of Norwegian banking crisis were a bit earlier than in Finland. The amount of loan losses was largest in 1991 while the number of firm bankruptcies was highest in 1992. A sharp fall in oil prices in late 1985 and the subsequent decrease in Norwegian export income was an early macroeconomic shock, which contributed to the deepening economic bust (Steigum 2004, p. 69). This happened when economic booms in Sweden and Finland were still accelerating.

Figure 1. **FINLAND: Banks' loan losses, changes in lending and nonperforming loans as well as corporate bankruptcies, January 1980 – September 2004**
Hodrick – Prescott smoothed (lambda: 1000) monthly time series



Source: Bank of Finland and FSA

Figure 2. **FINLAND: Loan losses & LLprovisions, million e**

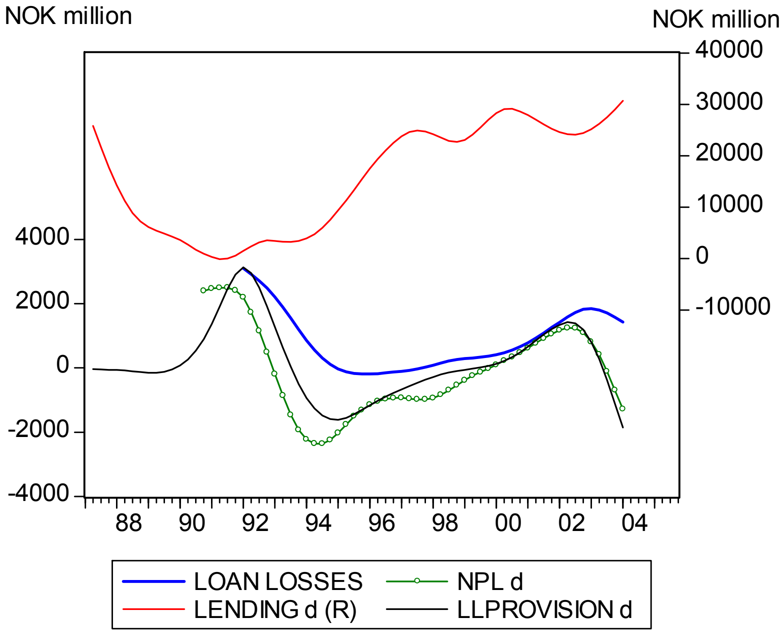


Source: Bank of Finland and FSA

Figure 3 shows Hodrick-Prescott filtered quarterly time series of the Norwegian banks' loan losses and changes in the stocks of lending, nonperforming loans and loan loss provisions. Similar kind of stylized facts can be traced here as in the Finnish case above. The peak in the change in lending was reached in 1986, according to the annual observations (Appendix A, available from the author by request). The change in lending had since decreased rather evenly approaching zero before loan loss provisions started to increase in late 1989. The change in loan loss provisions peaked in 1992 while loan losses already decreased. The Norwegian loan loss provisioning rules were changed in 1992 which probably affected the provisioning behaviour (see Appendix A). Also the change in NPLs started to diminish in 1991. Thus, there was some five years between lending boom and loan losses in Norway in connection of the banking crisis in the early 1990s. NPLs, loan losses and their provisions dived steeply after the peak years.

After the crisis period the Norwegian banks' annual lending has increased evenly as also the NPLs, loan losses and their provisions (Figure 3). The situation differs from that of Finland where both NPLs and loan losses have stayed on an extremely low level despite rather rapidly increasing lending. In 2000 there seems to be a kind of local maximum in the Norwegian banks' lending growth and a couple of years later in the changes in NPLs and loan loss provisions. In loan losses, this time, the peak is nevertheless about a year later. Hence, the dynamics between different banking distress indicators can vary in time. In the early 2000s the lag between the peaks in lending growth and loan losses seems to be only three years.

Figure 3. **NORWAY: Banks' loan losses and changes in lending, nonperforming loans and loan loss provisions, 1987Q1–2004Q1** Hodrick – Prescott smoothed (lambda: 50) quarterly time series



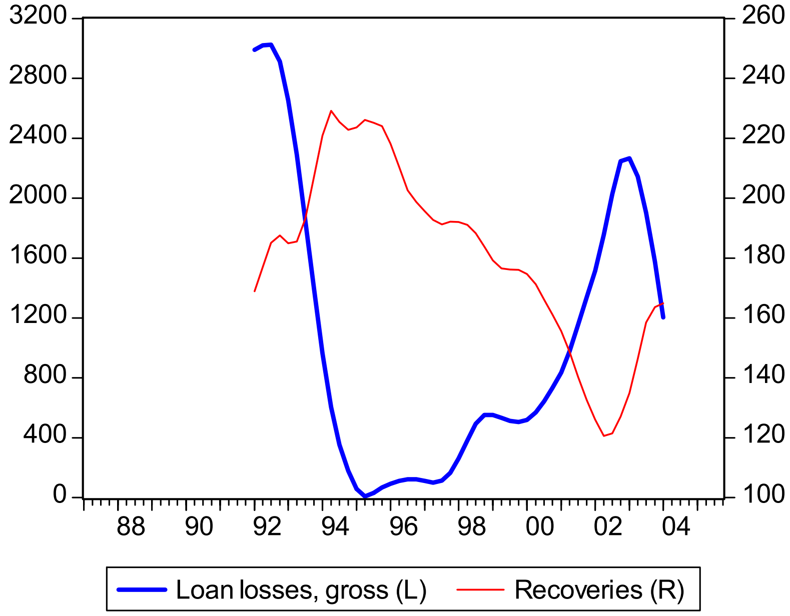
Source: Norges Bank

Loan losses in Figure 3 are expressed in net terms ie they include recoveries. That is the common way to publish loan loss figures. The Finnish loan losses in Figure 2 are expressed in net terms, too. The Norwegian data comprises also quarterly series of recoveries starting in the beginning of 1992.

In Figure 4 are Hodrick-Prescot smoothed gross loan losses (recoveries excluded) and recoveries plotted. First observation is that the amount of recoveries is relatively small. On the average, recoveries have been under twenty percent of gross loan losses in 1992–2003. Another feature is that it looks like recoveries would lag gross loan losses. The length of lag seem to be somewhere between half a year and a year. That is quite natural; a default probably 'produces' a recovery after the judicial process.

It might be worthwhile to mention in this connection that the average Finnish recoveries in monthly data from January 2000 to September 2004 have been almost 90 per cent of gross loan losses. The marked difference between the relative levels of Finnish and Norwegian recoveries might point to differences in accounting or statistical practices. However, as the loan losses have been on an exceptional low level in Finland in recent years, the validity of this comparison is questionable.

Figure 4. **NORWAY: gross loan losses and loan loss recoveries, 1992Q1–2004Q1,** Hodrick – Prescott smoothed (lambda 10), NOK million



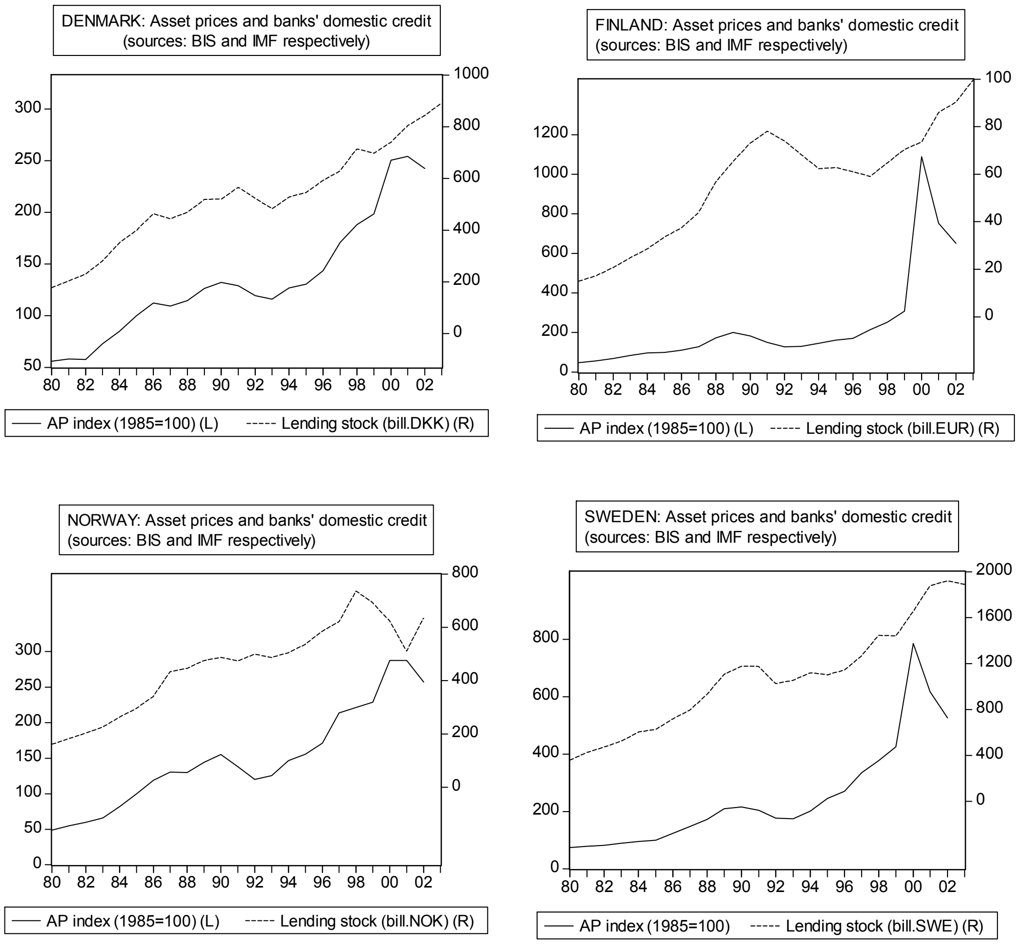
Source: Norges Bank

As mentioned earlier, Borio and Lowe (2002) have pointed out that a joint effect of asset prices and indebtedness can create a bubble like boom which tends to strongly increase financial fragility. Especially, if such a boom is followed by a rapid decline in asset prices, the likelihood of debt deflation is high. In Figure 5 the asset price index calculated in the Bank for International Settlements (BIS) and lending stock in four Nordic countries are plotted. It looks like the increase in asset prices would in many cases start a bit earlier than lending acceleration in the late 1980s.[6] It should be mentioned in this connection that the financial liberalisation started a bit earlier than the asset price and lending boom started in Finland, Norway and Sweden.[7] Some estimation experiments based on the Borio and Lowe's approach have been presented in Appendix 4.

[6] This is a parallel observation with one of the results of Davis and Zhu (2004), who concluded that commercial property prices are rather 'autonomous', in that they tend to cause credit expansion, rather than excessive bank lending boosting property prices.

[7] Englund and Vihriälä (2003) conclude that financial deregulation in Finland and Sweden contributed to that the credit booms, together with expansive macro policies, had a strong impact on aggregate demand. That led to banking crisis because of bad incentive structure and the absence of effective supervision. On the other side, Detken and Smets (2004) conclude, after analysing 18 industrial countries, that a relatively high real credit growth usually prevails in the first year of booms.

Figure 5.



3.2 Loan losses as the dependent variable

The loan loss provision data could in principle be used as proxy for the loan loss data but the difference between those two should be borne in mind. While a realised loan loss should be more or less a kind of real time event, the loan loss provision is an accounting concept. A loan loss provision is usually made when the likelihood of default passes some threshold. Loan loss realisation in gross terms (ie recoveries excluded) follows if and when the default takes place, although there can be some room for judgement in timing when the event is registered in accounting. There can however be a considerable time lag between gross and net (ie recoveries included) loan losses as there usually is some judicial process in between.

Furthermore, the statistical customs on loan loss provisioning differ. For instance, the loan loss will be abolished immediately from P&L account statistics when the provision has been made in Finland, while many other countries make a loan loss reserve in balance sheet where it waits for recovery. Only after applying the recovery the rest is then removed from statistics and the loan loss is ultimate. In Finland the recoveries are not tied to a specific reserve but are crediting the P&L account.

The concepts of specific and general provisions add an extra complication to the significant differences in provisioning rules and practices. Specific provisions are made on an individual basis on identifiable impaired assets, whereas general loan loss provisions can be made either against non-impaired assets or impaired assets that cannot be individually identified. The use of general and specific provisions varies both between countries as well as between time periods in some countries. Moreover, Spain has recently launched as statistical provisioning procedure, which focuses on decreasing the procyclical nature of provisioning and taking more into account ex ante credit risk (See eg Fernandes de Lis-Martines Pages and Saurina, 2000).

We can summarize the discussion about loan losses vs their provisions by saying that realized loan loss is a rather close to a kind of real time phenomenon and, hence, is more suitable as a dependent variable in the econometric analysis we are aiming at than loan loss provisioning. Moreover, the provisioning data is affected also by various kind of accounting interests. A further discussion about the differences between the timing of banks' loan losses and their provisions as well NPLs in the Nordic countries and a selection other EU countries is in Appendix A, which is available from the author by request.

4 Framework

We try first to place our research framework in the relevant macroeconomic context where firm bankruptcies are generated and, hence, loan losses to banks are caused.

As seen from the aggregate level, a certain amount of bankruptcies belongs to everyday business. This risk is normally taken into account when the numerous economic agents make different decisions about investing, borrowing or lending. Those decision makers even try to take into account that the probability of bankruptcies and defaults tend to vary in time for cyclical or other obvious reasons. Yet, economic downturns often seem to come as a surprise, at least to a part of economic agents. A normal business cycle alone nevertheless seldom triggers any systemic event in financial market.[8]

Usually there are some more fundamental reasons involved in launching a systemic event or crisis. These reasons can be 'external' like a change in economic regime caused by eg some more or less fundamental innovation, financial liberalization or so which seriously disturb the economic environment.[9] Financial fragility, in turn, could be classified into category of 'internal' reasons.[10] The two types of reasons can perform simultaneously because of their potential interaction. The earlier mentioned cyclical factor can be relevant also in this connection as financial fragility tends to be highest in recessions.

The empirical part of this study relies mainly on observations with strong cyclical component. Consequently, the cyclical element is clearly involved in analysis. We nevertheless must not forget that in many of the sample countries, eg Finland, Norway and Sweden, the economic recession was abnormally deep, as we saw in stylized facts. Hence, there might be both elements of cyclical variations and more fundamental structural breaks involved. Therefore, we introduce the story with some background observations about credit cycles vs. credit distress cycles.

4.1 Credit cycles

We mentioned earlier that banking crisis or distress is a very rare event in a single country and there can typically be several decades of tranquil time between systemic events. This means that not every downturn in business cycles necessarily create deep financial distress. Actually, Koopman, Lucas and Klaassen (2002) discusses the possibility of two parallel cycles affecting the business failure rates and, consequently, the amount of loan defaults.

[8] The concept 'systemic event' is not uniquely defined. For example, De Bandt and Hartman (2000) discuss the concept widely and thoroughly. Perhaps the simplest way is to approach it indirectly as De Bandt and Hartman (2000, p. 10) express it: 'A full systemic crisis in the financial system may have strong adverse consequences for the real economy and general economic welfare'. Allen and Gale (2004, p. 6), in turn, define that 'a systemic event occurs only if the number of defaulting banks is large enough to affect the equilibrium asset price'.

[9] Actually, Allen and Gale (2004b, p. 747) point out that the long tranquil time without banking crises between the second world war and the early 1970s was due to a world wide tight banking regulation. The collapse of Bretton Woods agreement started a general deregulation development ending the tranquil time.

[10] Allen and Gale (2004) focus on the internal causes of crises. A default can in a fragile system contagiously spread through the interbank asset market. This is however outside the scope of this study as we focus only on the aggregate level banking sector.

Koopman, Lucas and Klaassen find in addition to a short, ten-year, credit cycle a longer cycle which lasts about 40 years.[11] It could be that, for example, a coincidence of the troughs of those two cycles creates a circumstance where a probability of a systemic financial event is high.

The authors do not discuss or model very widely the intuition of internal dynamics or macroeconomic determinants of those cycles as do eg Kiyotaki and Moore (1997) or von Peter (2004). Kiyotaki and Moore have constructed a dynamic credit cycle model. Credit constraints on firms in form of diminishing collateral values start an oscillating economy between certain floor and ceiling where recessions lead to booms which, in turn, lead back to recessions.[12] With numerical simulations they estimate the length of a cycle to be about 10 years.[13] According to a theoretical model designed by von Peter (2004), a macroeconomic shock can reduce asset prices with a debt deflationary effect. In the worst case it can lead to a credit crunch situation as banks' insufficient capital base starts to limit lending.

When a credit cycle is vigorous enough so as to cause a systemic event, we could talk about credit distress cycle. As we will see later, one important factor in generating distress cycles is financial fragility. The situation could be compared with tsunami shock waves, which do little harm in deep waters ('low fragility') but when they come to a shallow area or shore ('high fragility') they have an enormous destroying power.

4.2 Credit distress cycle

A significant increase in banks' loan losses does not emerge suddenly as we saw in stylized facts. Loan losses have a rather long gestation period when the borrowers' vulnerability or fragility to negative shocks gradually increases. An unexpected impact, for example a macroeconomic shock, causes then increased number of bankruptcies and loan defaults. Economic agents naturally try to adjust their actions and plans according to the new environment and outlook. However, the net worth of the most fragile agents – measured usually with indebtedness – can turn negative causing defaults.

The systemic event or crisis, which hit Norway, Sweden and Finland in the early 1990s, could be called a prototype of credit distress cycle. Credit distress cycle has four stages as seen from macro level. First, some reason triggers an

[11] For curiosity, there might be some consensus among researchers about so called long inflation cycles of some 40–60 years. See eg Korpinen 1981. Those cycles can be triggered by some fundamental technological innovations or political reasons.
[12] Nobuhiro Kiyotaki and John Moore: Credit Cycles, Journal of Political Economy, 1997 vol. 105, no. 2.
[13] Kiyotaki-Moore (1997, p. 238).

accelerating indebtedness. Second, the accelerating indebtedness gradually increases financial fragility. Third, the sudden deterioration in macroeconomic circumstances and outlook aggravates borrowers' ability to honour their obligations. NPLs and loan loss provisions increase. Fourth, increased amount of loan losses follow. The whole cycle can take several years.

There have been a number of studies on the different phases of credit distress cycle. Keeton (1999) states that relaxed loan standards by banks can generate lending booms that end up in increased loan losses. In that case banks tend to reduce the interest rate charged on new loans and to lower their minimum credit standards for new loans.[14]

It is possible that mere expectations of exceptionally vigorous growth can initiate such a lending boom, where the problems of asymmetric information become significant. Even borrowers who have no intention to repay can get loans in certain cases, as banks' project screening resources become stretched. In those cases no significant shocks are needed to generate loan losses. Allen and Gale (2004) approach the same idea from a bit different viewpoint. They assume a sunspot equilibrium where prices can fluctuate in the absence of aggregate exogenous shocks and crises appear to occur spontaneously provided a sufficiently fragile financial system where contagion is the propagation channel.

Financial liberalisation has often been a cause of lending booms. According to Gourinchas et al (1999), a poorly regulated financial liberalisation in particular tends to end in a banking crisis. A lending boom is the natural outcome of liberalisation in a country that has had an overly regulated banking industry. The ratio of credit to GDP is usually considerably lower in strictly regulated countries than in countries with less repressed financial markets.[15] Eichengreen and Arteta (2000) get a similar result using a sample of emerging market economies. This suggests that a banking system is most at risk when financial deregulation and macroeconomic environment combine to create an unsustainable lending boom.[16]

This kind of changes in policy regimes can produce the structural breaks, mentioned by Koopman, Lucas and Klaassen (2002). Those breaks can disturb economic model parameters. One such structural break was the imposing of a tight financial regulation in the USA in the aftermath of problems in the 1930s. Another one is the relative quick deregulation in several European countries in the

[14] In contrast, an increase in lending due to a shift in borrowers' demand for bank loans or their productivity will not necessarily lead to increased loan losses, see Keeton (1999, p. 61–63).

[15] Gourinchas et al (1999, p. 33). The authorities compared 80 cases of lending boom episodes in a sample of over 90 countries.

[16] Barry Eichengreen and Carlos Arteta: Banking Crises in Emerging Markets: Presumption and Evidence, Centre for International Development Economics Research Working paper 115, August 2000, Haas School of Business, University of California Berkeley, p. 29.

1970s and 1980s.[17] A third one could be the introduction of euro, which might have a financial stabilizing effect.

Regarding the second phase of credit cycle, Borio and Lowe (2002) have shown that combined asset price and lending boom increases risk for banking distress (see also Hansen, 2003, for the Nordic countries and Dinc and McGuire, 2004, for Japan). If the asset prices grow vigorously boosted by borrowed financial resources (collateralized by the same assets), the probable sudden fall in prices later decreases the collateral value of debt. That can start a debt deflation process as the nominal value of debt stays unchanged.[18] A vicious circle of debt deflation can also start and spread in fragile interbank market according to Allen and Gale (2004, p. 7). The result is that banks are forced to default and liquidate assets because their prices are low and, on the other hand, asset prices are low because weakened banks are forced to sell them, as Allen and Gale put it.

If there is an asset price bubble, the underlying deterioration in fragility is hidden until the bubble bursts and the indebtedness abruptly worsens because the asset price fall cuts borrowers' wealth. The whole process, from lending to asset price bubble and the following defaults, can take a rather long time. Perhaps the building of such bubble is boosted by overly optimistic expectations in a period when the ridges of Koopman, Lucas and Klaassen's short and long cycles coincide.

The third and fourth phases, shock, bankruptcies and loan losses have been econometrically studied with diverse Nordic data by Pesola (2001) and Fröyland and Larsen's (2003). According to Pesola (2001), a combined effect of fragility and shock was the crucial factor for increased loan losses. The financially fragile Nordic countries were hit by several severe macroeconomic shocks in the late 1980s and early 1990s.[19]

If an economic recession will be sufficient severe in the fourth phase, certain dynamics may start to work. A vicious circle can emerge, in which bankruptcies and loan losses give rise to new bankruptcies and so on until a banking crisis. A deep banking distress/crisis situation can become a vicious circle where loan losses hit banks' capital base limiting lending capacity and eventually cause credit crunch. According to a theoretical model designed by von Peter (2004), a macroeconomic shock can reduce asset prices with a debt deflationary effect. The following increase in firm bankruptcies and defaults causes growth in banks' loan losses. A modest shock can be absorpted by banks' capital bufferts, but when a

[17] Even though the timing of different liberalization measures differ between countries, it can be said that the bulk of financial liberalization is placed in the 1980s (see eg Demirgüc, Kunt and Detragiache (2001) p. 100 and Wyplosz (2002) p. 32 and Lindgren, Garcia and Saal (1996) p. 47–51. Yet, the big countries in our sample Germany (the late 1960s) and UK (the early 1970s) as well as also Belgium (the early 1970s) liberalized lending rates far earlier than the Nordic countries (see Bingham 1985, p. 131).

[18] The idea of debt deflation was originally stated by Fisher (1932 and 1933).

[19] Koskenkylä (2000), Drees and Pazarbasioglu (1998).

shock is sufficiently severe the induced loan losses probably reduce banks' capital. This can set in a credit crunch development and a related further asset price decline according to von Peter. The adverse developments described in both that and the above mentioned approach of Kiyotaki and Moore model, curb macro level investment activity and growth, which probably leads to further loan losses as a feedback effect.

Kocherlakota (2000) couples the financial and real cycles closer together. According to Kocherlakota, credit constraints are an asymmetric propagation mechanism where changes in fiscal and monetary policy can lead to big, persistent changes in aggregate output. If producing agents are close to their borrowing limits, the shock could depress output dramatically.

Recently Dell'Ariccia et al (2005) have found empirical evidence that bank distress has an adverse effect on growth in real terms, as banks must cut back their lending. Among other things, this effect is the stronger the more severe the distress is. In those cases, the bank lending channel can ratchet up the macroeconomic effects of an adverse shock, leading to a downward spiral in which a contraction in economic activity and bank distress reinforce each other.

In this study we mainly focus on the third and fourth phases of the credit distress cycle. Also the second phase, when the financial fragility is aggravating, is paid attention to.

4.3 The basic model

The aim in this section is to construct a simple equation, which gives a macroeconomic explanation to banking sector's aggregate loan losses. We approach the explanation from the viewpoint of credit distress cycle ie a situation where a financially fragile economy faces a severe macroeconomic shock. The equation will then be empirically tested in the data set of a panel of the sample countries. Despite the straightforward search for explanation on macroeconomic level, it might be helpful to start on the microeconomic level in order to easier introduce some crucial concepts and definitions. Those are then modified, with certain restrictions, to apply on the macro level.

4.3.1 A microeconomic approach to explain banks' loan losses

Our microeconomic framework is based on a theoretical approach to credit default modelling, which Moody's KMV Corporation's Credit Monitor has made instrumental.[20] According to that framework, a bank's expected loan loss LT_i^e for a single loan is a product of probability of borrower's default P_i, the amount of loan L_i (given) and the expected rate of loss given default LGD_i^e:

$$LT_i^e = P_i \cdot LGD_i^e \cdot L_i$$

where expected variables are denoted with superscript e, like in LT^e.

The approach is illustrated in Figure 6A. For the illustrational point of view we keep the underlying assumptions as simple as possible and also drop out subscripts i. Assume that a bank lends money to a firm for buying a producing asset. The value of asset is set by the net present value of expected future sales profits of its products. Point L on vertical axis marks the amount of loan. Assume a bullet type loan which is collateralized with asset A and has to be paid back at time point H.[21] There is no problem as far as the asset value is larger than debt L. Instead, if the asset value is smaller than the loan at H, the loan is defaulted. That is the case for an alternative asset A'. The amount of bank's ultimate loan loss depends on the resale value of collateral. In this case the loss is $L\text{-}A'_H$.

Before lending, the bank estimates a probability distribution of asset values at H, as does also the borrowing firm for its part.[22] The default probability P is shown as a black tail area in Figure 6A. Hence, P is derived jointly from the expected distribution of the value of asset A and from the amount of loan L at H. The expectation in that particular case is that the asset value is A^e at the time horizon H in Figure 6A.

The position and form of an asset value distribution can vary depending on the macroeconomic situation and outlook.[23] In Figure 6B three alternative possible distributions are drawn. Distribution ed3 is an example of a curve with more optimistic expectations than is the case with distribution ed1. Consequently, the estimates of default probability (lending given) are different when the cyclical outlook is for upswing than for downturn, but in all of the alternative expectation cases a financing with loan looks profitable.

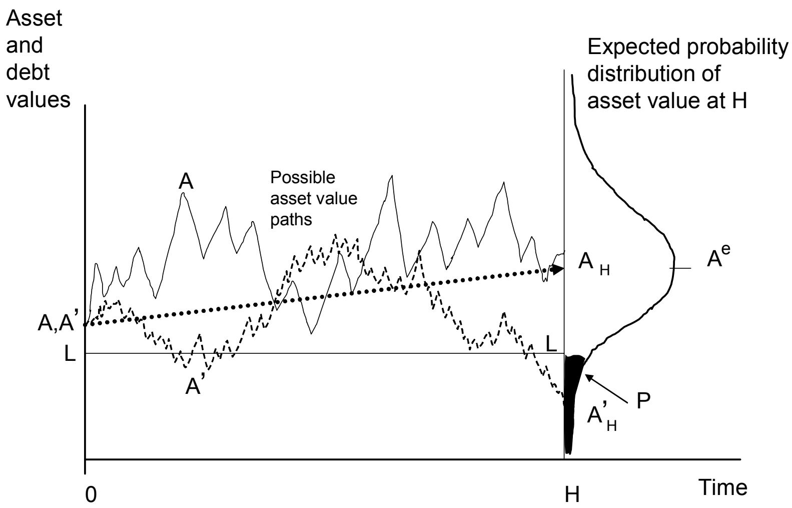
[20] See eg Bessis 2003, p. 479. The original idea of this approach is presented in Merton's article in 1974. According to his option theoretic approach – assuming that markets are complete and efficient – a firm's equity is viewed as a put option to be sold to lenders with a strike price equal to debt. If the firm's equity holders cannot repay the debt, they exercise their option, and the lenders get the assets.

[21] From the option theoretic viewpoint we assume an European put option allowing exercise at horizon H only.

[22] These follow a lognormal distribution in the option theoretic approach.

[23] Allen and Saunders (2003) have widely analysed the cyclical variation in distribution functions.

Figure 6A



The form of distribution indicates the degree of uncertainty. Distributions ed1 and ed2 in Figure 6B have same expected value of A but the form of ed2 is flatter. Consequently, in ed2 probability of extreme outcomes for the value of A is expected greater than in ed1, which has a steeper form. The flatter form points to a bigger uncertainty ie a larger volatility in the expected value path of asset A.

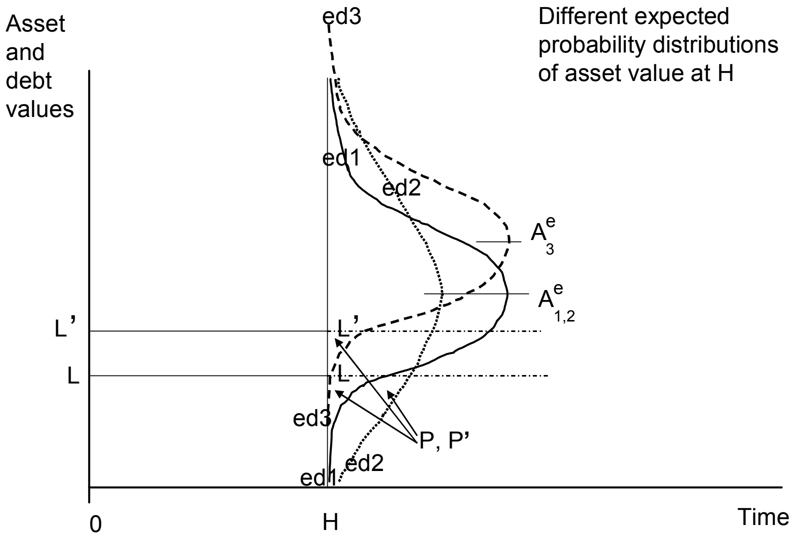
The concept of fragility and how it depends on the mutual positions of the ed-curve and the amount of loan is illustrated in Figure 6B. It was shown above how the default probability P depends on the amount of loan. For example, P grows as the amount of loan is increased from L to L' in Figure 6B. For example, as compared to the rather 'safe' combination of distribution ed3 and loan L, the situation is clearly riskier if the amount of debt happens to be L'. The downward shift of probability distribution (eg from ed3 to ed1; L given) has a similar effect. The business with asset A looks now riskier than during the lighter outlook. Also an increased uncertainty (asset price volatility shifts from ed1 to ed2) means increased fragility.

Hence, increasing leverage raises fragility simultaneously through two channels. The probability of default grows extending, in turn, the room for the size of potential loan losses. Instead, the last mentioned effect is not present if a shift in expectations alone raises fragility (eg from ed3 to ed1; L unchanged). Note that existing debt is a necessary condition of fragility by definition. A system without debt financing cannot be fragile.

Economic shock can be illustrated simply as such a deviation of the outcome from expectations that it causes a loan default, for example the case A'_H in Figure 6A. Such a shock can be a macroeconomic or idiosyncratic, a firm specific, shock. Both of them can affect the profit outlook so that the asset value sinks below the amount of loan. As the borrower's net worth is negative at the moment of payback

(H), the firm goes bankrupt causing a loan loss to the lender. The bank's net loan loss depends on the selling proceeds of the asset.

Figure 6B



An important observation for the later use is that the combined effect of shifts in either the distribution or the amount of lending on P is non-linear due to the form of the density function of the distribution ed. In particular, the effect is increasingly non-linear on the relevant part of the ed due to the convexity of the density function in the lower end of the ed.

It would perhaps be worthwhile to remind in this connection that net loan loss, probably varies (ceteris paribus) according to the cyclical situation. The asset value tends to be lower in recession than in boom.[24] On the aggregate level this means that the recovery rate and, hence, the LGD varies. We will discuss that more in the empirical part.

4.3.2 Macroeconomic model for loan losses

We move now from a single loan over to the total lending of a banking sector. Ultimately, we are interested in banking sector's realised total loan losses.

We start with the equation of an expected single loan loss in section 4.3.1

$$LT_i^e = P_i \cdot LGD_i^e \cdot L_i$$

[24] A wide discussion and research references are presented eg in Altman et al (2002). In many studies have a simplified assumption made that recovery rate is constant.

Next we analyse with the help of tools used in figures 6 how a single realised loan loss is generated. A realised loan loss LT_i is a result of the difference between the loan L_i and asset (collateral) A_i provided that the value of asset is short of the amount of loan

$$LT_i = L_i - A_i \quad \text{if} \quad A_i < L_i$$
$$LT_i = 0, \quad \text{if} \quad A_i \geq L_i$$

If the value of asset is higher than the amount of loan, there are no loan losses. That can be expressed with the help of a binomial indicator function I, which 'picks' the default cases

$$LT_i = I(A_i < L_i) \cdot (L_i - A_i)$$

Aggregating the function of single realised loan loss over banks and borrowers[25] and dividing with the aggregated total banking sector loans gives the following simple relation between banking sector's loan loss ratio and its driving forces

$$\frac{\sum_i LT_i}{\sum_i L_i} = \frac{\sum_i \left(I(A_i < L_i) \cdot (L_i - A_i) \right)}{\sum_i L_i}$$

Two things drive the aggregate loan losses. Analogical with Figures 6: One is the set of those asset value outcomes which are connected with excess leverage giving the cases of defaulted firms. Another is the difference between loans and their collaterals in the default cases. That in turn gives the size of ultimate loan loss in each case (loan loss in net terms). Adding together the ultimate losses gives the aggregate amount of loan losses.

The empirical part constraints the analysis in two crucial ways, which must be taken into account at the outset. First, we cannot directly observe ex ante variables or expected variables. Second, we have no such asset value data either at firm level or at aggregate level which, as such, could represent collateral values. Instead, we have observations on banking sector's realised aggregate loan losses and outstanding lending stock. Consequently, we have to approach the phenomena of economic shocks and financial fragility indirectly.

Financial fragility F can be indicated at the macro level by the ratio between banks' outstanding debt L and borrowers' total assets (wealth), A: F = L/A. For

[25] This can be done by assuming no correlation between the individual loan portfolios to be 'aggregated'. In reality, there probably is correlation, which tends to give amplified variations to the aggregate level of loan losses. In addition, the correlation tends to skew the loan loss distribution towards big losses.

simplicity, we have dropped out subscripts i and the sum-operators because the symbols now refer to aggregate banking sector. As we saw earlier, indebtedness, and financial fragility, can be built gradually in lapse of several years before a systemic event hits markets. Thus, fragility is usually changing rigidly and should be rather easy to anticipate. Consequently, regarding the fragility as a base for borrowing and lending decisions, we can assume that the known fragility of preceding period F_{-1} is used

$$F_{-1} = \frac{L_{-1}}{A_{-1}}$$

That is the only part of fragility we have available in practice as the ex ante probability distributions of asset values (shown in Figures 6) cannot be observed.

Regarding economic shocks, we are looking at the aggregate level of banking and borrowers. Hence, we abstract away the idiosyncratic events and focus on the macroeconomic shocks only. A macroeconomic shock S_j ($j = 1,\ldots,m$) is defined as the difference between realized variable X_j and its expected value, X_j^e

$$S_j = X_j - X_j^e$$

There are several potential macroeconomic variables X_j which may be hit by a shock with adverse effect on firms' profit outlook, asset (collateral) value and eventually borrowers' ability to honour their obligations. For example, the demand can surprisingly drop forcing the firms to production or price cuts. The reason behind could, among other things, be a drastic change in exchange rates. Interest rates can increase suddenly caused, say, by a change in investor sentiment. Wages or raw material prices can raise costs surprisingly fast. The original cause triggering those sudden changes can be war, natural catastrophe, a new innovation or, simply, a surprising political change. There are of course also positive shocks too, but those usually do not immediately threat the financial balance.

Macroeconomic shocks S_j affect aggregate asset value A in the current period ($=\Sigma A_i$)

$$A = f(S_j)$$

If we assume a sufficiently short time period, the effects of the shock does not change expectations. As fragility is set by the situation in preceding period, then the only variable affecting loan losses in the current period is asset value A ($LT = L-A$). Hence, macroeconomic shocks affect loan losses or loan losses over lending LT/L

$$LT/L = f_s(S_j)$$

Next we look at how fragility and macroeconomic shocks affect jointly the aggregate net loan losses. As we saw in Figures 6, both expected values of A_i and the amount of loan L_i affected the P, expected amount of loan losses, by a non-linear way. The non-linear relationship between loan losses and the explaining shock and fragility variables can also be motivated by empirical experiment. The severe banking distress situations are rare, but their eruption has many times developed a systemic crisis. The correlation between asset prices tends to amplify cyclically their price variation. For instance, the asset prices are likely to be depressed the stronger, the deeper the economic depression is. Moreover, Drehmann (2005) has recently empirically shown that the macroeconomic explanatory factors have a clear non-linear impact on credit risk.

Hence, the realised loan losses of banking sector are affected by combined effect of financial fragility and macroeconomic shocks, which appear in the relevant macroeconomic variables or hit those variables (Pesola 2001). The basic idea about how the probability of crisis depends on the interaction of fragility and shock is illustrated in the simple matrix presentation below

Probability of banking distress in different states

Shock / Fragility	Weak	Severe
Low	**Unlikely**	**Possible**
High	**Possible**	**Likely**

For example, in a very fragile system, a fairly weak shock could be sufficient to trigger a crisis. Thus, banks' loan losses are determined jointly by elements of fragility F and macroeconomic shock S

$$LT/L = f_x(F_{-1} \cdot S_j)$$

If we assume that the shocks are uncorrelated with each other, we can express the set of different macroeconomic shocks in an additive form. Hence, by further assuming a linear f_x and by combining fragility F and shock S terms we get the following model for the banking sector's loan losses divided by lending

$$\frac{LT}{L} = f_x(F_{-1}\sum_j S_j) = b_j \frac{L_{-1}}{A_{-1}} \sum_j (X_j - X_j^e)$$

Coefficients b_j measure the sensitiveness of loan losses to macroeconomic shocks, given fragility L_{-1}/A_{-1}. Lagged fragility L_{-1}/A_{-1} increases loan losses, given adverse macroeconomic shocks. Further model specification will be left to the connection of econometric analysis.

Regarding the empirical analysis, the extremely simplified assumptions made above must be relaxed somewhat. Especially, as we use annual data, there are some dynamic features which must be taken into account in the empirical part as is laid down in following examples.

Surprising negative macroeconomic shocks weaken the profit outlook and, hence, debtors' resources to pay back loans. The more severe the shock is, the bigger is the number of defaulting firms with negative net worth (like case A'_H in Figure 6A). The situation can get even worse, as an unfavourable outlook tends to generally depress asset prices. As illustrated in Figure 6B, many individual probability distributions move downwards after such a shock resulting in an increased expected fragility. The observation time unit which we use, a year, is long enough so as to embrace such dynamic reactions.

Borrowers' first reaction immediately after a shock might be to borrow more so as to bridge over the problems. After a while, when the severity of shock has been fully appreciated, borrowing is likely to start to decrease. Both lenders and borrowers become more cautious along with the deteriorated outlook. Despite it, fragility will get worse as long as the gloomy outlook depresses asset prices faster than the amount of loans shrink. Such a debt deflation situation can generate a vicious circle of continuous firm bankruptcies and eventually a systemic event.

5 Empirical study

As wide country sample as possible is important in order to get more universally valid results in the econometric study. That is why the sample of countries is widened outside the rather homogeneous area of four Nordic countries: Denmark, Finland, Norway and Sweden. However, the data limitations unfortunately limit the set of additional countries to only Germany, UK, Spain, Belgium, Greece and also Iceland.

The main tool in the econometric study is pooled least squares, where a panel of countries is estimated. The estimations are done in two sets: the Nordic countries only and all the sample countries.

5.1 Estimating the basic model

5.1.1 Model specification

According to the framework derived in chapter 4, banks' credit risks will be realised because of the joint effect of financial fragility and economic shocks. Realized credit risks cause loan losses to banks as firms go bankrupt and households become unable to repay their debts. According to the discussion in section 3.2 the choice for dependent variable is banks' loan losses divided by total lending. The dependent variable country by country is shown in Appendix 1.

As it is reasonable to keep the model parsimonious, only a limited set of the most crucial macroeconomic shock factors are included in it. In this particular approach we limit the variables to income shock and interest rate shock variables. Y stands for net income which includes both sales proceeds and related costs. Interest rates which represent capital costs are denoted by r.

By combining fragility and these shock terms we propose the following empirical model for banks' loan losses relative to lending

$$\frac{LT}{L} = f_x(F_{-1}\sum_j S_j) = b_1 \cdot \frac{L_{-1}}{A_{-1}}(Y - Y^e) + b_2 \cdot \frac{L_{-1}}{A_{-1}}(r - r^e)$$

The dependent variable, banks' (net) loan losses relative to lending, is assumed to depend negatively on the first term and positively on the second term. For example, a negative net income shock, the outcome falls short of expectations, tends to raise loan losses. Consequently, the sign of coefficient b_1 should be negative, $b_1 < 0$. Interest rate shock, the outcome exceeds expectations, tends to raise loan losses, so coefficient b_2 should be positive, $b_2 > 0$.

Regarding the operationalization of explanatory variables, fragility is presented by aggregate indebtedness, L/A.[26] As there is no appropriate aggregate wealth data available for all the sample countries, we use GDP value data to represent A in estimation. Debt L is banks' total outstanding lending stock. We denote this indebtedness indicator (L/GDP) by LYV. Indebtedness indicator covers thus both the corporate and household sectors.

Consequently, we implicitly assume that roughly the same behavioural principles apply both to households and firms. Moreover, these two sectors are closely interconnected. Indebtedness and macroeconomic shocks affect both sectors roughly similarly. For instance, deteriorating outlook weakens households'

[26] Indebtedness is, according to the IMF, one of the crucial macroprudential indicators. Both the firm debt-equity ratios and household indebtedness are listed as important aggregated microprudential indicators (see the IMF, 2000).

employment and wage income expectations and high indebtedness raises the probability of loan default.

Hence, it is assumed that given adverse shocks indebtedness affects loan losses positively – an increase in indebtedness tends to raise the amount of loan losses. Furthermore it is assumed that the lender knows borrower's indebtedness when they agree on a new loan. Consequently, indebtedness is lagged by one year in the model to be estimated. In many countries fragility increases before loan losses (see Appendix 1).

The plans of economic agents are based on the current state of affairs, the economic outlook and expectations. As expectations are incorporated in agents plans macroeconomic shocks lead to unexpected deviations from these plans. Although economic agents may try to react by changing their actions and plans, the effect of a shock can be seen in the number of bankruptcies, unemployment development and eventually in loan losses.

We start from the assumption that the basis for agents' expectations is the outlook for GDP, which represents generally the expected flow of income. For practical reasons we use growth figures instead of level data and denote the expected growth of GDP by y^e. We can do that as the agents know the outcome of preceding period Y_{-1} and the expectation is directed to the outcome of current period Y^e. Thus, $y^e = (Y^e – Y_{-1})/Y_{-1}$ and correspondingly realised GDP growth $y = (Y – Y_{-1})/Y_{-1}$.

These expectations in turn affect investment and borrowing plans, ie future indebtedness. This variable also includes both firms and households.[27] Interest rate is another crucial variable which directly affects the profitability of an investment project financed by borrowed money.[28]

Instead of deriving theoretically the optimal function for expected GDP from an underlying theory, we use the OECD forecasts for the sample countries on percentage changes in GDP volume and GDP deflator, denoted by y_q^e and y_p^e respectively.[29] It is assumed that a positive shock or surprise in GDP volume, $y_q - y_q^e$, decreases the amount of loan losses and vice versa at any given level of fragility.

The effect of a GDP deflator surprise, $y_p - y_p^e$, can nevertheless be ambiguous ex ante. The direction of the effect depends on whether the change in deflator is due to demand pull or cost push. In the latter case the surprising increase in deflator tends to boost the amount of loan losses.

[27] To be exact, both variables, indebtedness and GDP, as well as also lending rate, include public sector and net export. Public sector could be treated here as an extension of household sector.

[28] Even though a project is not financed by loan capital, the alternative cost of interest rate (and its expectations) affects the selection of projection (ie whether to start the project at all or to invest the money on other placement). Hence, it affects indirect on the investment project.

[29] We use the june forecast in each year in OECD economic outlook as the forecast for the GDP next year.

By adding together the GDP volume surprise part and deflator surprise part we get an income surprise variable $y_q - y_q^e + y_p - y_p^e$. We denote that income surprise variable YS. Despite the ambiguity in the deflator surprise part of income surprise variable, we assume that income surprises affect loan losses negatively at any given level of fragility.

Regarding the interest rate[30], the difficulty is that usually there are no regularly published predictions of that variable by the OECD or any other public body. However, assuming it behaves approximately like a random walk, we can simply use annual changes in interest rate to measure unexpected changes in them.[31] On these grounds, we assume that an increase in interest rates will tend to increase loan losses.

As the price expectation component already is included in income surprise variable, we use a change in real bank lending rate in order to avoid duplication in explanation. Thus, the change in OECD GDP deflator forecast, $y_p^e - y_{p-1}^e$, is subtracted form the change in nominal lending rate. The resulting real interest rate surprise variable is denoted RS.

We discussed in section 4.2 that if an economic recession is sufficiently severe, a vicious circle can emerge, in which bankruptcies and loan losses generate new bankruptcies and so on until a banking crisis. A theoretical basis for this kind of development is laid down by Kiyotaki-Moore and von Peter.[32] If banks' capital base is hit and lending capacity thus limited, the situation can eventually cause credit crunch. Furthermore, Dell'Ariccia et al (2005) have found empirical evidence of a feedback effect from banking distress to macroeconomic growth, which – in turn – reinforces additional distress. This connection is striking especially in severe cases of distress. A lagged dependent variable can capture the feedback effect in such a vicious circle.

Moreover, the residuals in a preliminary estimation without lagged dependent variable as a regressor displayed statistically significant positive autocorrelation. The autocorrelation in residuals looked particularly striking during the crisis years. Also the explanatory power of estimated equation was rather poor. These

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[30] Exchange rates and terms of trade are other relevant variables for formation of expectations that are mentioned in the literature. In particular, in the Nordic countries (small open economies) they should have an significant impact (see eg Pesola 2001).

[31] In an augmented Dickey-Fuller one sided test the hypothesis assuming a unit root for interest rate series had to be rejected in three of ten sample countries. Hence, assumption of random walk could not be rejected in seven countries.

The static expectations for interest rates can also be motivated by a period of regulation, especially in the Nordic countries. The financial markets were strictly regulated in the Nordic countries until the 1980s, when a gradual liberalization started. Interest rates were very rigid during regulation and there is usually some inertia in changing the way in which expectations are formed (Pesola 2001).

[32] See the discussion in section 4.2 and Kiyotaki and Moore's (1997) and von Peter's (2004) theoretical analyses. Van der Zwet and Swank (2000) present empirical evidence on cases where financial fragility affects macroeconomic performance.

facts indicate that the variation in dependent variable has some persistence, which seems not to be captured with the other explanatory variables. Hence, the once lagged dependent variable is incorporated as an explanatory variable in the equation to be estimated.

Based on the above discussion the basic model for estimation of loan losses is thus as follows

$$LTL = d_1 + d_2 \cdot LTL_{-1} + d_3 \cdot YS \cdot LYV_{-1} + d_4 \cdot RS \cdot LYV_{-1} + u$$

where

LTL	=	$\frac{LT}{L}$ = loan losses per banks' outstanding lending stock
YS	=	$y - y^e$ = income surprise (y = actual nominal percentage growth of GDP, y^e = expected nominal percentage growth of GDP, based on the OECD forecast in June preceding year)
RS	=	change in real interest rate
LYV	=	indebtedness indicator: banks' domestic credit L divided by GDP in current prices, YV: L/YV (a proxy for L/A where L = total debt, A = total assets)
d_1, d_2, d_3, d_4	=	coefficients ie the parameters to be estimated
u	=	residual

YS and RS are shock variables and LYV is the fragility variable in the model. Coefficients d_2 and d_4 should both get a positive sign whereas coefficient d_3 should be negative. Lagged indebtedness is as a kind of magnifying factor. As fragility increases, the effect of a surprising shock likely gets stronger.

Although the model is closed economy model it contains many elements of open economy, which give right to apply it in the small open economies like the Nordic and some other countries in our sample. First of all, the income shock often comes from exports. Also interest rate and asset prices are more and more international phenomena along with liberalised capital movements. The Economic and Monetary Union (EMU) and the introduction of euro have removed the exchange rate uncertainty between the euro area countries, which earlier easily increased tensions also in interest rates. The EMU has thus contributed to the financial stability of its member countries and also indirectly to the other European non-member countries. While the EMU has changed the whole euro area towards a closed economy system, it has at the same time contributed to the opening of the economies in its member countries.

5.1.2 The role of recoveries in net loan losses

Loan loss variable is expressed in net terms. It is worthwhile to look at the recoveries a bit closer in this connection as it affects the timing of observed loan losses and at the same time it might give extra cyclical dynamics to net loan losses.

As seen first from the viewpoint of a single loan, the ultimate amount of loan loss depends on the market value of the loan's collateral. The timing of ultimate loss depends on the length of judicial process needed to close the case and to sell the collateralized asset. Both the resale value and selling time may vary along with the macroeconomic situation and outlook, in addition to the micro level specific factors. The usual case is that the recovery does not cover the whole value of the defaulted loan, but only a part of it. Hence, the creditor also suffers some loss ultimately.

On the banking sector level in a selected time period (eg a year), deducting the aggregate flow of recoveries from the aggregate flow of new loan losses (gross) gives the flow of net loan losses. It is however likely that the recoveries observed this year are due to gross loan losses in earlier years.

Interesting cyclical dynamics follows for the aggregate flow of net loan losses. For example, a downturn generates increased gross loan losses, which probably will be (at least to some extent) recovered later. If then an upswing is already going on, the amount of new gross loan losses is decreasing, while the prices of collateralized assets are increasing. On the other hand, a cyclical peak reduces the amount of new loan losses, which in turn generates decreased recoveries to be observed in a downturn when also collateral prices are decreasing. The likely result is an amplified cyclical pattern in net loan losses as compared to the gross ones. The earlier in section 3.1 analysed Norwegian case points to that direction (see Figure 4). See also Altman et al (2002, p. 21) where different approaches in empirical studies regarding recoveries in loss given default are compared.

5.1.3 Econometric estimation

The sample of countries consists of the Nordic countries, Belgium, Germany, Greece, Spain and UK. Model estimation is done separately both with the panel data of four Nordic countries and with the larger panel data including both the Nordic and the additional available EU-15 countries. The summary of results is presented below in Table 1. The extensive set of econometric test results and graphs of the respective country by country model fit are shown in Appendix 2. The equation numbers in Appendix 2 correspond to those in Table 1.

The basic estimation was first done for four Nordic countries in period 1983–2002. The method of seemingly unrelated regression (SUR) was applied in estimating the model on pooled data. Preliminary estimation results suggested the data favours a specification with a once lagged real interest rate variable on the right hand side

Model 1a is able to explain more than 70% of the observed variation in loan losses relative to total loans, which as such is satisfactory. The coefficients have expected signs and are all significant at conventional confidence levels. Modest positive autocorrelation remains in the residuals. Proper caution should, however, be exercised in interpreting the DW-statistic when a lagged dependent variable is on the right hand side of equation.[33]

Therefore, a separate Wald test was run on the residuals. According to the results of Wald test the hypothesis of no first order autoregression in the residuals could not be rejected except for Sweden (see Appendix 2). Ie the lagged dependent variable did not totally remove the problem of positive autocorrelation from the Swedish part of the model.

The SUR estimation method should, with panel data, give more precise coefficients, as it takes into account possible contemporaneous correlation between the country specific regression error terms.[34] As a small, fairly homogeneous open area, the Nordic countries can be affected by some common outside factor that is not captured here. Furthermore, as close neighbouring countries, their trade and other economic ties make the contagion of events between the countries fast and easy. The SUR estimation can eg take such omitted factors into account in this particular case.

Figure 7 shows actual and fitted loan losses as well as out of sample forecasts for 2003 and 2004 plotted for Finland. The model fit is in general good. The fit is particurly good during the banking crisis years. The relatively poor fit in 1992 is due to an exceptional amount of filed loan losses associated with the bank support offered by the Finnish Government that year.[35] In the 1980s and again early this decade the model tends to generate changes in loan losses that did not materialize. Those features could be explained by the fact that, on the other hand, loan losses in the 1980s remained modest under the then prevailing tighter financial market regulation. The regime change towards a more stable environment after the introduction of euro in 1999, on the other hand, has also contributed to the fall in loan losses. In addition, an increased cautiousness in the aftermath of banking crisis could still affect the behaviour of both lenders and borrowers.

Out of sample forecast is very good. The model forecast converges rapidly towards the prevailing very low level of loan losses in 2003 and 2004. Actually,

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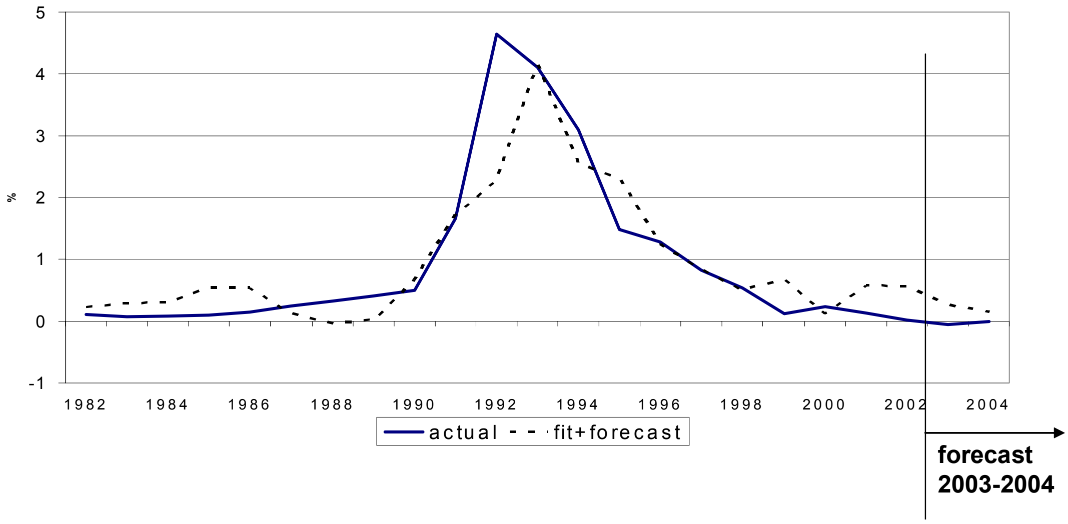
[33] DW-statistics tends to be biased when a lagged dependent variable is on the right hand side of the equation. See eg Brooks (2002) p. 164.
[34] See eg Greene (2000, p. 614–623).
[35] See Pesola (2000) pages 16 and 17.

loan losses in net terms were slightly negative in 2003 because recoveries exceeded gross loan losses. The amount of net loan losses was about zero in 2004.

Figure 7. **FINLAND: Banks' loan losses/lending, %**
forecast 2003–2004 (model 1a)

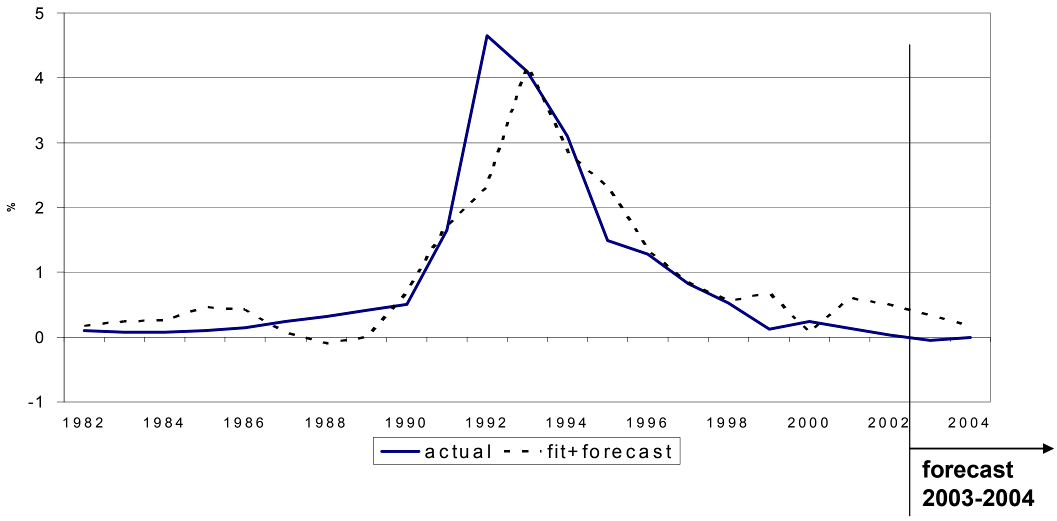


The next step was to redo the estimation over all the sample countries: The four Nordic countries plus Germany, UK, Spain, Greece and Belgium. Seemingly unrelated regression (SUR) method is not feasible in an unbalanced panel (data including with different length of time series). Only Spain and Greece have as long data as the Nordic countries, 1983–2002. The UK data covers the period 1987–2002 and the German and Belgian data the period of 1993–2002. Moreover, it is likely that the extended set of countries is more heterogeneous than the Nordic group. That also reduces the need and motivation for using the SUR method as the probability of some common omitted factor is smaller. Hence, the PLS (pooled least squares) method is used. The estimation results of equation 1b are shown below in Table 1.

The results for equation 1b are roughly similar to those of equation 1a except for the total explanatory power, which is clearly lower than for equation 1a. Different estimation methods can explain some of this difference, since SUR estimation tends to give, by very its nature, a higher R-square than PLS. All regression coefficients – including that of real interest rate – are now significant at the 99 percent confidence level. There is slightly stronger positive autocorrelation in the residuals compared to the case of using only nordic data.

Figure 8 shows actual, fitted and predicted loan losses for Finland. The overall picture is similar as in Figure 7 and here too the out of sample forecast converges quickly towards realised loan losses.

Figure 8. **FINLAND: Banks' loan losses/lending, %**
forecast 2003–2004 (model 1b)



Adding Iceland in the estimated set of countries did not significantly change the results. It should be borne in mind that when the number of countries increases, the cross sectional dimension of the data gets more weight. This phenomenon comes out increasingly clearly as the length of the additional time series falls.

Pooled regression imposes a common set of parameters on the explanatory variables throughout the panel. Separate country by country estimation would probably give a better overall fit. In order to assess whether the implied parameter restrictions in the pooled estimation are valid an F-test on the validity of these restrictions was performed (Appendix 2). According to the test results (1a) for the Nordic countries, the pooling restriction for the parameter of income surprise variable cannot be rejected, while it looks like the parameter restriction for real interest rate variable is not borne by the data.

The reason for the test failure regarding interest rates is most likely related to the different role of country specific interest rate movements during the period of exchange rate tensions before the late 1990s. Interest rates have since moved more in unison along with adoption of the euro and the integration of financial market. Hence, the pooling restriction would probably better fit to the few last years than the earlier estimation period.

The F-test result for the total set of countries (1b) shows that also the restriction on the income surprise parameter fails to be supported by the data. The evidence against common parameters is, however, stronger for the real interest variable.

The autocorrelation in loan losses raised the question whether there would be a feedback effect from loan losses to GDP. An experiment was done by using instrumental variable estimation technique so as to capture the possible feedback.

The income surprise variable includes GDP variable as a part. Because of the potential endogeneity problem, OLS estimates can suffer from a simultaneity bias. Therefore, a two stage least square (TSLS) estimation procedure followed where in stage one estimated fitted values for the income surprise variable was used as an explanatory variable in stage two estimation. The outcome was essentially no changes in the estimated parameter values. This result is not inconsistent with the view that banking distress does not affect the real economy or it could reflect the idea that the lead-lag structure between credit losses and the real economy is relatively involved.[36]

There can also be other underlying factors affecting the persistency of loan losses. It could be simply that it is associated with the general cyclical dynamics. Moreover, it could reflect the legal process, whereby the completion of bankruptcies in the legal system can take several years.

Since the correct indebtedness measure is debt relative to assets, the available measure of the capital stock (CA) was used instead of the GDP in the denominator of fragility variable as a next step. The CA data is available from 1980 onwards in five countries whereas no measure is available for Spain and Greece.[37] The data is gross capital stock in nominal terms except for Sweden where only net capital stock data is available. These PLS estimation results (Iceland excluded) are presented in Table 1 as equation 1b', where the indebtedness variable LCA is banks' domestic credit divided by capital stock CA: L/CA.

The results in 1b', based on data that exclude Greece and Spain are roughly similar with 1b, but in 1b' the coefficient of lagged change in real interest rate is not significant. Even though the debt to capital stock ratio should in theory be closest to the correct fragility measure, in practice this is not often the case. For example, the collateral value can differ from the value of capital in statistics, because the latter one expresses gross nominal capital stock in book value terms albeit influenced by market prices when ever available.

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[36] This result is in line with the conclusion made in Lowe (2002, p. 13) based on several empirical studies. According to his conclusion, the evidence is largely inconclusive that reductions in bank lending caused by financial stress would affect the macroeconomy.

[37] The gross capital stock data (Sweden: net capital stock) is available for following years (see also Appendix 2):

Finland	1980–2003
Sweden	1993–2001 (net capital stock)
Denmark	1980–2003
Norway	1980–2003
Iceland	1980–2003
UK	1980–2003
Germany	1991–2003
Belgium	1995–2000

Table 1.

Regression analysis: panel estimation over countries
Dependent variable: banks' loan losses/lending, LTL
(t-statistics in parenthesis)

Equation Estim. method Variable	1a (SUR)	1b (PLS)	1b' (PLS)	2a (SUR)	2b (PLS)
Constant	0.3497	0.2607	0.2424	0.3528	0.2673
	(3.01)**	(3.69)**	(3.17)**	(3.12)**	(3.81)**
LTL_{-1}	0.6899	0.7081	0.6593	0.6729	0.6954
	(9.79)**	(13.55)**	(11.25)**	(9.80)**	(13.38)**
$YS \cdot LYV_{-1}$	-0.1010	-0.1195			
	(-3.52)**	(-4.67)**			
$RS_{-1} \cdot LYV_{-1}$	0.1783	0.0862			
	(2.56)*	(2.81)**			
$YS \cdot LCA_{-1}$			-0.3922		
			(-3.56)**		
$RS_{-1} \cdot LCA_{-1}$			0.3157		
			(1.61)		
$YS \cdot LYVAP_{-1}$				-0.1214	-0.1357
				(-3.87)**	(-5.12)**
$RS_{-1} \cdot LYVAP_{-1}$				0.2051	0.0863
				(2.80)**	(2.63)**
Fixed effects:					
Denmark	0.0057	0.0595	0.1430	0.0250	0.0654
Finland	-0.1353	-0.0601	0.0467	-0.1701	-0.0978
Norway	0.0029	0.0860	0.1606	0.0147	0.0937
Sweden	0.1267	0.1780	-0.3765	0.1305	0.1749
Belgium		0.1662	-0.1884		-0.1966
Spain		-0.1389			0.1590
Greece		-0.3291			-0.0850
Germany		-0.0815	-0.2186		-0.3527
United Kingdom		-0.1811	-0.0347		-0.0895
R^2	0.7361	0.6936	0.6836	0.7482	0.7028
Adj. R^2	0.7144	0.6697	0.6516	0.7275	0.6795
SEE	1.0094	0.6550	0.5646	1.0139	0.6461
DW	1.8296	1.6601	1.7703	1.8318	1.7011

Symbols of explanatory variables in Table 1 (see the contents of variables in section 5.1.1):

YS = income surprise variable
RS = change in real interest rate
LYV = indebtedness indicator (banks' lending divided by GDP)
LYVAP = indebtedness indicator with asset price variation (see section 5.2)
LCA = indebtedness (banks' lending divided by capital stock)

Summarising the test results, we can say that both of the surprise variables, income and real interest rate, appear to contribute to explaining observed variations in banks' loan losses in the sample countries. Out of sample tests give the same impression. Also the strong autocorrelation in loan losses is a typical feature, albeit the cause could not be found. The validity of pooling restriction on the interest rate parameter is not supported by the data. The validity of that restriction is probably on a firmer ground towards the end of estimation period.

5.2 Estimations with asset price variation

It was stated in section 4.3 that not only the cyclical outlook but also increased uncertainty ie asset price volatility tends to raise financial fragility. In order to explore this idea, we use the BIS asset price data and data on market asset prices we have received from the central banks of Greece and Iceland. These two countries were not included in the BIS data set. The BIS-data is an aggregate asset price index where stock exchange price indices are combined with real estate price indices. The BIS-data should better take into account the market value changes than the above applied nominal capital stock data. On the other hand, the BIS-data does not cover all the capital items, whereas the capital stock data does.

There are several technical ways to express asset price variation. Here we use percentage changes or alternatively trend deviations. In the following we incorporate asset prices in the fragility indicator LYV and then re-estimate the model. We modify the debt to GDP ratio to accommodate annual changes in asset prices.[38] The new fragility indicator LYVAP, say, is thus

$$\mathrm{LYVAP} = \frac{\mathrm{L}}{\mathrm{YV} \cdot (\mathrm{API}/\mathrm{API}_{-1})} \quad (= \mathrm{LYV} \cdot \frac{1}{\mathrm{API}/\mathrm{API}_{-1}})$$

where
L = banks' lending
YV = GDP value
API = asset price index (source: BIS)

The graph of the resulting time series is shown in Appendix 2.

The corresponding SUR estimation result for four Nordic countries, equation 2a, is shown above in Table 1. The estimation results are similar to those in equation 1a. Real interest rate is now a little bit stronger explanatory variable than

[38] Another way to incorporate the asset price variation in the model would be to apply it as a separate shock variable. That kind of experiment was done in Appendix 4, but the results suggested that asset prices as separate explanatory variable were not statistically significant.

earlier. The evidence in favour of a significant real interest effect is now somewhat stronger.

The PLS estimation for all countries (except for Iceland), equation 2b in Table 1, shows practically unchanged results. Including Iceland in the estimation did not improve results.

Appendix 2 reports the corresponding estimation results with logarithmic trend deviation in asset prices. Those results do not significantly differ from the ones shown here in Table 1 for equations 2.

5.3 Other experiments

In Appendix 4 are Borio and Lowe's (2002) idea of an early warning indicator tested. According to their hypothesis, a combined asset price and lending boom will easily lead to asset price bubble and a following debt deflation distress in banking sector. This belongs to the part two of lending distress cycle where financial fragility is build. Here we tried to find out the determinants which contribute the building of financial fragility.

Borio and Lowe's hypothesis cannot be rejected by the test. But, when we apply the estimated equation in an out of sample test for the Finnish loan losses in the early 2000s the hypothesis fails. A vigorous IT asset price growth generates through the equation an exceptional large increase in loan losses, which did not happen in reality. The explanation is that the Finnish IT boom was mainly financed by issuing equities in the stock exchange and not by bank loans. The model could not take that into account.

6 Conclusion

Macroeconomic determinants of banking fragility and distress was analysed in an econometric panel estimation framework of ten countries ie the Nordic countries and Belgium, Germany, Greece, Spain and the UK. A concept of credit distress cycle was defined on the basis of stylized facts of the Nordic banking crisis in the early 1990s. That cycle consists of four phases: triggering the cycle, increasing fragility, macroeconomic shock(s) and the vigorous growth of banks' loan losses. This study focuses on phases three and four, when macroeconomic shocks in highly fragile situation generate such an amount of loan losses which creates a systemic banking crisis.

The dependent variable in the estimated econometric model is the ratio of banks' loan losses to lending. The explanatory variables include, in addition to the lagged dependent variable, cross-product terms of a surprise change in incomes and real interest rates with lagged aggregate indebtedness. These terms capture the effects on loan losses of the joint occurance of high risk exposure and bad draws from the distributions of income and real interest rates. Consequently, the underlying macroeconomic story that this paper puts forward is that loan losses are basically generated by strong adverse aggregate shocks under high exposure of banks to such shocks. The underlying innovations to income and real interest rates are constructed using macro-economic forecast for these variables.

According to the estimation results, high customer indebtedness combined with adverse macroeconomic surprise shocks contributed to the distress in banking sector. The macroeconomic innovations or surprise variables were income surprise and real interest rate surprise. Income surprise variable was proxied with the difference between actual outcome of GDP in nominal prices and its OECD forecast from preceding year. Interest rate variable was banks' aggregated lending rate. It was assumed that a change in interest rates itself is a surprise. The out of sample forecasting of the Finnish loan losses supports the result that the model fit is rather good.

Loan losses seem also to have a strong autoregressive behaviour which might be connected to feedback effect from loan losses back to macroeconomic level in deep recessions. That feedback effect could however not be verified separately.

The estimated model is rather parsimonious and simple in structure using a few macroeconomic explanatory variables, which are standard variables to be forecasted. This makes our model to a practical tool in simulating banking distress development in connection of stress tests on financial systems.

Prevention of financial distress or crisis provides a strict macroprudential analysis and monitoring as well as simulating the risk factors for banks' lending in connection with different forecasting works. Central parts of those risk factors have been studied here, namely: financial fragility and macroeconomic shocks.

The most important lessons to be drawn from this study are

– Important variables to be monitored: loan losses, nonperforming loans, loan loss provisions, lending growth and asset prices.
– Macroeconomic and financial policies should, as far as possible, avoid producing suddenly unexpected shocks. The development of financial environment should favour solutions which contribute to robust and stable markets.

The estimated model builds on past facts and to a significant extent on cyclical events. It is thus limited to those historical structures. This is good to bear in mind as future crises need not be similar to the past ones.

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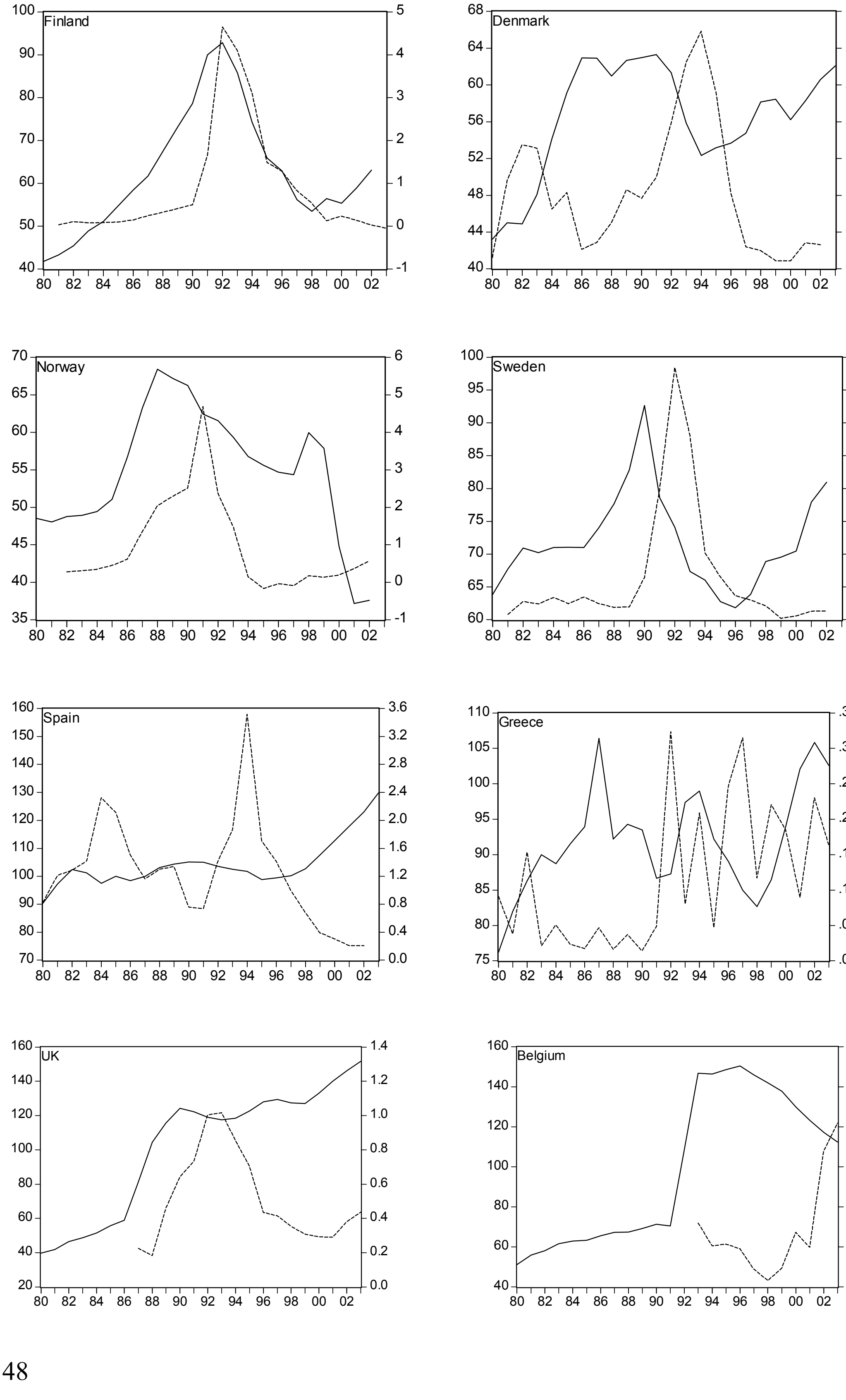
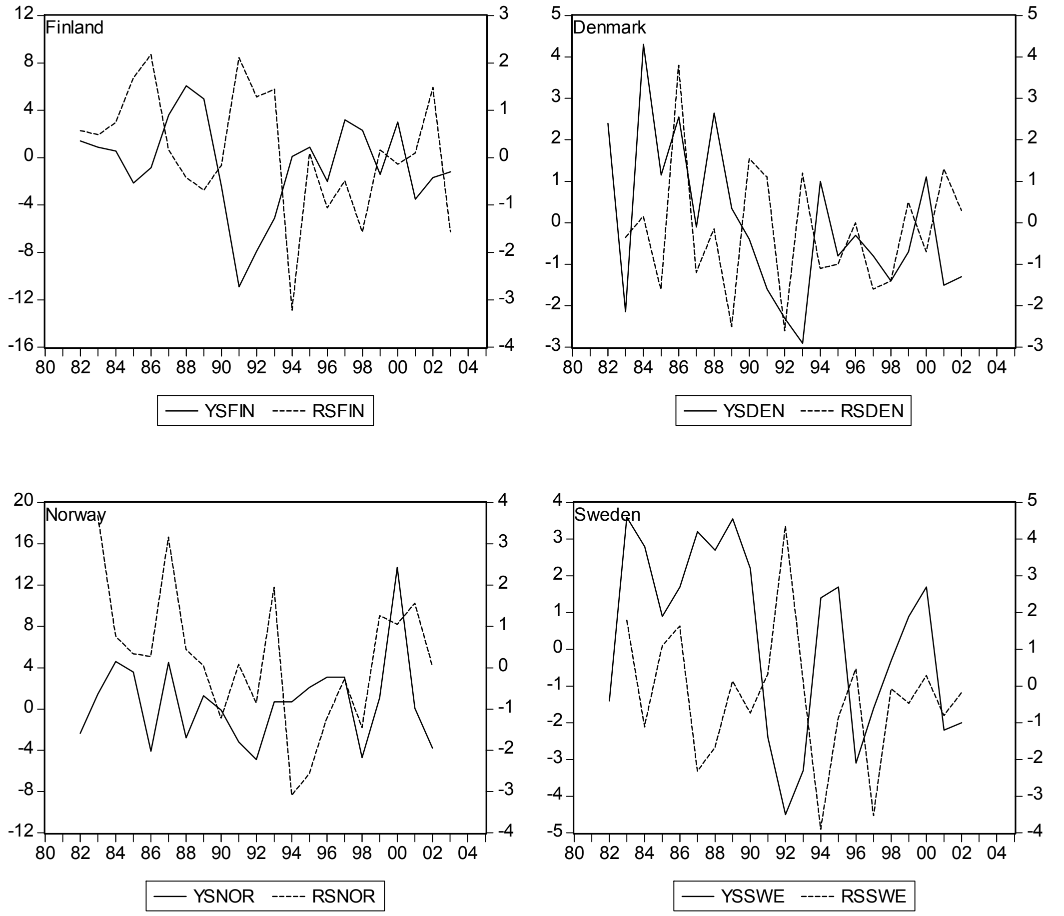
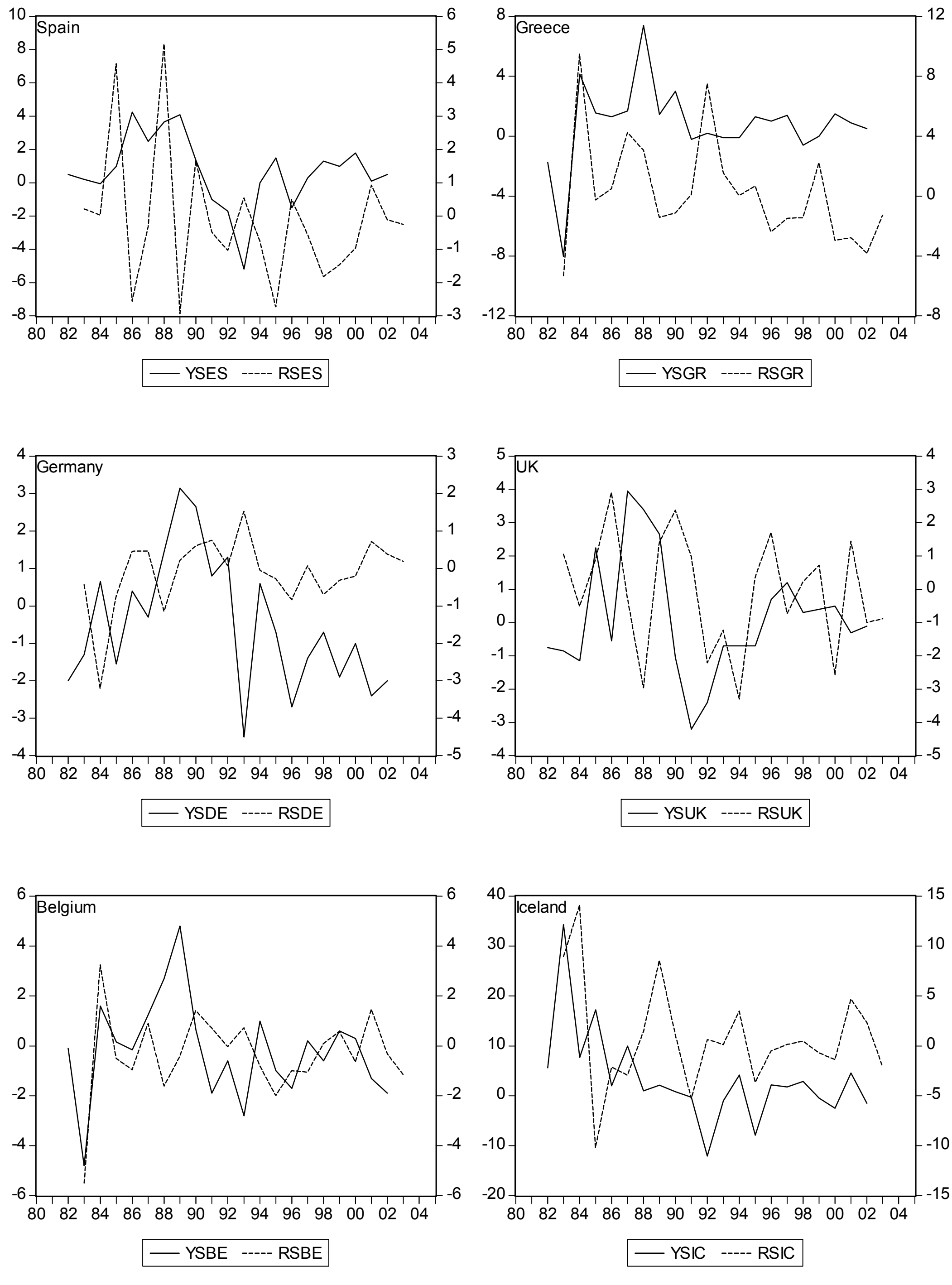
Appendix 1

Domestic credit/GDP, % (— left scale) and Loan losses/loan stock, % (- - - right scale).



Income Surprise (— YS, left scale)
Change in Real interest Rate (- - - RS, right scale.




Spain
YSES
RSES
Greece
YSGR
RSGR
Germany
YSDE
RSDE
UK
YSUK
RSUK
Belgium
YSBE
RSBE
Iceland
YSIC
RSIC

Appendix 2

Estimation results

1. The basic model

Key for variables:

LTL	=	banks' loan losses/lending stock, %
(YQS+YPS)	=	YS = income surprise variable
RLE	=	banks nominal lending rate
YPJ1-YPJ1(-1)	=	change in the OECD forecasted GDP deflator (forecast made in June preceding year)
LYV	=	domestic credit/GDP value, %

Countries:

DEN = Denmark
FIN = Finland
NOR = Norway
SWE = Sweden
ES = Spain
GR = Greece
DE = Germany
UK = United Kingdom
BE = Belgium
IC = Iceland

Equation 1A

Dependent Variable: LTL?
Method: Pooled EGLS (Cross-section SUR)
Date: 01/03/05 Time: 16:30
Sample: 1983–2002
Included observations: 20
Cross-sections included: 4
Total pool (balanced) observations: 80
Linear estimation after one-step weighting matrix

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.349685	0.116292	3.006951	0.0036
LTL?(-1)	0.689851	0.070498	9.785460	0.0000
(YQS?+YPS?)*LYV?(-1)	-0.109964	0.031210	-3.523336	0.0007
(RLE?(-1)-YPJ1?+YPJ1?(-1))*LYV?(-1)	0.178280	0.069665	2.559093	0.0126
Fixed Effects (Cross)				
DEN--C	0.005671			
FIN--C	-0.135332			
NOR--C	0.002921			
SWE--C	0.126739			

Effects Specification

Cross-section fixed (dummy variables)

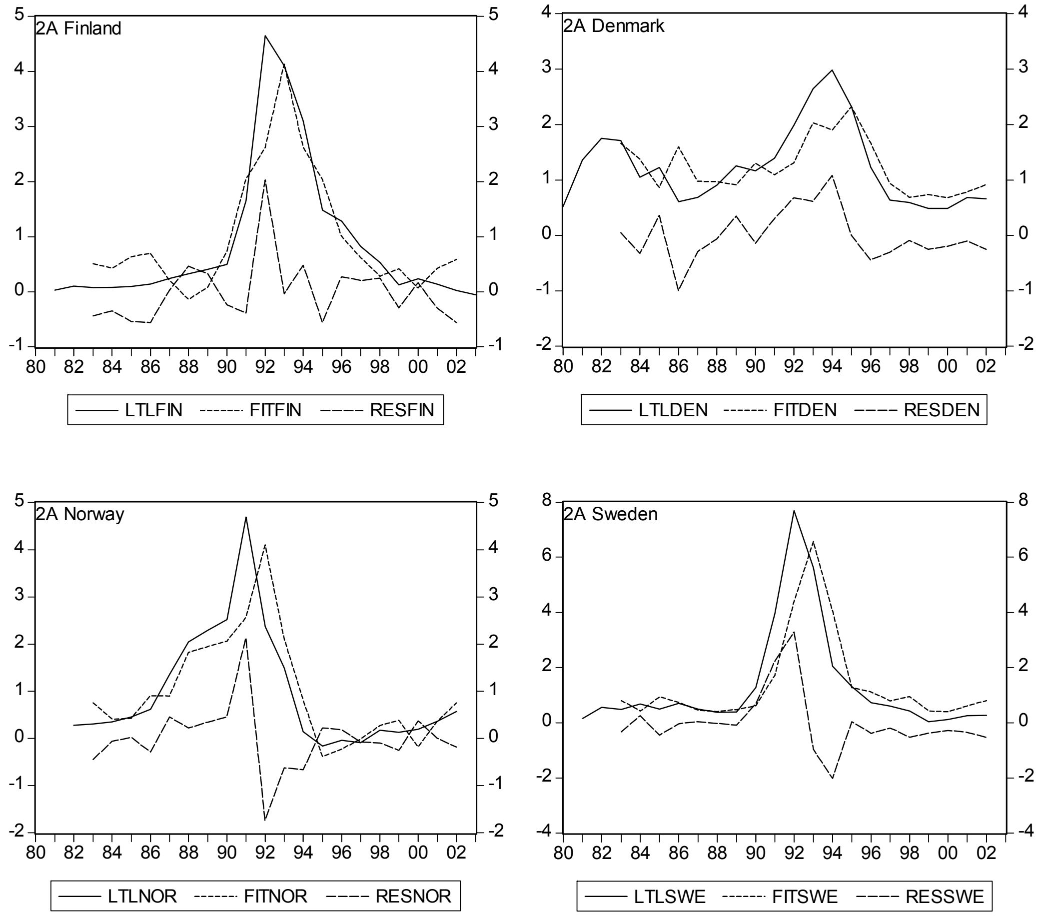
Weighted Statistics

R-squared	0.736082	Mean dependent var	1.193287
Adjusted R-squared	0.714390	S.D. dependent var	1.888727
S.E. of regression	1.009383	Sum squared resid	74.37634
F-statistic	33.93348	Durbin-Watson stat	1.829639
Prob(F-statistic)	0.000000		

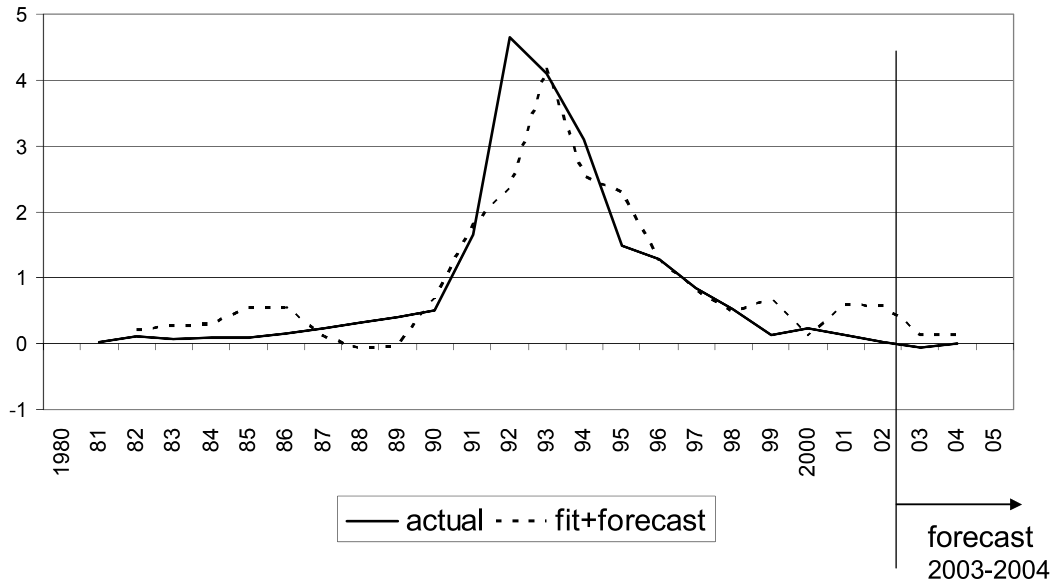
Unweighted Statistics

R-squared	0.695472	Mean dependent var	1.156388
Sum squared resid	47.58409	Durbin-Watson stat	1.519655

Fit and residual Figures 1A



FINLAND: Loan losses/lending, %
forecast 2003–2004 (model 1A)



Equation 1B

Dependent Variable: LTL?
Method: Pooled Least Squares
Date: 01/03/05 Time: 16:16
Sample: 1983–2002
Included observations: 20
Cross-sections included: 9
Total pool (unbalanced) observations: 153

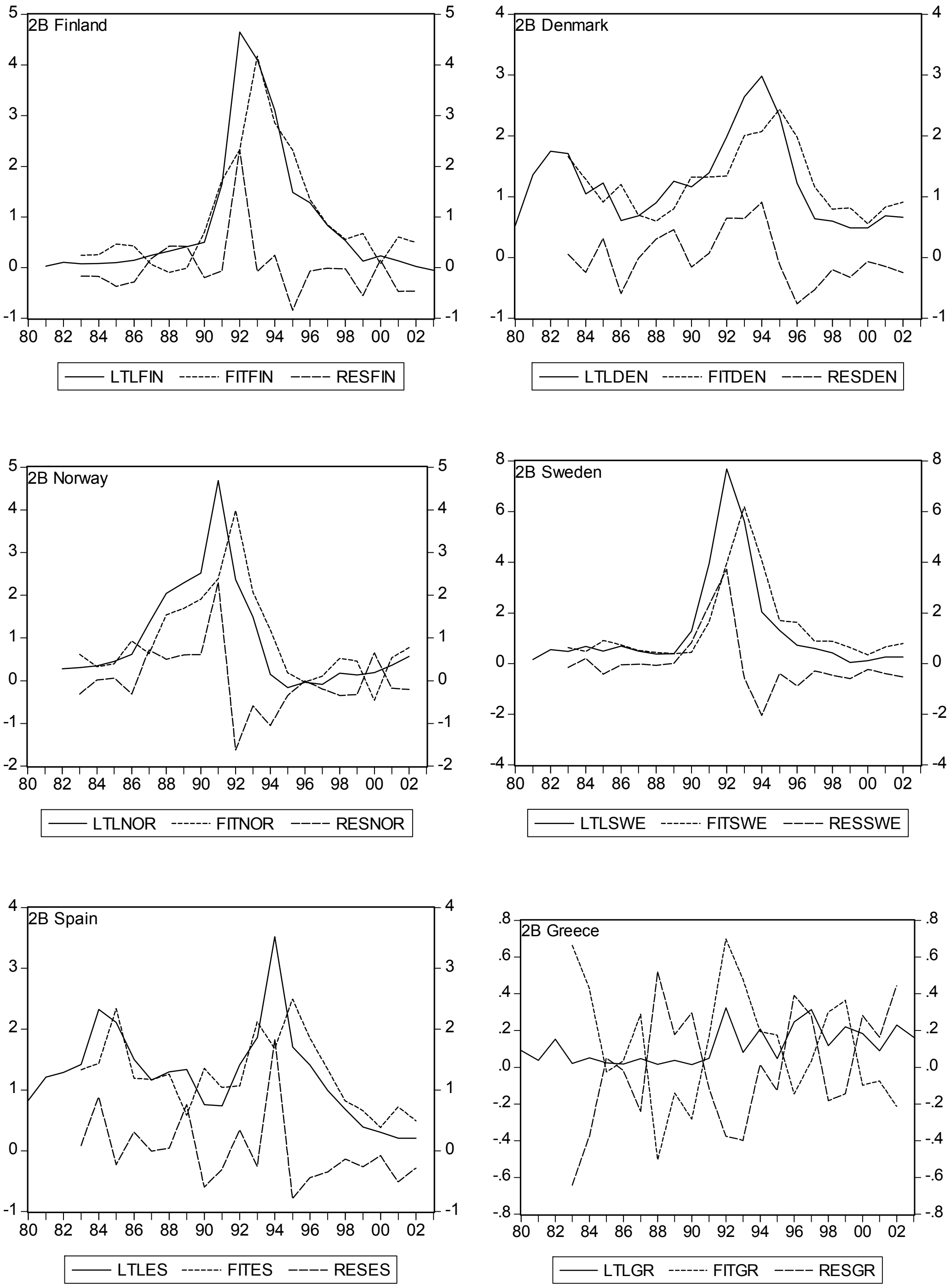
Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.260740	0.070710	3.687452	0.0003
LTL?(-1)	0.708135	0.052277	13.54581	0.0000
(YQS?+YPS?)*LYV?(-1)	-0.119521	0.025615	-4.666042	0.0000
(RLE?(-1)-YPJ1?+YPJ1?(-1))*LYV?(-1)	0.086228	0.030699	2.808858	0.0057
Fixed Effects (Cross)				
DEN—C	0.059462			
FIN—C	-0.060114			
NOR—C	0.086004			
SWE—C	0.177986			
ES—C	0.166237			
GR—C	-0.138892			
DE—C	-0.329068			
UK—C	-0.081481			
BE—C	-0.181092			

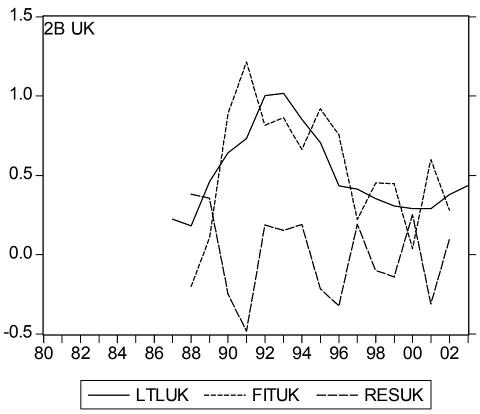
Effects Specification

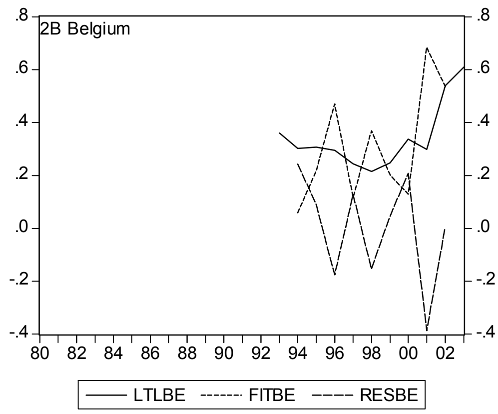
Cross-section fixed (dummy variables)

R-squared	0.693572	Mean dependent var	0.881443
Adjusted R-squared	0.669667	S.D. dependent var	1.139572
S.E. of regression	0.654965	Akaike info criterion	2.066714
Sum squared resid	60.48604	Schwarz criterion	2.304396
Log likelihood	-146.1037	F-statistic	29.01283
Durbin-Watson stat	1.660977	Prob(F-statistic)	0.000000

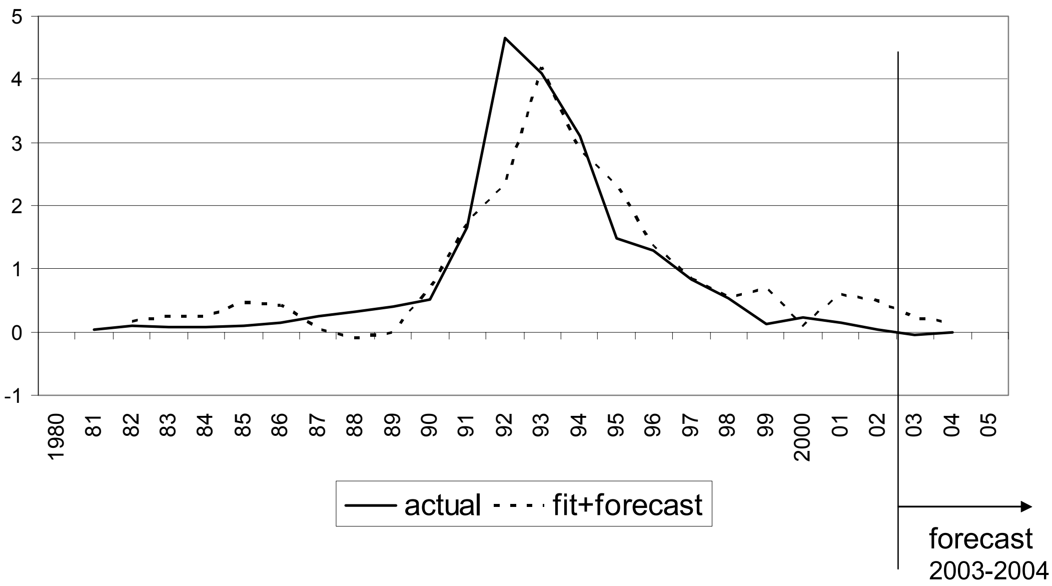
Fit and residual Figures 1B







**FINLAND: Loan losses/lending, %
forecast 2003–2004 (model 1B)**



2. Capital stock in fragility variable, LCA
(banks' domestic credit L divided by the value of capital stock CA: L/CA)

Available gross capital stock series (Sweden net capital stock):

Finland	1980–2003,	EURO mill.
Sweden	1993–2001,	EURO mill. (net capital stock)
Denmark	1980–2003,	DKK mill.
Norway	1980–2003,	NOK mill.
Iceland	1980–2003,	ISK mill.
UK	1980–2003,	GBP bill.
Germany	1991–2003,	EURO bill.
Belgium	1995–2000,	EURO mill.

Equation 1B'

Dependent Variable: LTL?
Method: Pooled Least Squares
Date: 02/04/05 Time: 10:31
Sample: 1983–2002
Included observations: 20
Cross-sections included: 7
Total pool (unbalanced) observations: 99

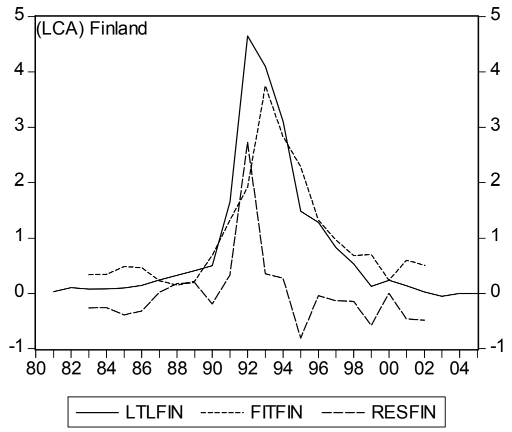
Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.242365	0.076372	3.173465	0.0021
LTL?(-1)	0.659285	0.058584	11.25362	0.0000
(YQS?+YPS?)*LCA?(-1)	-0.392233	0.110091	-3.562815	0.0006
(RLE?(-1)-YPJ1?+YPJ1?(-1))*LCA?(-1)	0.315685	0.196495	1.606584	0.1117
Fixed Effects (Cross)				
DEN--C	0.143036			
FIN--C	0.046687			
NOR--C	0.160616			
SWE--C	-0.376448			
DE--C	-0.218632			
UK--C	-0.034714			
BE--C	-0.188391			

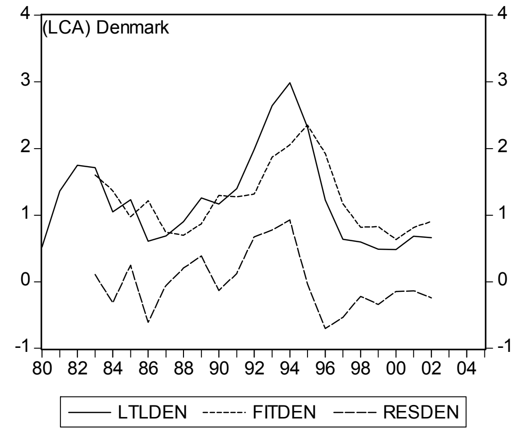
Effects Specification

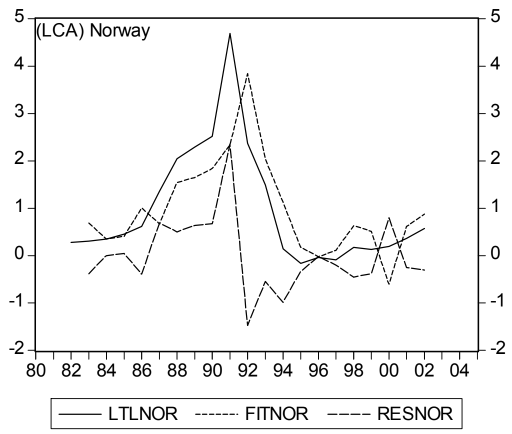
Cross-section fixed (dummy variables)

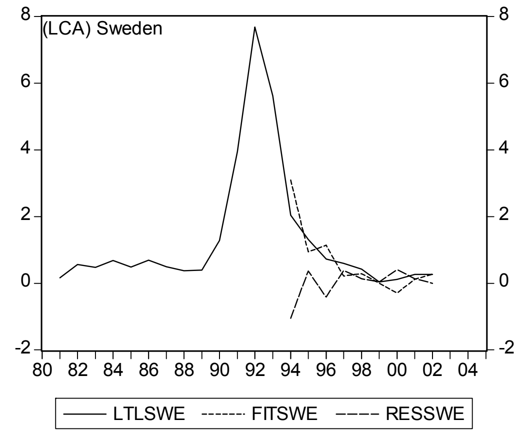
R-squared	0.683622	Mean dependent var	0.846950
Adjusted R-squared	0.651629	S.D. dependent var	0.956617
S.E. of regression	0.564624	Akaike info criterion	1.790222
Sum squared resid	28.37320	Schwarz criterion	2.052356
Log likelihood	-78.61601	F-statistic	21.36767
Durbin-Watson stat	1.770348	Prob(F-statistic)	0.000000

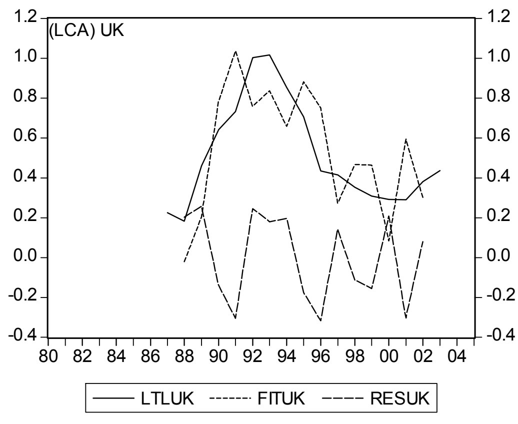
Fit and residual charts 1B'

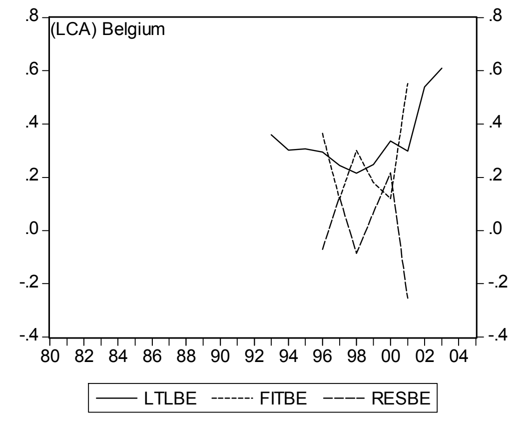












3. Testing the effect of asset price variation of financial fragility

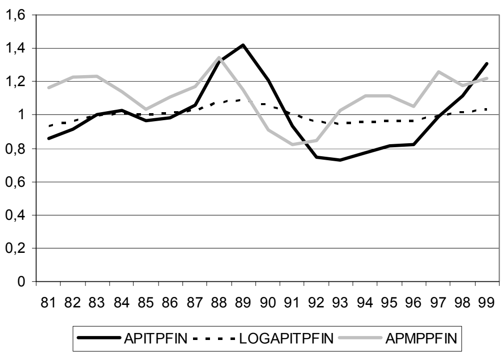
The BIS asset price data and data on asset prices we have received from the central banks of Greece and Iceland are used. The mentioned two countries were not included in the BIS data set.

Asset price variations in the sample countries are indicated by percentage change or deviation from trend. Trends in charts are estimated between 1981 and 2002 except for Finland and Sweden (1981–1999) and Greece (1982–2002).

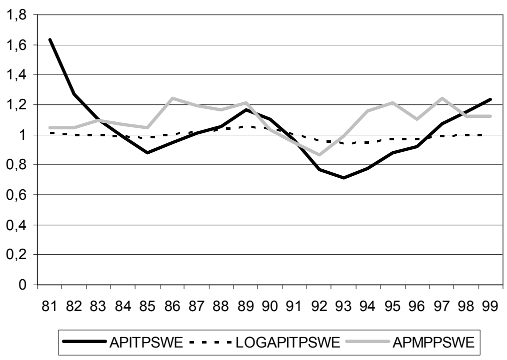
The symbols in charts are

(thick solid line)	Asset price deviation from trend
(dashed line)	Asset price deviation from logarithmic trend
(thin solid line)	Asset price change in a fraction form (price index/price index(-1))

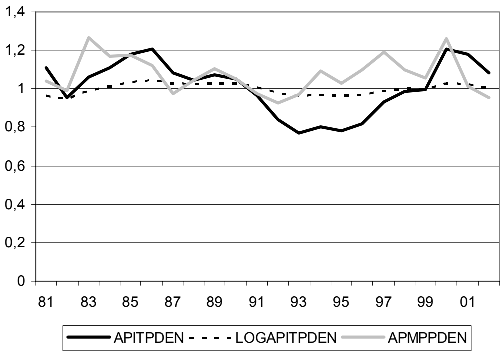
Finland



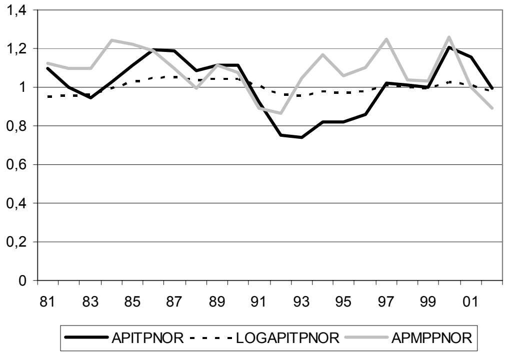
Sweden



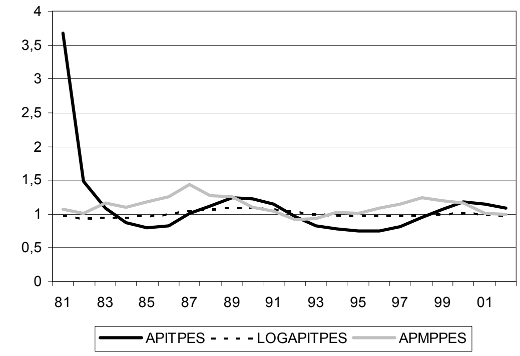
Denmark



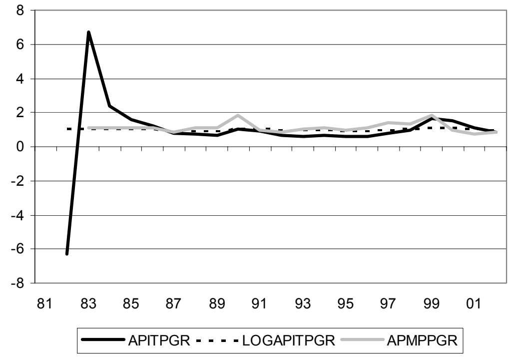
Norway



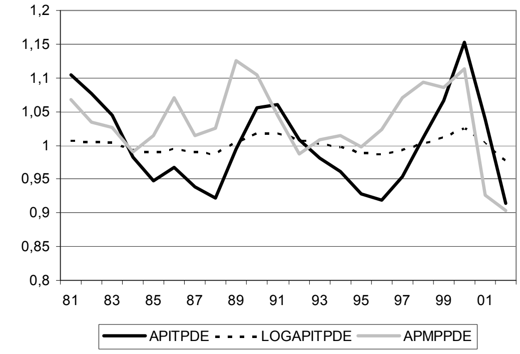
Spain



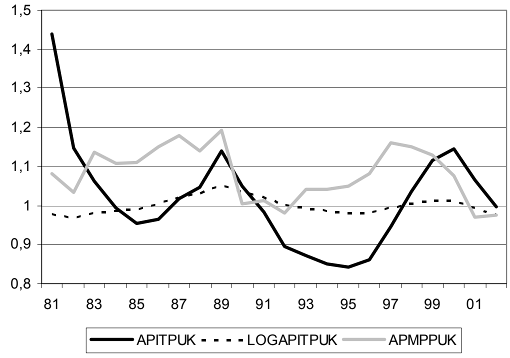
Greece



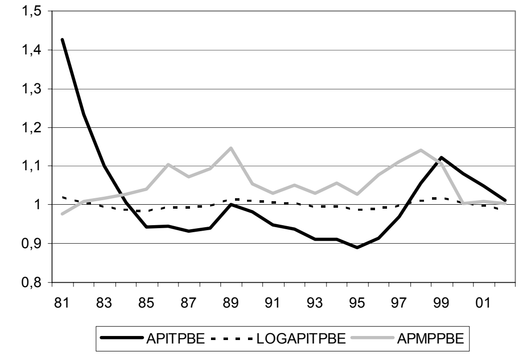
Germany



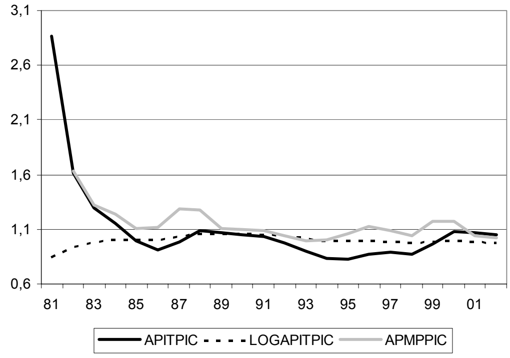
UK



Belgium



Iceland



Estimation results

Key for variables:

LTL	=	banks' loan losses/lending stock, %
(YQS+YPS)	=	YS = income surprise variable
RLE	=	banks nominal lending rate
YPJ1-YPJ1(-1)	=	change in the OECD forecasted GDP deflator (forecast made in June preceding year)
LYV	=	domestic credit/GDP value, %
API	=	Asset price index (BIS-data, except for Greece and Iceland, which use data received from their central banks)
LOGAPITP	=	asset price deviation from the logarithmic trend

Countries:

DEN = Denmark
FIN = Finland
NOR = Norway
SWE = Sweden
ES = Spain
GR = Greece
DE = Germany
UK = United Kingdom
BE = Belgium
IC = Iceland

Equation 2A

Dependent Variable: LTL?
Method: Pooled EGLS (Cross-section SUR)
Date: 01/28/05 Time: 11:23
Sample: 1983–2002
Included observations: 20
Cross-sections included: 4
Total pool (balanced) observations: 80
Linear estimation after one-step weighting matrix

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.352834	0.112925	3.124504	0.0026
LTL?(-1)	0.672883	0.068660	9.800197	0.0000
(YQS?+YPS?)*LYV?(-1)*API?(-2)/API?(-1)	-0.121423	0.031356	-3.872357	0.0002
(RLE?(-1)-YPJ1?+YPJ1?(-1))*LYV?(-1)*API?(-2)/API?(-1)	0.205098	0.073211	2.801468	0.0065
Fixed Effects (Cross)				
DEN--C	0.024976			
FIN--C	-0.170077			
NOR--C	0.014645			
SWE--C	0.130455			

Effects Specification

Cross-section fixed (dummy variables)

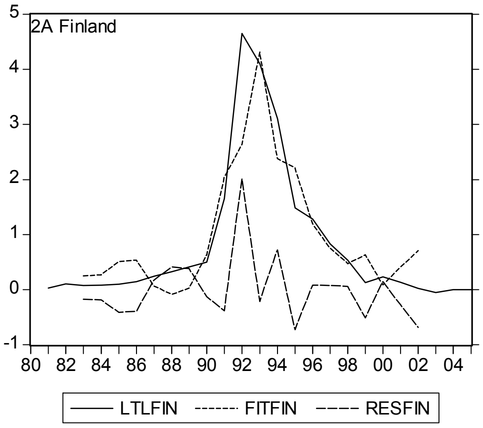
Weighted Statistics

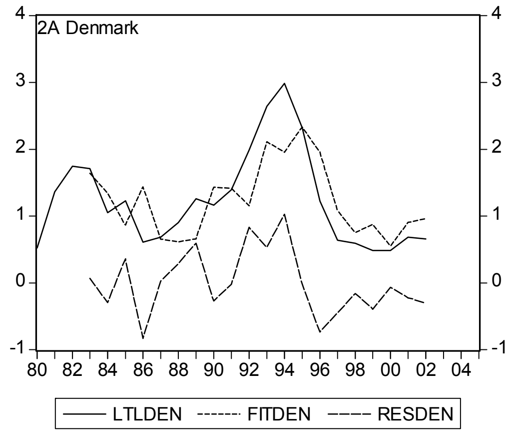
R-squared	0.748215	Mean dependent var	1.255887
Adjusted R-squared	0.727520	S.D. dependent var	1.942407
S.E. of regression	1.013928	Sum squared resid	75.04765
F-statistic	36.15500	Durbin-Watson stat	1.831758
Prob(F-statistic)	0.000000		

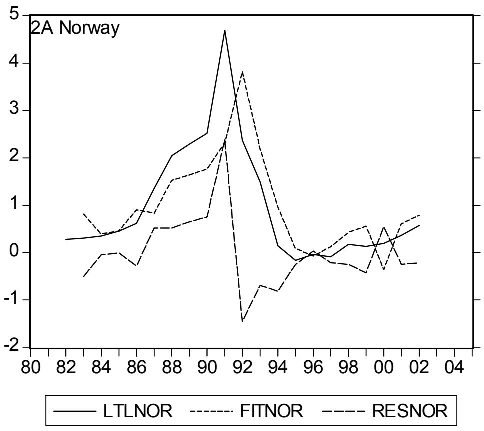
Unweighted Statistics

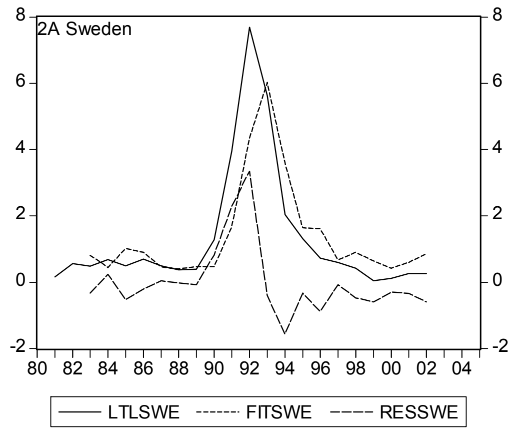
R-squared	0.711049	Mean dependent var	1.156388
Sum squared resid	45.14997	Durbin-Watson stat	1.544927

Fit and residual Figures 2A









Equation 2B

Dependent Variable: LTL?
Method: Pooled Least Squares
Date: 01/28/05 Time: 11:39
Sample: 1983–2002
Included observations: 20
Cross-sections included: 9
Total pool (unbalanced) observations: 152

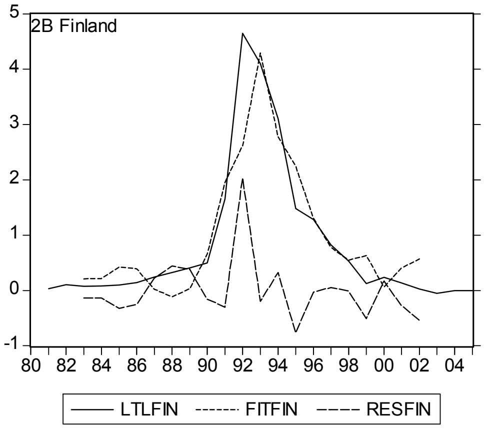
Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.267257	0.070172	3.808590	0.0002
LTL?(-1)	0.695397	0.051977	13.37888	0.0000
(YQS?+YPS?)*LYV?(-1)*API?(-2)/API?(-1)	-0.135721	0.026530	-5.115817	0.0000
(RLE?(-1)-YPJ1?+YPJ1?(-1))*LYV?(-1)*API?(-2)/API?(-1)	0.086300	0.032756	2.634601	0.0094
Fixed Effects (Cross)				
DEN--C	0.065393			
FIN--C	-0.097975			
NOR--C	0.093708			
SWE--C	0.174923			
BE--C	-0.196611			
ES--C	0.158993			
GR--C	-0.084950			
DE--C	-0.352685			
UK--C	-0.089541			

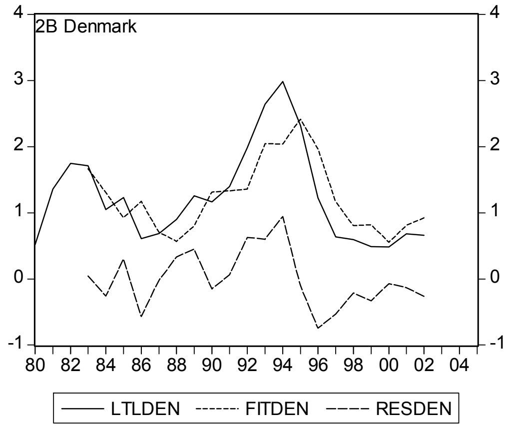
Effects Specification

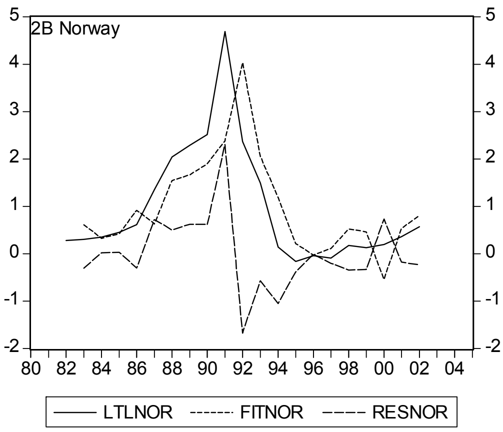
Cross-section fixed (dummy variables)

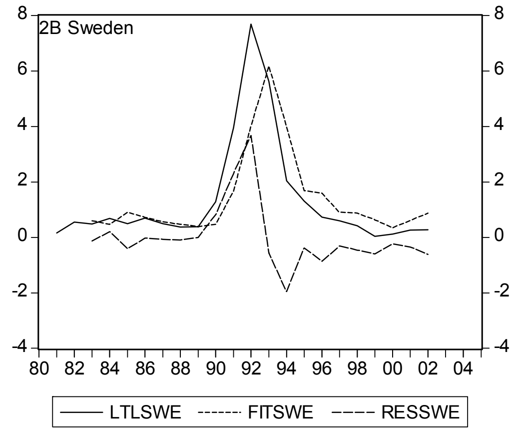
R-squared	0.702829	Mean dependent var	0.887101
Adjusted R-squared	0.679480	S.D. dependent var	1.141181
S.E. of regression	0.646073	Akaike info criterion	2.039849
Sum squared resid	58.43749	Schwarz criterion	2.278576
Log likelihood	-143.0285	F-statistic	30.10091
Durbin-Watson stat	1.701111	Prob(F-statistic)	0.000000

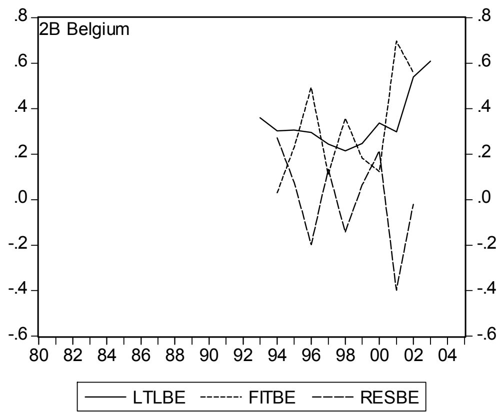
Fit and residual Figures 2B

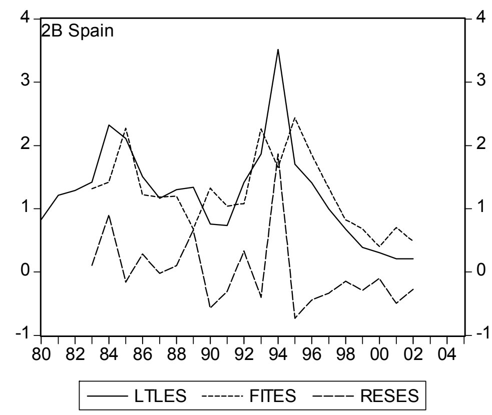


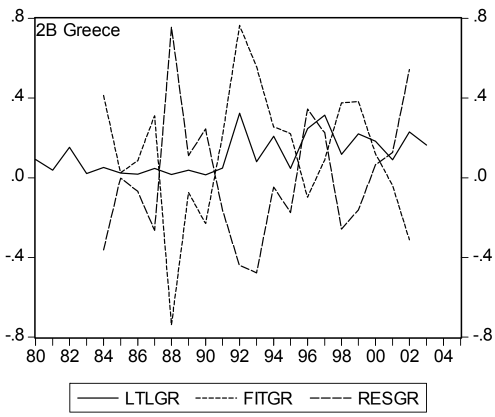


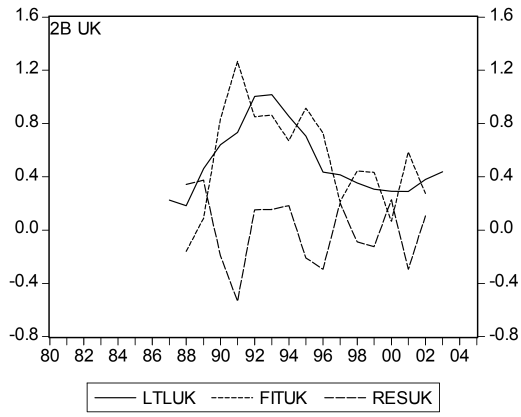












Equation 3A

Dependent Variable: LTL?
Method: Pooled Least Squares
Date: 01/31/05 Time: 13:44
Sample: 1983 2002
Included observations: 20
Cross-sections included: 4
Total pool (unbalanced) observations: 76

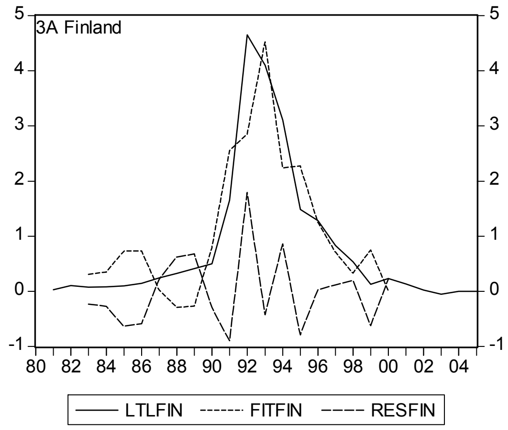
Variable	Coefficient	Std. Error	t-Statistic
C	0.384954	0.126328	3.047268
LTL?(-1)	0.684105	0.070496	9.704147
(YQS?+YPS?)*LYV?(-1)*LOGAPITP?(-1)	-0.160191	0.044286	-3.617234
(RLE?(-1)-YPJ1?+YPJ1?(-1))*LYV?(-1)*LOGAPITP?(-1)	0.299432	0.091446	3.274419
Fixed Effects (Cross)			
DEN—C	-0.014324		
FIN—C	-0.150294		
NOR—C	-0.018193		
SWE—C	0.186423		

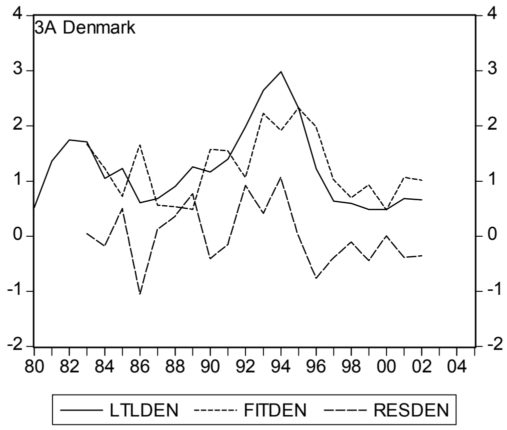
Effects Specification

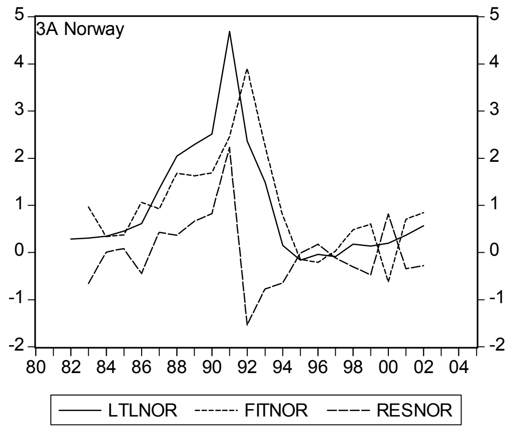
Cross-section fixed (dummy variables)

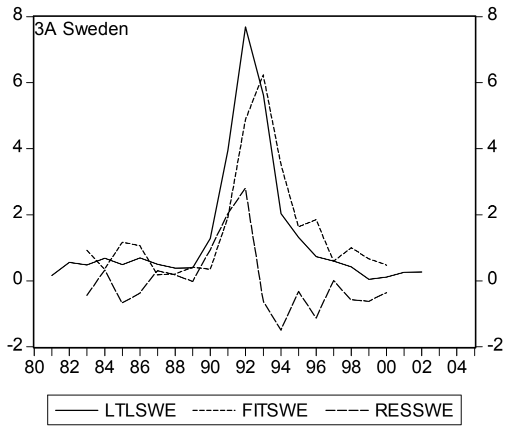
R-squared	0.710646	Mean dependent var
Adjusted R-squared	0.685484	S.D. dependent var
S.E. of regression	0.798753	Akaike info criterion
Sum squared resid	44.02240	Schwarz criterion
Log likelihood	-87.09001	F-statistic
Durbin-Watson stat	1.752987	Prob(F-statistic)

Fit and residual Figures 3A









Equation 3B

Dependent Variable: LTL?
Method: Pooled Least Squares
Date: 01/28/05 Time: 16:36
Sample: 1983–2002
Included observations: 20
Cross-sections included: 9
Total pool (unbalanced) observations: 149

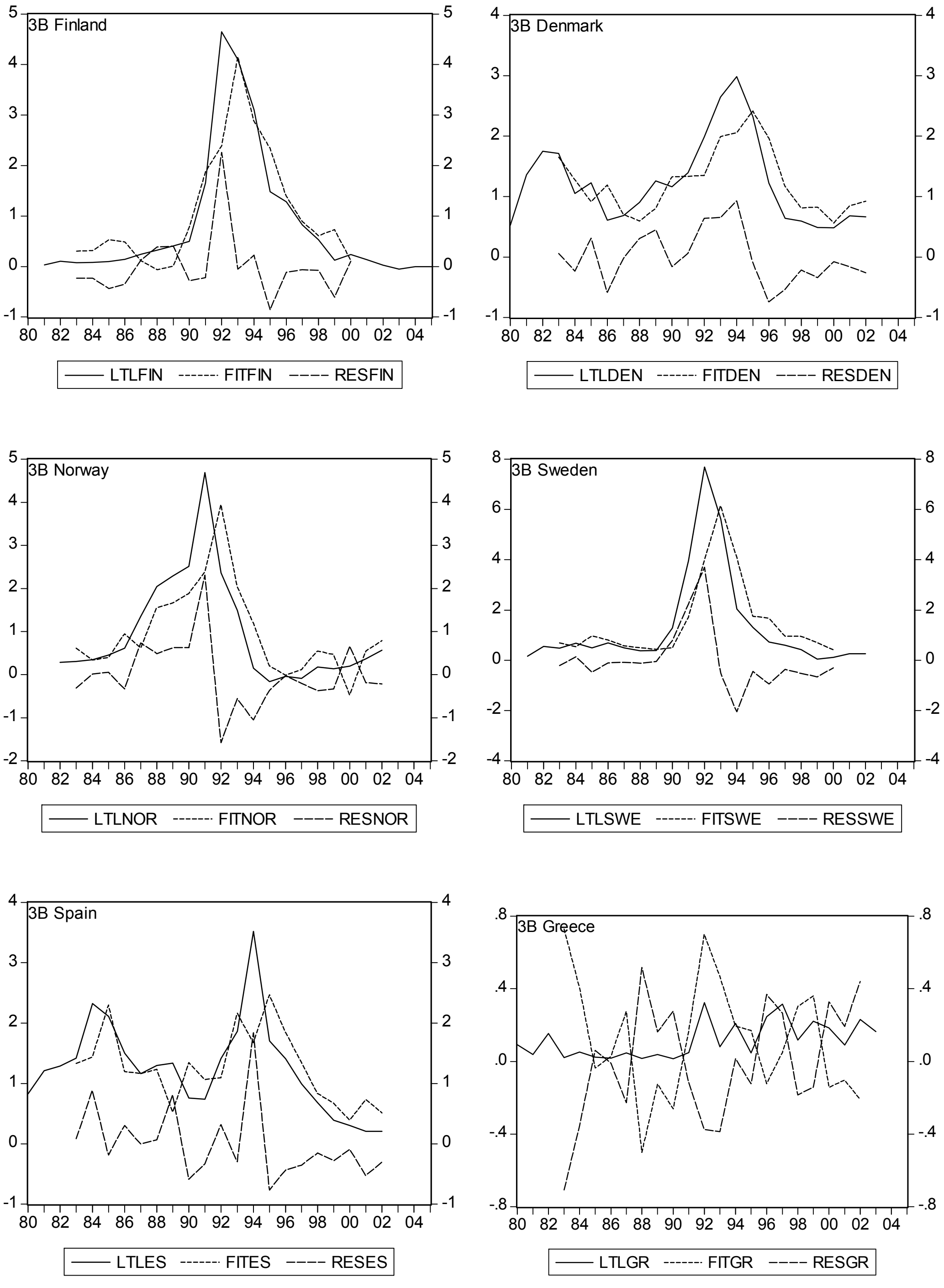
Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.283936	0.073244	3.876562	0.0002
LTL?(-1)	0.693035	0.053702	12.90529	0.0000
(YQS?+YPS?)*LYV?(-1)*LOGAPITP?(-1)	-0.123292	0.025746	-4.788799	0.0000
(RLE?(-1)-YPJ1?+YPJ1?(-1))*LYV?(-1)*LOGAPITP?(-1)	0.083702	0.030440	2.749747	0.0068
Fixed Effects (Cross)				
DEN--C	0.055185			
FIN--C	-0.018455			
NOR--C	0.076476			
SWE--C	0.231269			
BE--C	-0.203939			
ES--C	0.164483			
GR--C	-0.161498			
DE--C	-0.354705			
UK--C	-0.099718			

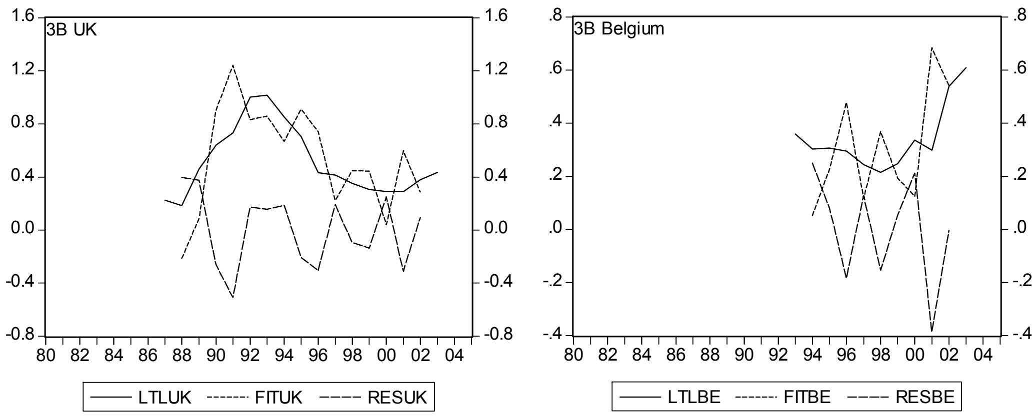
Effects Specification

Cross-section fixed (dummy variables)

R-squared	0.694455	Mean dependent var	0.900473
Adjusted R-squared	0.669922	S.D. dependent var	1.148699
S.E. of regression	0.659955	Akaike info criterion	2.083819
Sum squared resid	59.66913	Schwarz criterion	2.325748
Log likelihood	-143.2445	F-statistic	28.30716
Durbin-Watson stat	1.669205	Prob(F-statistic)	0.000000

Fit and residual Figures 3B

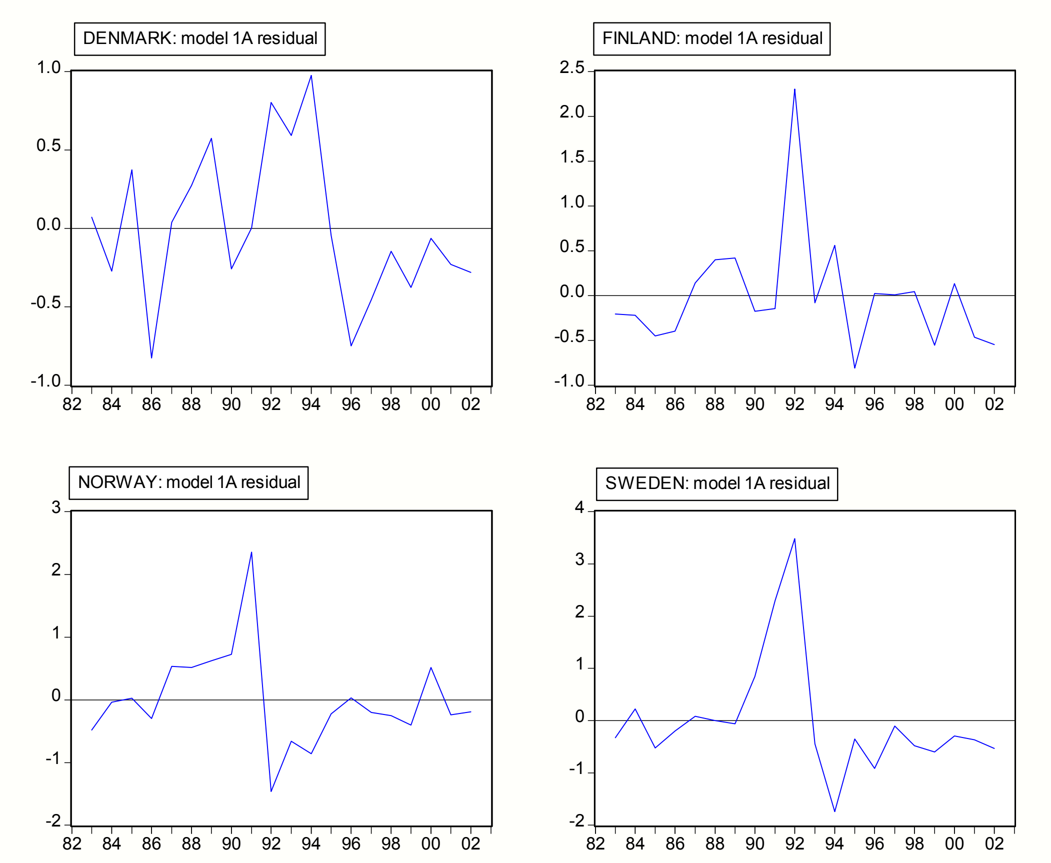




Wald test

Model 1a

Model 1a residuals of the Nordic countries



DENMARK: estimation residual regressed on its lagged value and the corresponding Wald test

Dependent Variable: RESID1ADEN
Method: Least Squares
Date: 02/23/05   Time: 17:54
Sample (adjusted): 1984–2002
Included observations: 19 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
RESID1ADEN(-1)	0.270892	0.228960	1.183139	0.2521

R-squared	0.072098	Mean dependent var	-0.003819
Adjusted R-squared	0.072098	S.D. dependent var	0.493438
S.E. of regression	0.475317	Akaike info criterion	1.401527
Sum squared resid	4.066674	Schwarz criterion	1.451234
Log likelihood	-12.31450	Durbin-Watson stat	1.947138

Wald Test:
Equation: RES1ADEN

Test Statistic	Value	df	Probability
F-statistic	1.399818	(1, 18)	0.2521
Chi-square	1.399818	1	0.2368

Null Hypothesis Summary:

Normalized Restriction (= 0)	Value	Std. Err.
C(1)	0.270892	0.228960

Restrictions are linear in coefficients.

FINLAND: estimation residual regressed on its lagged value and the corresponding Wald test

Dependent Variable: RESID1AFIN
Method: Least Squares
Date: 02/23/05 Time: 17:50
Sample (adjusted): 1984–2002
Included observations: 19 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
RESID1AFIN(-1)	-0.063653	0.239140	-0.266177	0.7931

R-squared	0.003643	Mean dependent var	0.010798
Adjusted R-squared	0.003643	S.D. dependent var	0.664414
S.E. of regression	0.663203	Akaike info criterion	2.067724
Sum squared resid	7.917081	Schwarz criterion	2.117431
Log likelihood	-18.64338	Durbin-Watson stat	1.947180

Wald Test:
Equation: RES1AFIN

Test Statistic	Value	df	Probability
F-statistic	0.070850	(1, 18)	0.7931
Chi-square	0.070850	1	0.7901

Null Hypothesis Summary:

Normalized Restriction (= 0)	Value	Std. Err.
C(1)	-0.063653	0.239140

Restrictions are linear in coefficients.

NORWAY: estimation residual regressed on its lagged value and the corresponding Wald test

Dependent Variable: RESID1ANOR
Method: Least Squares
Date: 02/23/05 Time: 17:56
Sample (adjusted): 1984–2002
Included observations: 19 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
RESID1ANOR(-1)	0.064579	0.233158	0.276975	0.7850

R-squared	0.003148	Mean dependent var	0.025343
Adjusted R-squared	0.003148	S.D. dependent var	0.784922
S.E. of regression	0.783686	Akaike info criterion	2.401578
Sum squared resid	11.05494	Schwarz criterion	2.451286
Log likelihood	-21.81500	Durbin-Watson stat	2.006167

Wald Test:
Equation: RES1ANOR

Test Statistic	Value	df	Probability
F-statistic	0.076715	(1, 18)	0.7850
Chi-square	0.076715	1	0.7818

Null Hypothesis Summary:

Normalized Restriction (= 0)	Value	Std. Err.
C(1)	0.064579	0.233158

Restrictions are linear in coefficients.

SWEDEN: estimation residual regressed on its lagged value and the corresponding Wald test

Dependent Variable: RESID1ASWE
Method: Least Squares
Date: 02/23/05 Time: 17:57
Sample (adjusted): 1984–2002
Included observations: 19 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
RESID1ASWE(-1)	0.459350	0.210373	2.183506	0.0425

R-squared	0.209220	Mean dependent var	0.017145
Adjusted R-squared	0.209220	S.D. dependent var	1.148911
S.E. of regression	1.021679	Akaike info criterion	2.931967
Sum squared resid	18.78889	Schwarz criterion	2.981674
Log likelihood	-26.85369	Durbin-Watson stat	1.665025

Wald Test:
Equation: RES1ASWE

Test Statistic	Value	df	Probability
F-statistic	4.767700	(1, 18)	0.0425
Chi-square	4.767700	1	0.0290

Null Hypothesis Summary:

Normalized Restriction (= 0)	Value	Std. Err.
C(1)	0.459350	0.210373

Restrictions are linear in coefficients.

F-test for coefficient restrictions

Null hypothesis: The coefficient restriction is valid

$$F = \frac{RRSS - URSS}{URSS} \cdot \frac{T - k}{m}$$

Degrees of freedom: $F(m, T-k)$

URSS = residual sum of squares for unrestricted regression
RRSS = residual sum of squares for restricted regression
m = number of restrictions
T = number of observations
k = number of regressors in unrestricted regression

Model 1a (Nordic countries)

RRSS	47.584			
T	80			
Both income and interest rate surprise set unrestricted				
URSS	36.955	F	9.635273	
m	2			
k	13	T-k	67	
Income surprise set unrestricted				
URSS	44.278	F	5.450517	(null hyp. cannot be rejected at 1% level)
m	1			
k	7	T-k	73	
Interest rate surprise set unrestricted				
URSS	38.691	F	16.77881	
m	1			
k	7	T-k	73	
Lagged dependent variable set unrestricted				
URSS	47.491	F	0.142953	(null hyp. cannot be rejected at 1% level)
m	1			
k	7	T-k	73	

Model 1b (All countries)

RRSS	60.51			
T	153			
Both income and interest rate surprise set unrestricted				
URSS	43.029	F	25.39131	
m	2			
k	28	T-k	125	
Income surprise set unrestricted				
URSS	54.869	F	17.38256	
m	1			
k	12	T-k	141	
Interest rate surprise set unrestricted				
URSS	47.105	F	40.12536	
m	1			
k	12	T-k	141	
Lagged dependent variable set unrestricted				
URSS	59.941	F	1.338466	(null hyp. cannot be rejected at 1% level)
m	1			
k	12	T-k	141	

Appendix 3

Correlations between the dependent and explanatory variables

Finland

Correlation: Banks' loan losses / lending stock (LTL), 23 observations

lag	loan losses (LTL)	loan stock (LV)	GDP value (YV)	GDP volume surprise (YQS)	GDP deflator surprise (YPS)	%- interest rate (RLE)	GDP deflator expectation (YPJ1)	?-% lending stock (LVMP)	?-% asset prices (APMP)	?-% exchange rate (NEUMP)
expected sign	+	+	-	-	-	+	-	+	+	?
of correlation										
+2		0,137	0,167	0,196	-0,278	-0,563	-0,322	-0,644	-0,052	0,325
+1		0,191	0,071	-0,096	-0,316	-0,612	-0,292	-0,741	-0,142	-0,071
0		0,244	-0,020	-0,421	-0,527	-0,400	-0,238	-0,741	-0,196	-0,486
-1	0,789	0,397	0,035	-0,749	-0,553	-0,123	-0,142	-0,529	-0,285	-0,470
-2	0,459	0,447	0,099	-0,606	-0,360	0,261	-0,047	-0,249	-0,197	-0,227
-3	0,161	0,389	0,109	-0,202	0,020	0,376	-0,050	0,045	-0,114	-0,018
-4	-0,018	0,250	0,054	0,154	0,360	0,388	-0,137	0,297	-0,020	0,028

Denmark

Correlation: Banks' loan losses / lending stock (LTL), 23 observations

lag	loan losses (LTL)	loan stock (LV)	GDP value (YV)	GDP volume surprise (YQS)	GDP deflator surprise (YPS)	%- interest rate (RLE)	GDP deflator expectation (YPJ1)	?-% lending stock (LVMP)	?-% asset prices (APMP)	?-% exchange rate (NEUMP)
expected sig	+	+	-	-	-	+	-	+	+	?
of correlation										
+2		-0,029	0,048	0,163	-0,183	-0,209	-0,055	0,072	0,163	0,087
+1		-0,206	-0,110	0,166	-0,213	-0,249	0,039	0,031	0,037	0,250
0		-0,266	-0,182	-0,046	-0,240	-0,145	0,116	-0,164	-0,204	0,289
-1	0,745	-0,298	-0,257	-0,156	-0,190	-0,044	-0,057	-0,330	-0,522	0,099
-2	0,364	-0,149	-0,176	-0,406	-0,228	0,005	-0,100	-0,414	-0,520	0,104
-3	-0,007	0,038	-0,069	-0,236	-0,079	0,141	-0,100	-0,296	-0,443	0,093
-4	-0,238	0,154	0,026	0,011	-0,020	0,091	-0,133	-0,140	-0,093	0,067

Norway

Correlation: Banks' loan losses / lending stock (LTL), 23 observations

lag	loan losses (LTL)	loan stock (LV)	GDP value (YV)	GDP volume surprise (YQS)	GDP deflator surprise (YPS)	%- interest rate (RLE)	GDP deflator expectation (YPJ1)	?-% lending stock (LVMP)	?-% asset prices (APMP)	?-% exchange rate (NEUMP)
expected sig	+	+	-	-	-	+	-	+	+	?
of correlation										
+2		-0,098	-0,210	-0,136	-0,196	-0,626	-0,081	-0,185	-0,363	0,086
+1		-0,107	-0,284	-0,251	-0,297	-0,317	0,075	-0,178	-0,508	0,052
0	0,752	-0,089	-0,272	-0,396	-0,171	-0,046	0,017	-0,151	-0,533	-0,066
-1	0,505	-0,112	-0,274	-0,288	-0,094	0,123	0,074	0,023	-0,270	-0,063
-2	0,192	-0,168	-0,256	-0,159	0,063	0,125	0,111	0,094	0,016	-0,135
-3	-0,078	-0,205	-0,268	-0,065	0,008	0,346	0,152	0,200	0,104	-0,215
-4	-0,289	-0,283	-0,286	0,314	0,055	0,479	0,147	0,490	0,319	-0,364

Sweden

Correlation: Banks' loan losses / lending stock (LTL), 23 observations

lag	loan losses (LTL)	loan stock (LV)	GDP value (YV)	GDP volume surprise (YQS)	GDP deflator surprise (YPS)	%- interest rate (RLE)	GDP deflator expectation (YPJ1)	?-% lending stock (LVMP)	?-% asset prices (APMP)	?-% exchange rate (NEUMP)
expected sig	+	+	-	-	-	+	-	+	+	?
of correlation										
+2		0,005	0,165	0,075	-0,148	-0,189	-0,228	-0,300	0,029	-0,072
+1		-0,063	0,065	-0,348	-0,287	-0,405	-0,128	-0,439	-0,184	-0,355
0		-0,036	0,032	-0,520	-0,409	-0,312	0,120	-0,685	-0,348	-0,199
-1	0,733	0,044	-0,005	-0,358	-0,287	0,012	0,505	-0,576	-0,364	0,065
-2	0,283	0,147	-0,027	-0,091	0,100	0,320	0,542	-0,145	-0,168	0,064
-3	-0,024	0,135	-0,061	0,181	0,362	0,448	0,257	0,224	0,027	0,117
-4	-0,170	0,043	-0,088	0,208	0,353	0,243	0,017	0,378	0,143	0,181

Belgium

Correlation: Banks' loan losses / lending stock (LTL), 23 observations

	loan losses	loan stock	GDP value	GDP volume surprise	GDP deflator surprise	%- interest rate	GDP deflator expectation	?-% lending stock	?-% asset prices	?-% exchange rate
lag	(LTL)	(LV)	(YV)	(YQS)	(YPS)	(RLE)	(YPJ1)	(LVMP)	(APMP)	(NEUMP)
expected sig of correlation	+	+	-	-	-	+	-	+	+	?
+2		-0,634	-0,502	0,138	0,176	0,072	0,189	0,074	-0,010	0,301
+1		-0,744	-0,646	0,272	0,315	0,220	0,254	0,291	0,144	0,253
0		-0,852	-0,722	0,358	0,276	0,063	0,326	0,207	0,155	0,014
-1	0,725	-0,856	-0,679	0,267	0,133	-0,094	0,301	-0,027	-0,072	0,074
-2	0,645	-0,769	-0,603	0,149	0,242	-0,062	0,327	-0,119	-0,091	0,049
-3	0,430	-0,625	-0,516	0,121	0,098	-0,201	0,438	-0,122	-0,018	-0,166
-4	0,220	-0,482	-0,445	-0,014	0,122	-0,230	0,362	-0,167	-0,168	-0,408

Greece

Correlation: Banks' loan losses / lending stock (LTL), 23 observations

	loan losses	loan stock	GDP value	GDP volume surprise	GDP deflator surprise	%- interest rate	GDP deflator expectation	?-% lending stock	?-% asset prices	?-% exchange rate
lag	(LTL)	(LV)	(YV)	(YQS)	(YPS)	(RLE)	(YPJ1)	(LVMP)	(APMP)	(NEUMP)
expected sig of correlation	+	+	-	-	-	+	-	+	+	?
+2		0,416	0,447	-0,004	-0,268	-0,427	-0,370	-0,392	0,192	0,401
+1		0,432	0,467	-0,255	-0,173	-0,374	-0,369	-0,242	0,066	0,302
0		0,533	0,576	-0,017	-0,121	-0,449	-0,497	-0,469	0,030	0,569
-1	0,213	0,452	0,494	0,018	-0,155	-0,406	-0,390	-0,421	-0,031	0,439
-2	0,373	0,311	0,353	-0,171	0,146	-0,088	-0,314	-0,557	0,298	0,328
-3	0,323	0,336	0,353	0,130	-0,076	-0,216	-0,298	-0,407	0,028	0,357
-4	0,177	0,256	0,257	-0,125	0,422	-0,088	-0,312	-0,175	0,075	0,314

Spain

Correlation: Banks' loan losses / lending stock (LTL), 23 observations

	loan losses	loan stock	GDP value	GDP volume surprise	GDP deflator surprise	%- interest rate	GDP deflator expectation	?-% lending stock	?-% asset prices	?-% exchange rate
lag	(LTL)	(LV)	(YV)	(YQS)	(YPS)	(RLE)	(YPJ1)	(LVMP)	(APMP)	(NEUMP)
expected sig of correlation	+	+	-	-	-	+	-	+	+	?
+2		-0,145	-0,089	0,252	-0,080	-0,074	0,026	-0,099	0,294	0,138
+1		-0,398	-0,326	0,110	0,091	-0,030	0,174	-0,127	0,096	-0,080
0		-0,497	-0,447	-0,091	-0,150	-0,258	0,395	-0,134	-0,084	-0,283
-1	0,595	-0,470	-0,453	-0,601	-0,173	-0,117	0,545	-0,397	-0,351	-0,568
-2	0,265	-0,305	-0,334	-0,607	0,183	0,106	0,542	-0,135	-0,459	-0,329
-3	-0,044	-0,221	-0,262	-0,385	0,255	-0,011	0,309	0,147	-0,264	-0,056
-4	-0,223	-0,189	-0,219	-0,059	0,154	0,068	0,068	0,282	-0,107	0,203

Germany

Correlation: Banks' loan losses / lending stock (LTL), 23 observations

	loan losses	loan stock	GDP value	GDP volume surprise	GDP deflator surprise	%- interest rate	GDP deflator expectation	?-% lending stock	?-% asset prices	?-% exchange rate
lag	(LTL)	(LV)	(YV)	(YQS)	(YPS)	(RLE)	(YPJ1)	(LVMP)	(APMP)	(NEUMP)
expected sig of correlation	+	+	-	-	-	+	-	+	+	?
+2		0,038	0,231	0,012	-0,262	0,049	0,092	-0,077	-0,087	-0,068
+1		0,204	0,284	-0,533	0,363	0,356	-0,150	-0,269	-0,232	0,161
0		0,676	0,796	0,212	0,007	0,409	-0,587	-0,809	-0,609	0,187
-1	0,341	0,283	0,284	-0,264	0,115	0,527	-0,186	-0,316	-0,136	-0,018
-2	0,231	0,254	0,231	0,066	-0,127	0,142	-0,205	-0,194	0,014	-0,117
-3	0,057	0,187	0,172	-0,086	0,114	0,106	-0,215	-0,159	0,007	-0,037
-4	-0,007	0,181	0,167	0,176	-0,116	0,010	-0,175	-0,141	0,011	-0,154

UK

Correlation: Banks' loan losses / lending stock (LTL), 23 observations

	loan losses	loan stock	GDP value	GDP volume surprise	GDP deflator surprise	%- interest rate	GDP deflator expectation	?-% lending stock	?-% asset prices	?-% exchange rate
lag	(LTL)	(LV)	(YV)	(YQS)	(YPS)	(RLE)	(YPJ1)	(LVMP)	(APMP)	(NEUMP)
expected sig of correlation	+	+	-	-	-	+	-	+	+	?
+2		-0,360	-0,399	-0,251	0,233	0,361	-0,178	0,138	0,207	0,094
+1		-0,604	-0,652	0,071	-0,332	0,133	0,267	0,053	0,074	-0,113
0		-0,788	-0,849	-0,148	-0,373	-0,340	0,699	-0,364	-0,033	-0,395
-1	0,606	-0,313	-0,379	-0,100	-0,250	-0,309	0,418	-0,182	-0,226	-0,261
-2	0,402	-0,042	-0,093	-0,080	-0,201	-0,292	0,329	0,016	-0,347	-0,340
-3	0,078	0,132	0,140	0,013	-0,134	-0,073	0,105	0,020	-0,130	-0,177
-4	-0,065	0,124	0,136	0,050	0,100	-0,053	-0,082	-0,051	0,031	0,094

Iceland

Correlation: Banks' loan losses / lending stock (LTL), 23 observations

	loan losses	loan stock	GDP value	GDP volume surprise	GDP deflator surprise	%- interest rate	GDP deflator expectation	?-% lending stock	?-% asset prices	?-% exchange rate
lag	(LTL)	(LV)	(YV)	(YQS)	(YPS)	(RLE)	(YPJ1)	(LVMP)	(APMP)	(NEUMP)
expected sig of correlation	+	+	-	-	-	+	-	+	+	?
+2		-0.5214	-0.5048	-0.3279	0.0730	-0.0556	-0.5722	-0.3759		0.1217
+1		-0.4606	-0.4862	0.1246	0.0253	-0.6607	-0.3518	-0.4475		-0.0458
0		-0.4532	-0.5752	-0.3266	-0.3344	-0.0635	0.4553	0.0070		-0.3821
-1	0.426	-0.2804	-0.3603	-0.3249	-0.6434	-0.5328	0.5802	-0.0766		0.0465
-2	0.453	-0.1374	-0.2616	-0.0577	-0.0199	-0.3078	0.1358	0.2064		-0.5019
-3	0.137	0.0122	-0.0933	-0.0261	0.0275	-0.4318	0.1764	0.2199		-0.4809
-4	0.100	0.1196	0.0560	0.2140	0.0441	0.0806	0.0927	0.3852		-0.3334

Appendix 4

Estimating the effect of preceding lending and asset boom on loan losses

1. On Borio-Lowe hypothesis based model

Normally in perfect markets, the outlook for GDP should not affect the ratio of loan losses to lending stock as all the information is exploited in the economic agents' plans. However, we discussed in the text that, during periods of strong growth, relaxed loan standards can generate lending booms that end up in increased loan losses. It is possible that mere expectations of exceptionally vigorous growth can initiate such a lending boom, where the problems of asymmetric information become significant. Even borrowers who have no intention to repay can get loans in certain cases, as banks' project screening resources become stretched. The same expectations of strongly increasing incomes can, in connection with and boosted by lending boom, feed an accelerating increase in asset prices. If the result is asset price bubble, a bursting of the bubble easily triggers debt deflation. In those cases no additional surprises are necessarily needed to generate loan losses. As we discussed in the text (section 3.1), Borio and Lowe (2002) have shown that combined asset price and lending boom increases risk for banking distress. Hence, it is possible that an exceptional strong lending boom, in particular combined with rapid increase in asset prices, affects loan losses with a lag.

In order to test econometrically whether Borio-Lowe's hypothesis is likely to be valid, we regress loan losses against lending and asset prices. According to the results of Borio and Lowe, the most feasible length of lag would be somewhere between two and four years. A preliminary correlation analysis (Appendix 3) suggests that a proper lag between loan losses over lending and percentage change in lending could be four years. The respective lag regarding the percentage change in asset prices could be three years. The combined effect of lending and asset price boom is traced by adding their lagged annual percentage changes together. The SUR estimation of four Nordic countries gives a following result

$$\mathrm{LTL} = -\underset{(1.2)}{0.18} + \underset{(12.5)^{**}}{0.85} \cdot \mathrm{LTL}_{-1} + \underset{(4.4)^{**}}{0.02} \cdot (\mathrm{LVMP}_{-4} + \mathrm{APMP}_{-3}) \tag{4a}$$

Adjusted R-squared: 0.74, DW 1.81

Fixed effect coefficients: Denmark 0.03, Finland -0.07, Norway 0.003, Sweden 0.03

where

LTL = banks' loan losses/outstanding lending stock

LVMP = percentage change of banks' lending

APMP = percentage change of asset prices

The total explanatory power is about as high as in the respective basic equation 1a (in text and Appendix 2). Again the lagged dependent variable is very significant, but also the combined credit and asset price boom variable is strongly significant. When estimated separately, the percentage change in lending seems to be the robust part, while the significance of asset prices weakens markedly. Lending boom alone would also do the job, but combining it with asset prices gives a bit better result.

One reason for the relative unstable result regarding asset prices might be the recent steep rise and fall in asset prices. It seems in Figure 4 that, in particular in Finland and Sweden, the rise in asset prices in 2000–2002 was exceptionally strong. This was the IT boom and bubble which was financed mainly by issuing new shares in stock exchange. Consequently, relative limited amount of bank loans were involved. To control that phenomenon, a dummy variable was applied. The dummy did not however get a significant coefficient.

Testing the Borio-Lowe hypothesis on the wider country sample gives following PLS result

$$\text{LTL} = -\underset{(0.3)}{0.03} + \underset{(14.3)^{**}}{0.79} \cdot \text{LTL}_{-1} + \underset{(3.1)^{**}}{0.01} \cdot (\text{LVMP}_{-4} + \text{APMP}_{-3}) \tag{4b}$$

Adjusted R-squared: 0.63, DW 1.59

Fixed effect coefficients: Denmark 0.09, Finland 0.03, Norway 0.07, Sweden 0.12, Belgium -0.11, Germany, 0.01, Spain 0.02, Greece -0.27, UK -0.10

The total explanatory power is a bit weaker here than in the four Nordic countries (4a), but otherwise the results are mutually rather similar. Adding Iceland did not change the results. Note that the estimation of lending and asset price variables in isolation points this time to a relatively more robust asset price variable than in the pure Nordic estimation.

In sum, it looks as if Borio and Lowe have a valid point. The combined lagged effect of percentage changes in bank lending and asset prices give a significant result in explaining banks' loan losses. Next we try whether we could combine the explanations for second, third and fourth phases of credit distress cycle. Let us call it hybrid model, where the factors of increasing fragility (phase two) and the surprise-fragility-combination (phase three) and the persistence of loan losses (phase four) are all working.

2. Hybrid model

The hybrid model attempts to explain banks' loan losses with a combined effect of surprising macroeconomic shocks, financial fragility, lagged effect of factors that likely contribute the fragility and the autoregressive element of loan losses. In practice this means that we add lending and asset price boom variable from equations 4 to the basic equations 1 (in text). The SUR estimation for four Nordic countries gives following result

$$\begin{aligned} LTL = &-\underset{(0.1)}{0.02} + \underset{(11.3)^{**}}{0.77} \cdot LTL_{-1} - \underset{(3.3)^{**}}{0.11} \cdot (YS \cdot LYV_{-1}) + \underset{(1.3)}{0.10} \cdot (RS_{-1} \cdot LYV_{-1}) \\ &+ \underset{(\ 2.8)^{**}}{0.01} \cdot (LVMP_{-4} + APMP_{-3}) \end{aligned} \tag{5a}$$

Adjusted R-squared: 0.76, DW 1.75
Fixed effect coefficients: Denmark 0.03, Finland -0.15, Norway 0.03, Sweden 0.09

The symbols are same as in the models above. Total explanatory power (adjusted R2) exceeds only slightly that of basic model (1a). The signs of coefficients are as expected and significant expect for the lagged real lending rate. The estimation results of real interest rate have commonly not been as robust as that of income surprise variable. A reason for that kind of unstable result could be that every variable includes lending stock in some form albeit with different lags in some variables. This might increase the problem of multicollinearity in the test results.

The respective PLS estimation on the total set of countries gives following results

$$\begin{aligned} LTL = &\underset{(0.9)}{0.10} + \underset{(13.7)^{**}}{0.73} \cdot LTL_{-1} - \underset{(4.2)^{**}}{0.12} \cdot (YS \cdot LYV_{-1}) + \underset{(2.3)^{*}}{0.08} \cdot (RS_{-1} \cdot LYV_{-1}) \\ &+ \underset{(2.3)^{*}}{0.01} \cdot (LVMP_{-4} + APMP_{-3}) \end{aligned} \tag{5b}$$

Adjusted R-squared: 0.68, DW 1.76
Fixed effect coefficients: Denmark 0.08, Finland -0.07, Norway 0.10, Sweden 0.17, Belgium -0.19, Germany -0.26, Spain 0.13, Greece -0.16, UK -0.10

Total explanatory power is slightly better than in the corresponding basic equation 1b (in text). All the coefficients have signs as expected and are statistically significant. The combined, lagged real lending rate and lending/asset price boom variable is only significant at 95 per cent confidence level.

In sum, the loan loss equations seem to be all in all rather robust. The hybrid model seems to take into account the combined effect of factors affecting the phases from two to four of credit distress cycle. However, when we apply the estimated equation in an out of sample test for the Finnish loan losses in the early 2000s the hypothesis fails. A vigorous IT asset price growth generates through the equation an exceptional large increase in loan losses, which did not happen in reality. The explanation is that the Finnish IT boom was mainly financed by issuing equities in the stock exchange and not by bank loans. The model could not take that into account.

Estimation results

Key for variables:

LTL	=	banks' loan losses/lending stock, %
(YQS+YPS)	=	YS = income surprise variable
RLE	=	banks nominal lending rate
YPJ1-YPJ1(-1)	=	change in the OECD forecasted GDP deflator (forecast made in June preceding year)
LYV	=	domestic credit/GDP value, %
LVMP4	=	%-change in banks' lending stock lagged by 4 years
APMP	=	%-change in asset prices

Countries:

DEN = Denmark
FIN = Finland
NOR = Norway
SWE = Sweden
ES = Spain
GR = Greece
DE = Germany
UK = United Kingdom
BE = Belgium
IC = Iceland

Equation 4A

Dependent Variable: LTL?
Method: Pooled EGLS (Cross-section SUR)
Date: 12/22/04 Time: 15:34
Sample: 1983–2002
Included observations: 20
Cross-sections included: 4
Total pool (balanced) observations: 80
Linear estimation after one-step weighting matrix

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-0.175535	0.147647	-1.188881	0.2383
LTL?(-1)	0.852346	0.068354	12.46965	0.0000
(LVMP4?)+APMP?(-3)	0.017613	0.004020	4.381234	0.0000
Fixed Effects (Cross)				
DEN—C	0.032180			
FIN—C	-0.065108			
NOR—C	0.003389			
SWE—C	0.029539			

Effects Specification

Cross-section fixed (dummy variables)

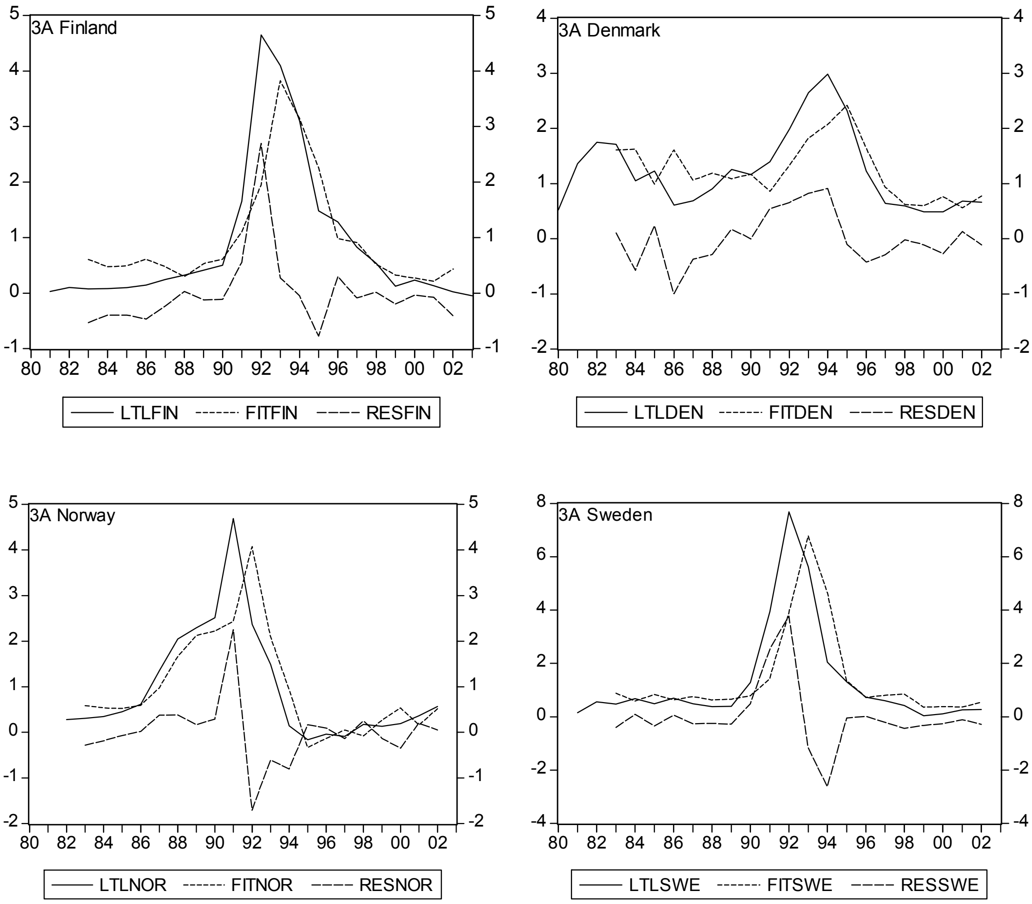
Weighted Statistics

R-squared	0.761114	Mean dependent var	1.177353
Adjusted R-squared	0.744973	S.D. dependent var	1.961596
S.E. of regression	0.990610	Sum squared resid	72.61679
F-statistic	47.15425	Durbin-Watson stat	1.808966
Prob(F-statistic)	0.000000		

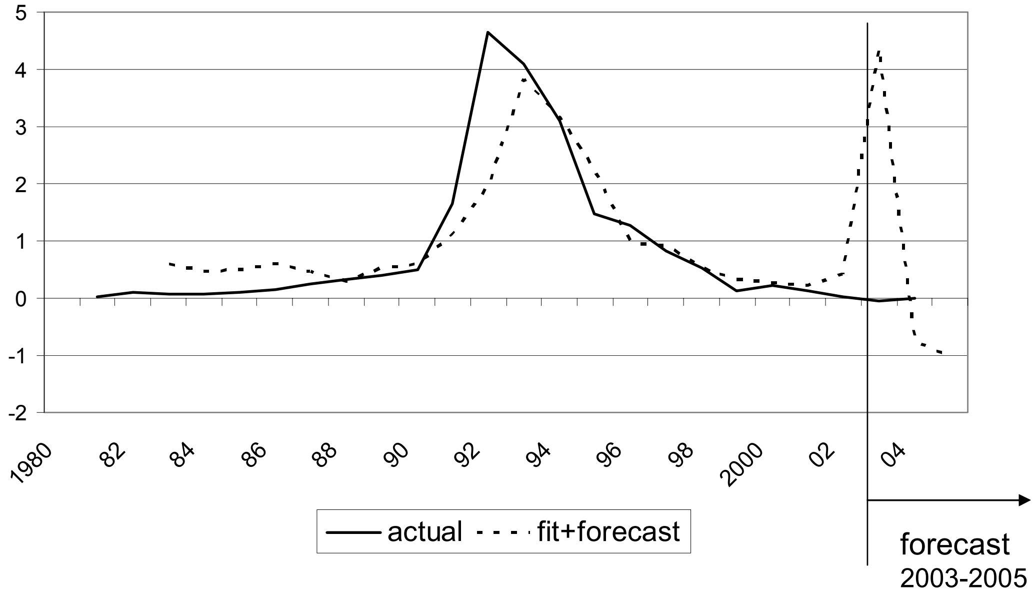
Unweighted Statistics

R-squared	0.656688	Mean dependent var	1.156388
Sum squared resid	53.64417	Durbin-Watson stat	1.573241

Fit and residual Figures 4A



FINLAND: Loan losses/lending, %
forecast 2003–2005 (model 4A)



Equation 4B

Dependent Variable: LTL?
Method: Pooled Least Squares
Date: 12/22/04 Time: 15:45
Sample: 1983–2002
Included observations: 20
Cross-sections included: 9
Total pool (unbalanced) observations: 150

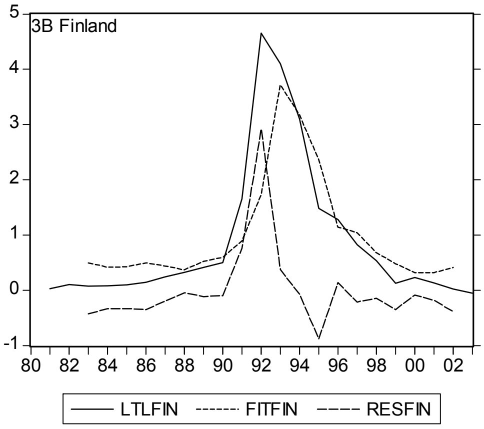
Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-0.029585	0.107893	-0.274207	0.7843
LTL?(-1)	0.788748	0.055253	14.27510	0.0000
(LVMP4?)+APMP?(-3)	0.009682	0.003099	3.124721	0.0022
Fixed Effects (Cross)				
DEN—C	0.094214			
FIN—C	0.026400			
NOR—C	0.068234			
SWE—C	0.126563			
ES—C	0.024127			
GR—C	-0.267689			
DE—C	0.011990			
UK—C	-0.088112			
BE—C	-0.114030			

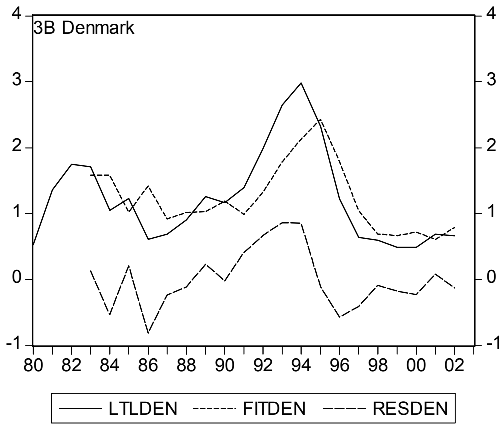
Effects Specification

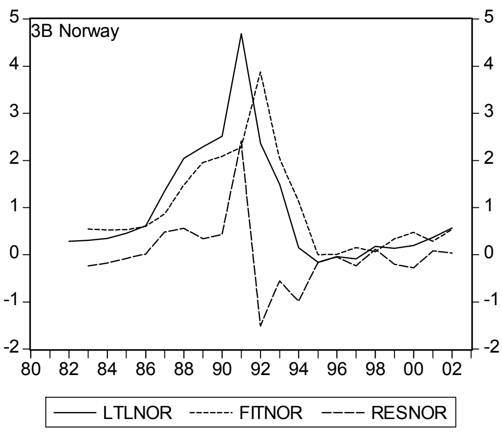
Cross-section fixed (dummy variables)

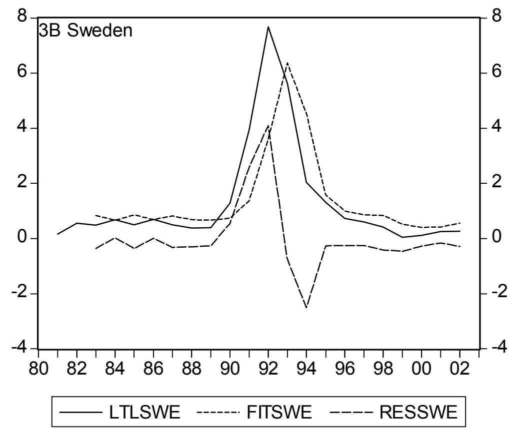
R-squared	0.651814	Mean dependent var	0.898434
Adjusted R-squared	0.626765	S.D. dependent var	1.144528
S.E. of regression	0.699226	Akaike info criterion	2.192821
Sum squared resid	67.95952	Schwarz criterion	2.413601
Log likelihood	-153.4616	F-statistic	26.02119
Durbin-Watson stat	1.585407	Prob(F-statistic)	0.000000

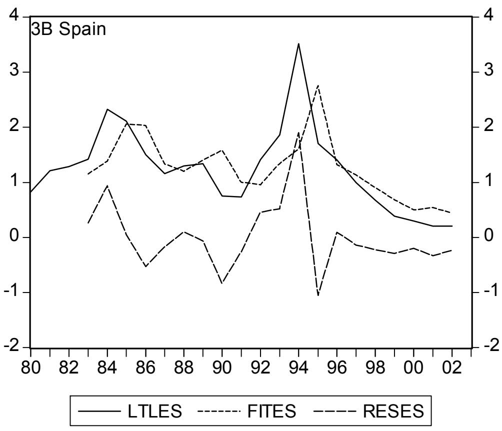
Fit and residual Figures 4B

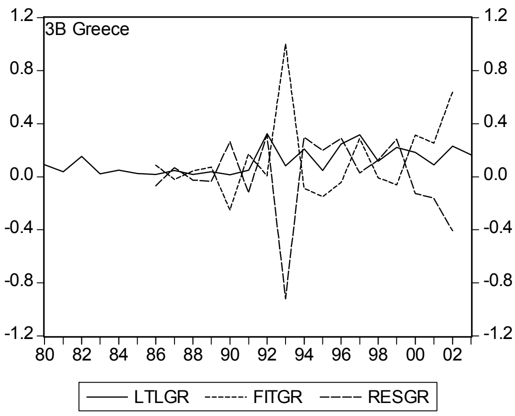


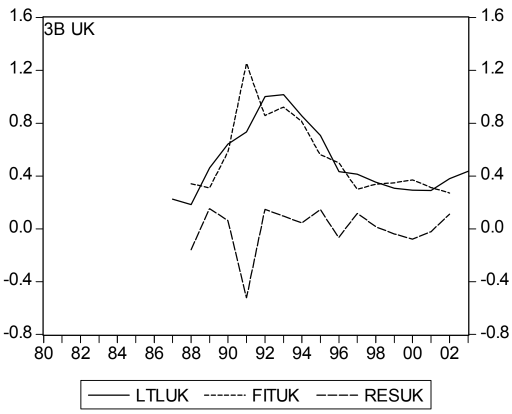


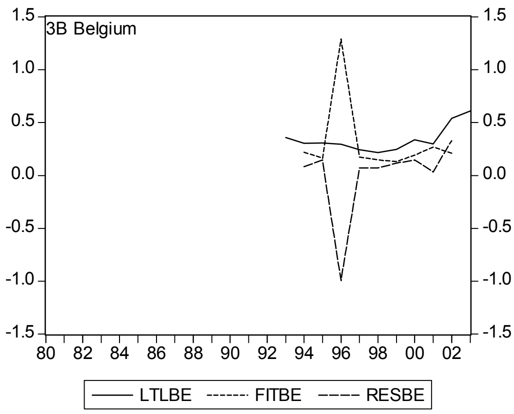




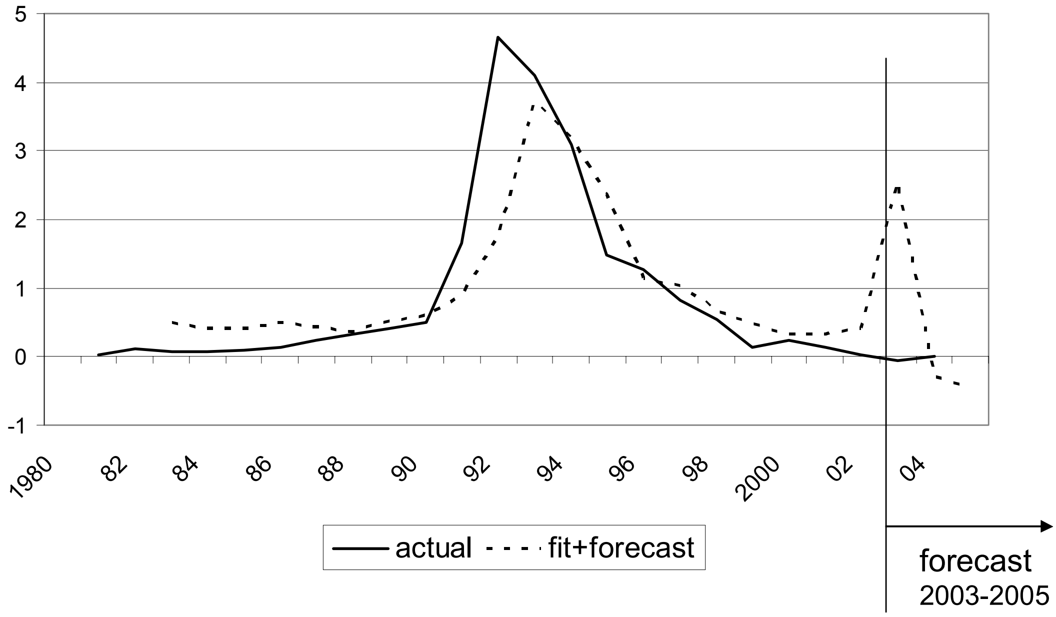








FINLAND: Loan losses/lending, %
forecast 2003–2005 (model 4B)



Equation 5A

Dependent Variable: LTL?
Method: Pooled EGLS (Cross-section SUR)
Date: 12/21/04 Time: 12:39
Sample: 1983–2002
Included observations: 20
Cross-sections included: 4
Total pool (balanced) observations: 80
Linear estimation after one-step weighting matrix

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-0.020565	0.162915	-0.126231	0.8999
LTL?(-1)	0.771200	0.068424	11.27084	0.0000
(YQS?+YPS?)*LYV?(-1)	-0.106098	0.031908	-3.325162	0.0014
(RLE?(-1)-YPJ1?+YPJ1?(-1))*LYV?(-1)	0.099476	0.075066	1.325191	0.1893
(LVMP4?)+(APMP?(-3))	0.014442	0.005129	2.815951	0.0063
Fixed Effects (Cross)				
DEN--C	0.033004			
FIN--C	-0.150883			
NOR--C	0.027602			
SWE--C	0.090276			

Effects Specification

Cross-section fixed (dummy variables)

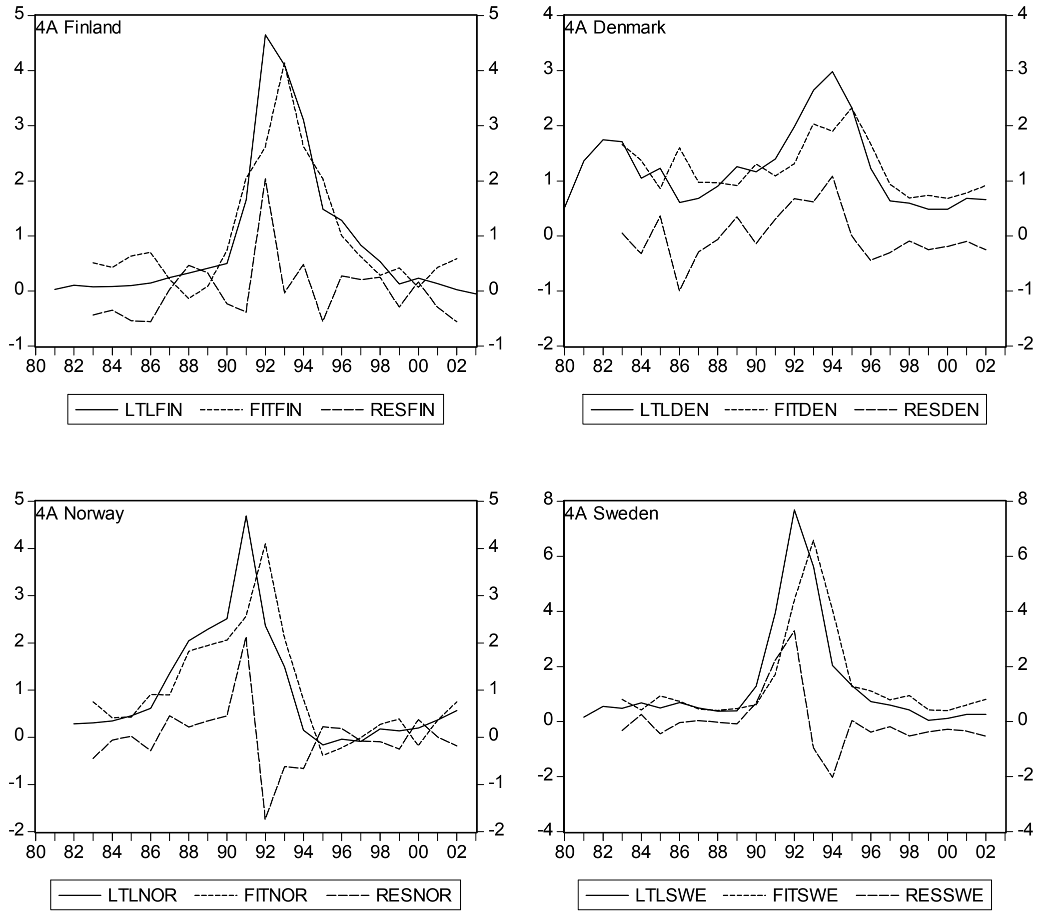
Weighted Statistics

R-squared	0.780772	Mean dependent var	1.537661
Adjusted R-squared	0.759458	S.D. dependent var	2.067264
S.E. of regression	1.013892	Sum squared resid	74.01428
F-statistic	36.63211	Durbin-Watson stat	1.746821
Prob(F-statistic)	0.000000		

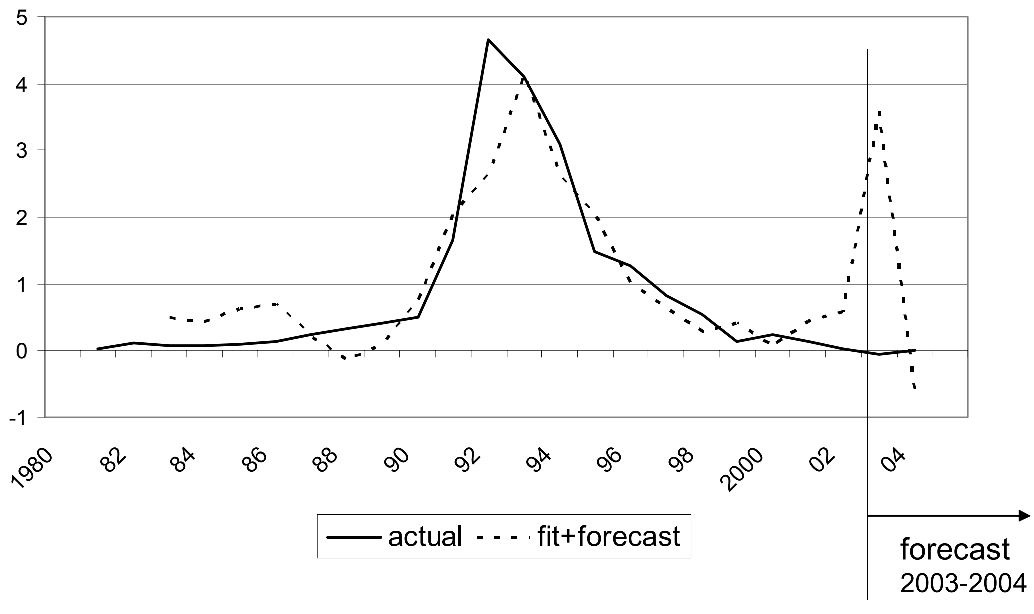
Unweighted Statistics

R-squared	0.724212	Mean dependent var	1.156388
Sum squared resid	43.09331	Durbin-Watson stat	1.674977

Fit and residual Figures 5A



FINLAND: Loan losses/lending, %
forecast 2003–2004 (model 5A)



Equation 5B

Dependent Variable: LTL?
Method: Pooled Least Squares
Date: 12/20/04 Time: 10:33
Sample: 1983–2002
Included observations: 20
Cross-sections included: 9
Total pool (unbalanced) observations: 150

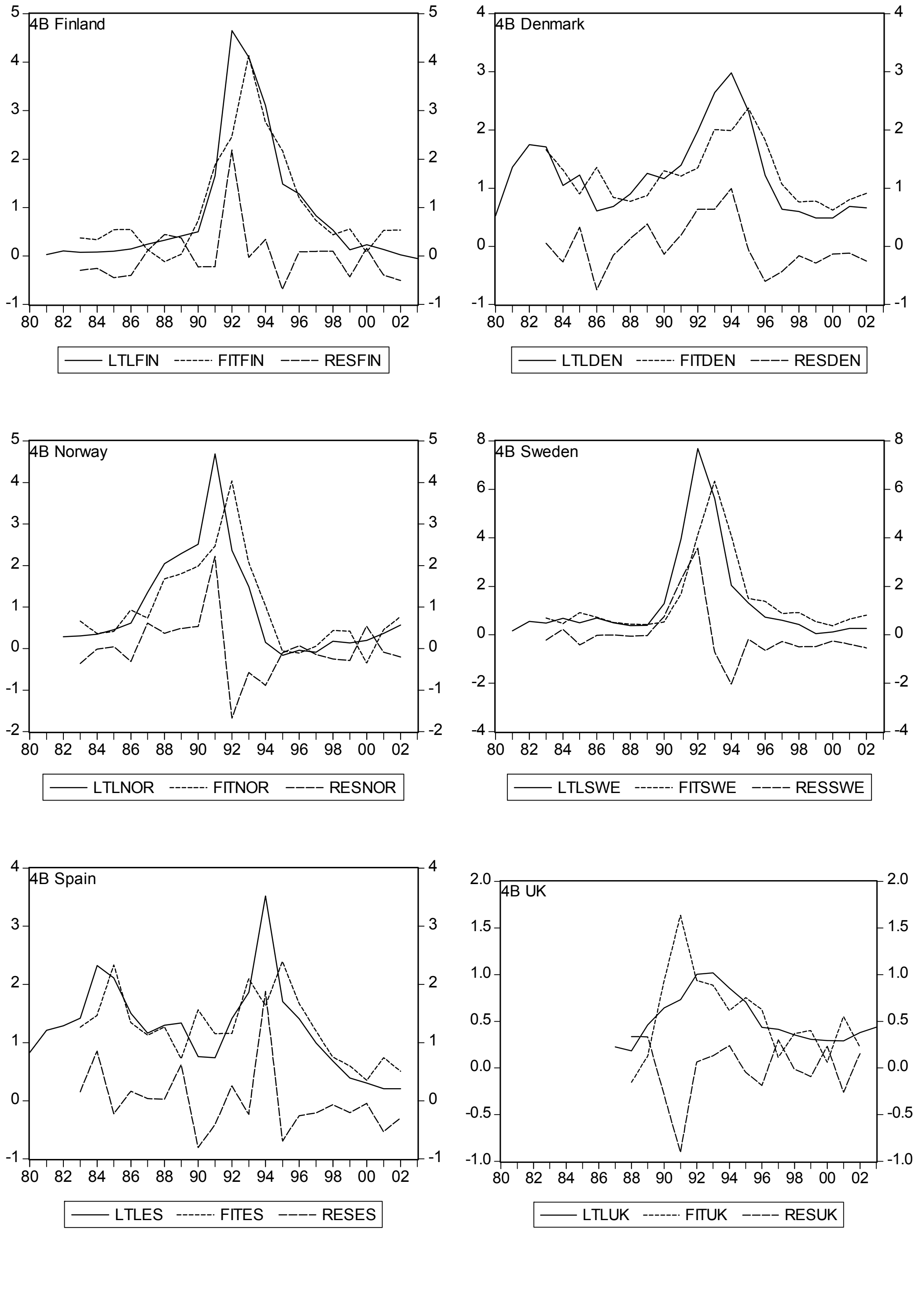
Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.097870	0.103499	0.945618	0.3460
LTL?(-1)	0.732105	0.053288	13.73854	0.0000
(YQS?+YPS?)*LYV?(-1)	-0.115851	0.027311	-4.241975	0.0000
(RLE?(-1)-YPJ1?+YPJ1?(-1))*LYV?(-1)	0.079552	0.034224	2.324460	0.0216
(LVMP4?)+APMP?(-3)	0.006841	0.002929	2.336128	0.0209
Fixed Effects (Cross)				
DEN--C	0.082403			
FIN--C	-0.067789			
NOR--C	0.096007			
SWE--C	0.173035			
ES--C	0.131016			
GR--C	-0.161894			
DE--C	-0.259567			
UK--C	-0.102285			
BE--C	-0.185652			

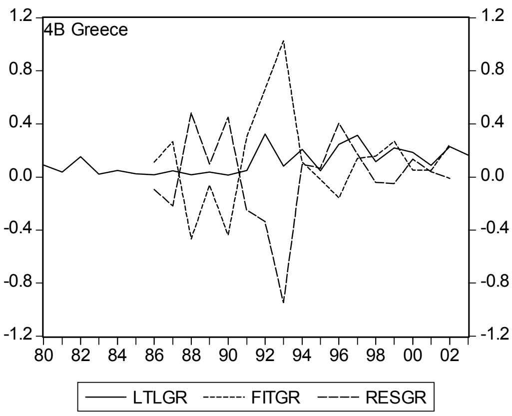
Effects Specification

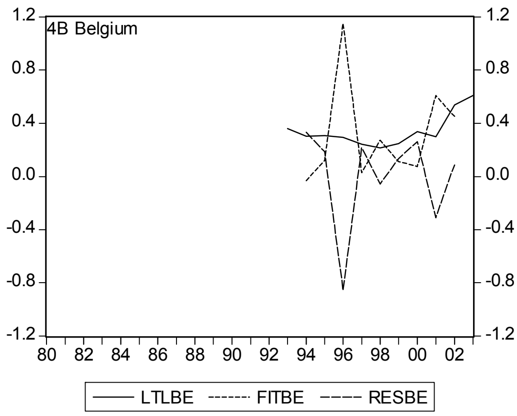
Cross-section fixed (dummy variables)

R-squared	0.705152	Mean dependent var	0.898434
Adjusted R-squared	0.679326	S.D. dependent var	1.144528
S.E. of regression	0.648125	Akaike info criterion	2.053211
Sum squared resid	57.54897	Schwarz criterion	2.314133
Log likelihood	-140.9909	F-statistic	27.30382
Durbin-Watson stat	1.762514	Prob(F-statistic)	0.000000

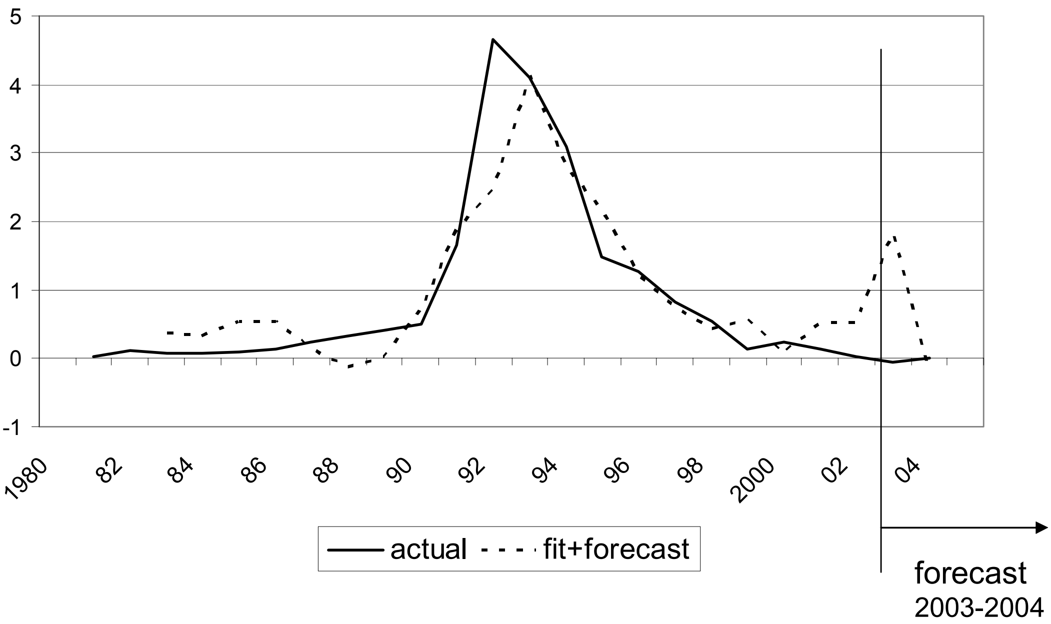
Fit and residual Figures 5B







FINLAND: Loan losses/lending, %
forecast 2003–2004 (model 5B)



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