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Abstract:

We model banks' loan losses with a panel of European countries for the period 1982–2012 using three country-specific macro variables: output growth shocks, real interest rates, and a measure of excessive private sector indebtedness. We find that a drop in output has an intensified impact on rising loan losses if the economy is excessively indebted. This may explain differences in loan losses in different recessions across time and across countries. For instance, the dramatic output drop in Finland in 2009 did not cause large loan losses compared with the Finnish crisis of the early 1990s because of the more moderate level of indebtedness. Low interest rates during the recent recession may have been another, perhaps the most important, factor mitigating loan losses.

Key words: loan losses, banking crises, indebtedness

JEL classification: E44, G28

Introduction

Recent financial crisis has again brought banks' bad loans and loan losses to the front. However, in spite of much research of the reasons and remedies for the banking problems, there has not been much empirical analysis of the propagation mechanism behind loan losses. One reason for this may be that data on loan losses are not publicly available;the data have to be collected on a country by country basis. For this study we have managed to collect the aggregate loan loss data from nine countries (Belgium, Denmark, Finland, Germany, Greece, Norway, Spain, Sweden and the UK) for the period 1982-2012 (from most of the sample countries). This period includes the recent financial crises in Europe as well as banking crises in many countries in the early 1990s.[1] We then model the determination of loan losses in this panel setting with a few key macroeconomic variables. Our country-specific results could provide an interesting complementary view to supervisory analyses such as the European Central Bank's Asset Quality Review of the European banking sector, scheduled for 2014.

Banking crises are counter-cyclical and often preceded by excessive credit growth (see e.g. Borio and Lowe, 2002; Demirgüç-Kunt and Detragiache, 2005, Davis and Karim, 2008 and Reinhart and Rogoff, 2009). A crisis is typically triggered by a shock which is reflected in the economic slowdown of negative growth. The negative output growth together with high corporate and household indebtedness forms a toxic combination which can be considered to be the main reason for eventual loan

[1] The data is obtained from the national central banks or financial supervision authorities, and extends and updates the data set used by Pesola (2011).

losses.[2] The outcome also depends on the state of financial markets and the stance of monetary policy. In an open economy, the stance of monetary policy should perhaps be measured by a combination of real interest rates and real exchange rates in the form of a monetary conditions index. However, usually one simply uses the real interest rate as an indicator of the stance of monetary policy and money markets.

These considerations suggest three factors; output growth, private indebtedness, and the real interest rate, to model loan losses. A similar model has been used e.g. by Sorge and Virolainen (2006) in modeling banks' loan losses in a stress-testing setup. The model might be further extended by taking into account asset prices, especially house prices. While the three above-suggested factors account for the default probabilities of loan customers, the actual loan losses also depend on the loss-given-default values which crucially depend on collateral policies and collateral values (see e.g. Schuermann, 2004, for more details). [3] However, asset prices and house prices especially are not independent of the three above factors. The growth of credit often coincides with asset price booms, most recently with increase of house prices in many countries (cf. e.g. Goodhart and Hoffman, 2008a and b). And although the collapse of asset prices may be caused by several factors, it is typically related to a severe downturn in economic activity. We may hence be able to explain loan losses

[2] Apparently, output growth as well as interest rates may also be to endogenous to loan losses, which should be taken into account in estimating the model; e.g., by using proper instruments for these variables.

[3] More precisely, Sorge and Virolainen (2006) explain default rates with the three-factor model for Finland, assuming a constant loss-given-default. Jokivuolle and Virén (2013) have extended their model to allow for a time-varying loss-given default as a function of additional macro variables, including asset prices.

reasonably well with the three factors only. This is what we do in this study, partly to avoid problems with availability of the house price data.

Our paper relates to and extends the work by Pesola (2011) who models loan losses with similar macro variables and the same set of countries with data until 2005. Our contributions are the following. First, as our data set extends to 2012 we are able to compare the recent financial crisis with the previous crises, especially those in the early 1990's. Second, we find a distinct non-linear effect of the output shock on loan losses, depending on the level of indebtedness. In particular, we use a measure of *excessive* indebtedness which we define as the deviation of the private sector debt to GDP ratio from its trend (trying several trend specifications). This non-linear effect helps us understand the differences in loan losses in different crisis episodes. To demonstrate this we use Finland as a case in point. Unlike in the early 1990s' Finnish economic depression, well-known for its severity (see e.g. Gorodnichenko et al., 2012), the dramatic output drop in Finland in 2009 of easily similar scale did not cause large loan losses. According to our model, this may be explained by the more moderate level of indebtedness that prevailed before 2009 than in the early 1990's. Low interest rates as a result of accommodative monetary conditions during the recent recession have been another important factor mitigating loan losses. In actuality, a variance decomposition style analysis suggests that the real interest rate is the most important in a three-factor model to explain loan losses.

Our paper is related also to several other strands of literature. Kauko (2012) models non-performing loans instead of considering the actual loan losses. Davis and Karim (2008), Demirgüç-Kunt and Detragiache (2005) and Pesaran et. al. (2006) use cross-country data in predicting banking distress. Foos et al. (2010) focus on the role of loan growth in predicting bank failures.

The structure of the paper is as follows. Section 2 introduces the empirical methodology and the data, and reports the results. Section 3 concludes with some policy implications.

1. Empirical analysis

1.1 Data and models

As discussed above, the analyses are based on the following three-factor model which is basically the same that is used in Pesola (2011) as well as in Sorge and Virolainen (2006) and Jokivuolle, Virén and Vähämaa (2010):

(1) $$lt_{it}/lv_{it} = \alpha_0 + \alpha_1(g_{it}-g^e_{it}) + \alpha_2 rr_{it} + \alpha_3 Debt_{it-1} + \alpha_{24} r(lt_{it-1}/lv_{it-1}) + u_{it}$$

where lt denotes loan losses, lv is the stock of outstanding bank loans, g is the output growth rate, g^e is the *expected* output growth rate, rr is the real interest rate and Debt denotes (excessive) indebtedness. The indexes “i” and “t” denote sample country and time period (in years), respectively. We do not use the conventional indebtedness variable such as outstanding loans over GDP but a measure of "excessive indebtedness", defined as the deviation of the outstanding loans over GDP from its trend which in the basic case is estimated as the linear trend over the sample period[4]. The reason behind this specification is the fact that several institutional and structural factors like changes in the structure of debt, general accumulation of wealth and prolongation of the average maturity of debt have contributed to the growth of debt. This sort of gradual growth cannot be considered completely excessive while deviations from the growth rate presumably represent more risk both to economic agents and the banking sector. This formulation of indebtedness also solves the "technical" problem of having one non-stationary variable in the model where the other variables are at least roughly stationary[5]. To ensure that the results do not overly depend on the specific way of defining excess indebtedness, we use two alternative measures. First, we used the HP trend instead of the linear trend. As the other alternative we used residuals $\hat{w}_{it}$ from the following regression,

(2) $$lv_{it}/GDP_{it} = \varphi_{1i} + \varphi_{2i}(Deposits_{it}/GDP_{it}) + w_{it},$$

where the Deposits variable is a bank's total deposits. Thus, the variable reflects bank lending which is financed by other sources than ordinary deposits. This meausure may be seen as a version of the idea of using the ratio of banks' non-core to core liabilities as an indicator of financial vulnerability; see Shin (2012).

[4] The trend has been estimated separately for each sample country. The corresponding graphs of the country-specific excessive indebtedness are reported in Figure 1.
[5] It turns out that when equation (1) is estimated for the data, the simple level form indebtedness variable performs rather poorly and its coefficient systematically fails to come statically significant. By contrast, the corresponding trend deviation accounts very well with the theory.

The basic idea in Pesola's (2011) version of the model in equation (1) is to assume that loan losses are consequences of planning or forecasting errors by economic agents. Agents have had too optimistic future plans and when these plans fail some of the households and firms are not able to service their debts. This may lead to defaults which in turn may cause loan losses to banks. This is why we also use in the first place "unexpected" output growth as one of the independent variables. The corresponding data were derived from OECD forecasts from where sufficiently long and similarly constructed time-series were available. It turned out, however, that the actual output growth performed slightly better than this unexpected growth proxy and therefore we later on simply used the output growth. Although the idea introduced by Pesola (2011) of using the "unexpected growth" or "growth surprise" is sound, it may be that the relevant long-term expected growth variable is closer to a constant than to the OECD forecasts[6].

Figure 1, in which the same scale is used for all countries, gives an idea of the role of indebtedness behind banking crises. We see that the excessive indebtedness has increased considerably prior to major banking crises such as in Finland, Norway and Sweden in the early 1990s and recently in Spain. Conversely, it is hard to find evidence of banking crises which would have occurred when indebtedness has been at a "normal" level. On the other hand it is well known that financial crises typically coincide with negative output shocks. Moreover, there can be a bidirectional causality at least towards the end of a crisis as banking crises usually lead to

[6] We used both the June and December forecasts of OECD for next year as the expected values. Accordingly we used OECD forecast of inflation (in terms of GDP deflator) in constructing the real interest rate. Estimation results with the June or December forecasts differed only little as would be expected by their small differences; see Figure 2 which displays the medians of the respective time series.

depressed output because of reduction in banks' lending. In this sense negative output shocks may have a negative credit multiplier and vice versa: if the banking sector were not much affected by the output shock, e.g. thanks to plentiful loss absorbing buffers, the overall effects of the shock on the real economy would remain much smaller.

Note that real interest rates have behaved quite differently in different crisis episodes. In the early 1990s, the crises in the Nordic countries were apparently exacerbated by high real interest rates which in turn were related to exchange rates. That time all Nordic and several other European central banks tried to preserve their exchange rate peg by relatively high policy rates. Although the fixed exchange rate regimes ultimately gave in, interest rates did not immediately fall back and at least in the transition period real interest rates were exceptionally high. This presumably caused severe problems to both firms and households. The exchange rate movements may have contributed to loan losses also directly as bank customers may have taken foreign currency denominated loans, having left them unhedged against the foreign exchange rate risk[7]. Although a similar episode in many respects took place during the recent global financial crisis, the presence of the European Monetary Union importantly stabilized the exchange rate and interest rate environment compared to the early 1990's in many countries. Perhaps only in the

[7] At least anecdotal evidence suggests this was the case in the early 1990s Finnish crisis. The firms may have been lured into such unhedged positions by the lower interest rates on such foreign loans and by the trust in the fixed exchange rate policy regime.

case of Iceland the global financial crisis had similar effects as in the early 1990's in the other Nordic countries.

When estimating the model we had to overcome a slight technical problem due to the fact that actual loan losses were in some instances negative due to delayed payback of loans which have already been written off. Hence, we cannot take a log transformation of our dependent variable, defined as V = loan losses over outstanding loans (i.e., V=lt/lv; cf. above). We solved the problem by taking a logistic transformation of the variable in such a way that $v = -(1/(1+e^{-V}))$. This transformation of loan losses over outstanding loans is always between 0 and 1. The model is estimated by using the linear terms and by using this logistic transformation which in fact improves the explanatory power of the equation considerably.

Estimates of equation (1), both with and without the logistic transformation of the dependent variable, are reported in Table 1. The corresponding residuals (from regression 2 of Table 1) are displayed in Figure 3. In Table 1 we investigate the robustness of the results in terms of different panel estimators, including the GMM estimator. In Table 2, we present a set of additional results which intend to demonstrate the robustness of the basic results for different model specifications. In particular, we also consider nonlinear versions of the basic model (cf. e.g. Mayes and Viren (2010) and Marcucci and Quagliariello (2009)). Specifically, we introduce nonlinearity in the form of a smooth transition threshold model as follows:

(3) $$v_{it} = \alpha_0 + \alpha_{11}(g_{it}-g^e_{it}) + \alpha_{12}(g_{it}-g^e_{it})\,STR(x_t) + \alpha_2 rr_{it} + \alpha_3 Debt_{it-1} +$$

$\alpha_4 v_{it-1} + u_{it}$,

where the function STR is of the logistic form so that STR(x) = $1/(1+e^{-\psi(x-\gamma)})$ where ψ and γ are parameters to be estimated. As for the threshold variable, x, we used both output growth g and excessive indebtedness (cf. e.g. Mayes and Viren, 2010, for details).

Identification of parameters ψ and γ of the STR model turned out to be rather cumbersome so we decided on the basis of a grid search to set them to values that minimized the sum of squares (see Table 2). In addition, we also used a simple "threshold" model with the value of the fixed threshold parameter set to zero. [8]

1.2 Results

The basic model estimated with alternative methods in Table 1 seems to perform strikingly well. The coefficients have in all cases correct signs and they are of reasonable magnitude. Moreover, the panel estimates are relative precise, and quite robust with regard to the estimation method panel fixed effects. In particular, we wish to stress that even the GMM estimates (see regression 11 in Table 1) come close to the basic OLS estimates. Also, when comparing quantile regression estimates for the 25th and 75th percentiles of the residuals (regressions 7 and 8 in Table 1), there is relatively little difference between the two sets of coefficient estimates. The means of country-specific coefficients for the three explanatory variables, and their standard

[8] As an alternative way of modeling nonlinearity, we also considered quadratic and cross-terms of all explanatory variables in equation 1. However, these terms did not perform very well. Neither of them was significant and we could not reject the hypothesis that the respective coefficients are identically equal to zero ((F(6)=1.08 (0.38)). The results are available from the authors upon request. In what follows we focus on nonlinearity results from the STR model and the fixed threshold model.

deviations, reported in regression 9 of Table 1 indicate that there is some variation across countries in the model, but the “aggregation bias” seems of minor importance. The results are also fairly robust with respect to the alternative measures of the excess indebtedness variable. The size and the t-ratio of the coefficient vary somewhat but in qualitative terms, the results are the same. In this sense, we cannot really discriminate between different proxies of excess indebtedness. Nonetheless, the measures based on the trend of the loans to GDP variable give more precise coefficient estimates for the indebtedness variable (see regressions 3 and 5 in Table 1) than the measure which is based on the relative growth of non-deposit sources of bank lending, estimated by equation (2) above, and motivated by Shin (2012) (see regression 6 in Table 1).

One indication of the performance of the model in equation (1) is its good tracking performance. This is illustrated by the dynamic simulations for Finland which experienced an extraordinary severe banking crisis in the early 1990 which shows up as a sharp peak in the loan losses (Figure 4, the upper chart). The model predictions for Finnish loan losses (based on unreported country-specific coefficient estimates of equation (1)) come quite close to the actual data during that period and also towards the end of the sample period when the global financial crisis and later the so called Euro crisis hit the European banking system. As can be seen, there was only a small amount of loan losses after 2007. According to our model, this may be explained by the fact that compared to the early 1990s depression, the cumulative output shock in Finland during the recent crisis was smaller, interest rate shock was very much smaller, and during the run-up to the crisis excessive indebtedness was less of a problem in Finland (see Figure 1).[9] It is interesting to compare the Finnish experience to that of Spain (Figure 4, lower chart). In Spain, loan losses increased dramatically in 2012. The model could not produce the observed 2012 peak in loan losses but the cumulative development of loan losses in 2009-2012 comes quite close to the model predictions. This suggests that realization of some loan losses were delayed until 2012 and even after that (see the forecasts for 2013-2015). The forecasts for Finland and Spain give some idea of the usefulness of the model in practical policy work – the three factors that the model uses can typically be derived from most macro forecasts and hence the model can be easily linked to other forecasting systems.

Loan losses show quite a lot of persistence which is indicated by the relatively high coefficients of the lagged dependent variable, present in all alternative regression in Table 1. This may be partly explained by accounting practices as the decision to write-off a bank asset may sometimes be postponed in hope of a recovery. There may also be domino effects: a bankruptcy of one firm may cause a bankruptcy of another firm. Thirdly, the lagged loan losses may capture a feedback effect from loan losses to the real economy via reduction in bank lending. In any case, we conclude that even the parsimonious three-factor model, augmented with the lagged dependent variable, can reasonably well explain most changes in loan losses during the last three decades in the sample countries.

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[9] Moreover, it is commonly understood that the structure of the private sector indebtedness in Finland has also changed considerably from the early 1990s; notably the corporate capital structures have become less debt driven.

We next consider the potential nonlinearity in the effect of output growth on loan losses (see equation 3 above). In the regressions of Table 2 we find such evidence when the excessive indebtedness is used as the variable determining the smooth transition regime (or the fixed threshold) When the excessive indebtedness is high, the effect of the output growth on loan losses is much stronger. If indebtedness is very low (i.e. the measure of the excessive indebtedness is negative), the effect of an output shock is close to zero.[10] However, we detect no nonlinearity in the output growth on loan losses when the output growth itself is used as the regime determining variable (see regressions 7-9 in Table 2). Thus, the phase of the business cycle as such does not seem to affect the strength of the impact (irrespectively of the way the threshold model is specified).

Closer scrutiny reveals that the effect of the excessive indebtedness on the size of the output coefficient is almost monotonically increasing which shows from an experiment with two thresholds in the output coefficient (see Figure 5)[11]. This threshold effect also shows up as expected in country-specific coefficients of the output growth variable; see Figure 6.[12] Hence, both the panel data and individual

[10] We also allowed all coefficients of the three explanatory variables (except for the lagged dependent variable); output shock, real interest rate, and the excessive indebtedness to change with the threshold. The coefficients of all variable increased when excess indebtedness became positive, but the hypothesis that coefficients in the different regimes, for each variable, are equal could not be rejected.

[11] Here we have three regimes for the output growth coefficient depending on the size of the excess indebtedness so that debt<-x, -x<debt<x and debt>x where x equals 1, 2, 5 or 10 per cent.

[12] Only with the exception of Belgium, the relative size of the output coefficient corresponds to our assumptions. The case of Belgium may be explained by the fact that, as shown in Figure 1, there the excessive indebtedness in either direction is hardly noticeable.

country results support well our considerations presented in the introduction: the most toxic combination for loan losses is an economy which is excessively indebted and that suffers from severe output shocks, but the outcome may be alleviated by accommodative monetary policies.[13]

The importance of interest rate shocks as a factor of loan losses shows up in the beta coefficients of our model. Among those, the coefficient of real interest rate is the biggest (0.304) compared with -0.263 for output shock and 0.133 for the excessive indebtedness (in the case of the basic linear model in equation (1) without the lagged dependent variable). This result is understandable when one compares the very volatile interest rate history in the early 1990 to the much more moderate interest rate volatility period in the aftermath of the recent financial crisis.

2. Conclusions

In this paper we have revisited the model of Pesola (2011) for banking sector loan losses and extended the sample period for the nine European countries, from which the loan loss data was available, to include the global financial crisis and the subsequent "Eurocrisis". We showed that three factors; output growth shock, real interest rate, and excessive indebtedness (of the private sector), still account well for loan losses. However, the model is further enhanced by accounting for the nonlinear,

[13] One should keep in mind that even when policy rates are low, high risk premia may still result in high lending rates which worsen the overall situation. Unfortunately, it is not straightforward to measure the actual financing costs of firms and household. We attempted to do so by using the average banks' lending rate (see regressions 4 and 5 in Table 2) although the data do not very well cover the most recent periods. Nonetheless, the results are close to those obtained with the market real interest rate. Hence, it seems that the specific form of the interest rate channel causing loan losses may not be so crucial after all.

intensified impact of output shock on loan losses when excessive indebtedness is high. We also considered alternative measures of the excessive indebtedness, including a measure motivated by Shin (2012), based on the relative share of non-deposit funding sources of banks' lending.

Our model for loan losses provides the following policy recommendation. To avoid loan losses large output growth and monetary policy shocks should be avoided and excessive indebtedness should be curbed well in advance. As output changes are more difficult to control, policy should focus on interest rates and indebtedness. Because interest rates as a policy instrument may have several goals, more attention should probably be paid to instruments which can tackle excessive indebtedness. Further analysis on the drivers of excessive indebtedness and the best instruments to tackle it is still needed.

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Table 1. Estimation results for loan losses (equation 1) with the panel of nine countries

	1	2	3	4	5	6	7	8	9	10	11
Dep.var	V	V	v	v	v	v	Q25 v	Q75 v	v	v	v
c	.035	.248	.048	-.079	.145	.147	-.092	-.007	-.081	-.061	
	(0.64)	(4.10)	(3.48)	(5.21)	(6.91)	(6.43)	(6.52)	(0.46)	(4.83)	(4.81)	
$g-g^e$	-.084										
	(4.89)										
g		-.086	-.010	-.009	-.011	-.013	-.006	-.010	-.011	-.010	-.014
		(5.32)	(4.29)	(3.62)	(4.62)	(5.22)	(3.12)	(4.07)	(.009)	(6.12)	(2.10)
rr	.046	.044	.005	.004	.050	.008	.003	.006	.006	.006	.005
	(4.08)	(3.98)	(3.57)	(2.22)	(3.92)	(5.38)	(3.25)	(5.27)	(.006)	(5.05)	(1.83)
debt	.608	.459	.066	.069	.141	.070	.043	.022	.072	.048	.266
	(2.46)	(1.83)	(2.34)	(2.50)	(2.73)	(1.80)	(1.92)	(1.17)	(.082)	(2.31)	(0.92)
lag	.734	.732	.838	.815	.788	.783	.801	.912	.751	.812	.522
	(19.19)	(19.21)	(27.72)	(21.42)	(24.09)	(22.02)	(27.22)	(23.05)	(19.29)	(27.42)	(1.38)
Estimator	OLS	OLS	OLS	OLS	OLS	OLS	QR	QR	OLS	GLS	GMM
fixed e.	no	no	CE	TE & CE	CE	CE	no	no	CE	CE	dif
debt	trend	trend	trend	trend	HP	deposits	trend	trend	trend	trend	trend
R^2	0.663	0.686	0.827	0.857	0.836	0.837	0.522	0.689	0.871	0.833	..
SEE	0.581	0.576	0.054	0.054	0.054	0.054	0.061	0.060	.050	0.053	0.066
DW	1.62	1.64	1.49	1.48	1.55	1.60	..	..	1.64	1.53	J=5.01

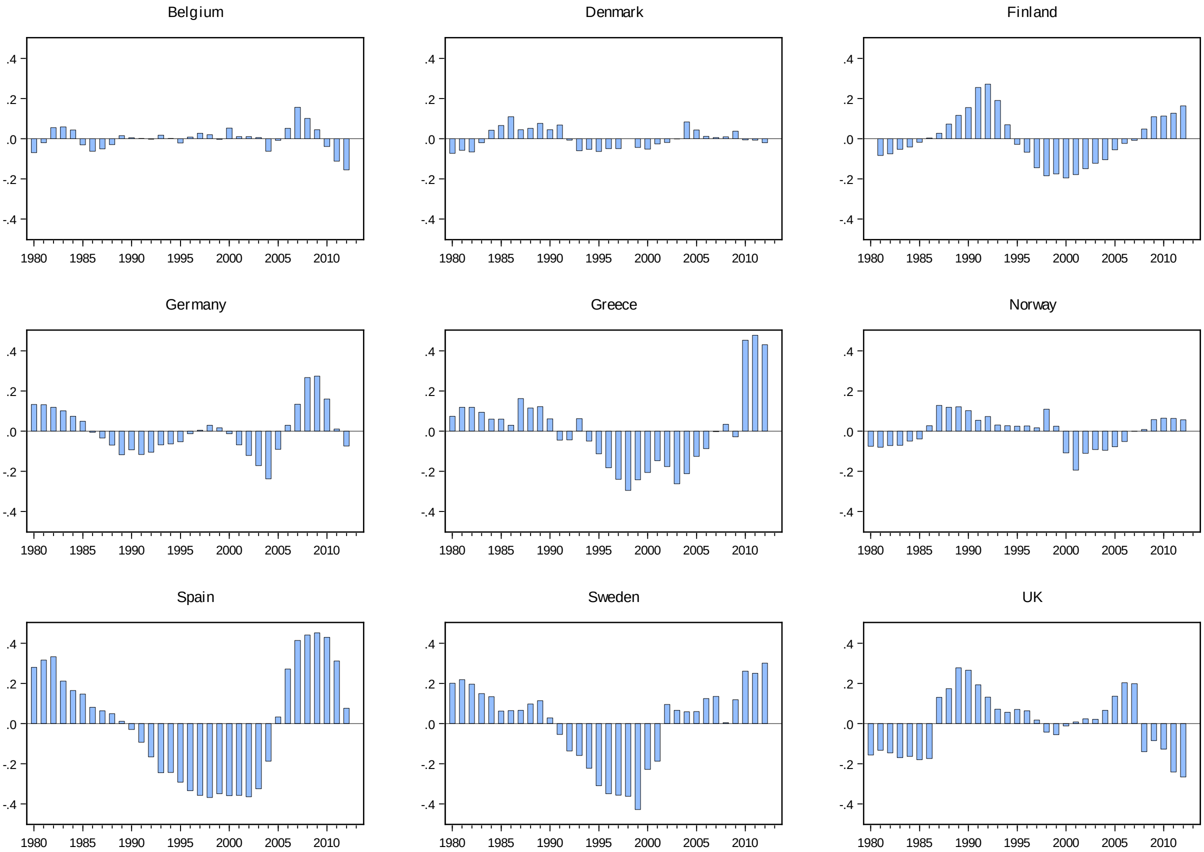
The lower case "v" denotes the logistic transformation of V=lt/lv. Corrected t -ratios are inside parentheses. CE denotes cross-section fixed effects and TE fixed time effects. In regression 9, the coefficients of g, rr and debt have been estimated freely for each country and the mean values are reported (with the corresponding sample standard deviations in parentheses). In GMM estimation in regression 11, the instrument rank is 9. In estimating regression 1, we used OECD's June forecasts for the following year. QR in regressions 7 and 8 denotes the quantile regression estimator that was used together with the logistic transformation with the V= lt/lv variable. Excess indebtedness debt is measured by using the linear trend except for using the HP trend in regression 5 and deviations from the estimated relationship between the loans to GDP and the deposit/GDP ratio in regression 6 (see equation 2 above).

Table 2. Further robustness checks of the estimation results

	1	2	3	4	5	6	7	8	9	10	11	12
Dep.var	v	v	v	v	v	v	v	v	v	v	v	v
c	.595	.623	.630	.599	-.054	.114	.112	.113	.111	.112	.098	.098
	(61.33)	(58.44)	(68.33)	(35.33)	(4.73)	(5.62)	(5.96)	(5.81)	(5.71)	(5.80)	(5.18)	(5.18)
$g-g^e$	-.011			-.012								
	(3.11)			(2.23)								
$g-g^{ed}$			-.007		-.012							
			(1.49)		(4.03)							
g		-.011				-.010		-.011	-.011		.068	.183
		(2.95)				(4.29)		(1.80)	(1.80)		(2.43)	(2.66)
$g \mid x>0$							-.010			-.014		
							(3.96)			(4.73)		
$g \mid x<0$							-.011			-.006		
							(1.76)			(2.17)		
$g*1/(1-e^{-x})$								.001	.001		-.155	-.385
								(0.12)	(0.19)		(2.81)	(2.81)
rr	.012	.012	.003			-.005	.005	.005	.005	.005	.005	.005
	(4.77)	(4.75)	(1.21)			(3.57)	(3.59)	(3.59)	(3.59)	(3.84)	(4.18)	(4.18)
rr_l				.008	.003							
				(2.88)	(1.66)							
debt	.163	.147	.209	.209	.029	.066	.028	.066	.066	.111	.146	.146
	(3.23)	(2.71)	(4.10)	(3.10)	(0.93)	(2.39)	(2.38)	(2.38)	(2.38)	(2.20)	(3.11)	(3.12)
lag					.813	.838	.838	.838	.838	.835	.846	.847
					(19.71)	(27.72)	(27.78)	(27.78)	(27.78)	(27.61)	(28.43)	(28.43)
x							g	g	g	debt	debt	debt
Estimator	OLS	OLS	OLS	OLS	OLS	OLS	OLS	OLS	OLS	OLS	OLS	OLS
fixed e.	no	no	no	no	TE & CE	no	no	no	no	no	no	no
R^2	0.201	0.203	0.096	0.162	0.895	0.828	0.827	0.828	0.828	0.834	0.840	0.841
SEE	0.116	0.116	0.124	0.122	0.048	0.054	0.054	0.054	0.054	0.053	0.052	0.052
DW	0.35	0.34	0.27	0.26	1.59	1.49	1.49	1.49	1.49	1.53	1.53	1.53

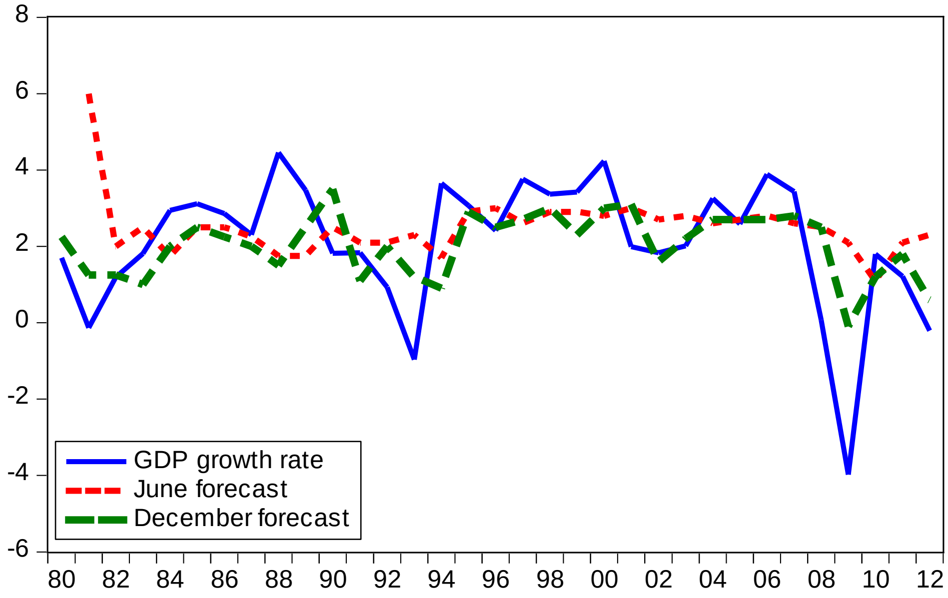
v denotes a logistic transformation of V=lt/lv. g^{ed} denotes the OECD December forecast for output growth, rr_l denotes the real average lending rate of banks. In equation 8, the smooth transition threshold term is simply of the form $g(1/(1+e^{-g}))$,while in equation (9) it takes the form $g(1/(1+e^{-\psi(g-\gamma)}))$, were the values ψ = 4.0 and γ = 0.6 minimized the sum of squares. Equations (11) and (12) are specified similarly in terms of the excess indebtedness threshold variable. In equation 12 the optimal parameter values were $\psi = 0.4$ and $\gamma = 0$. With equation 10 (but not with 7) the hypothesis of equal coefficients $\alpha_{11} = \alpha_{12}$ can be clearly rejected: $F(1,252)=5.45$ (0.020)

Figure 1. Excessive indebtedness in sample countries



Note that the scale is the same for all countries.

Figure 2. Actual and forecast output growth according to OECD



The lines represent median values of the nine country series.

Figure 3. Residuals from the panel estimates

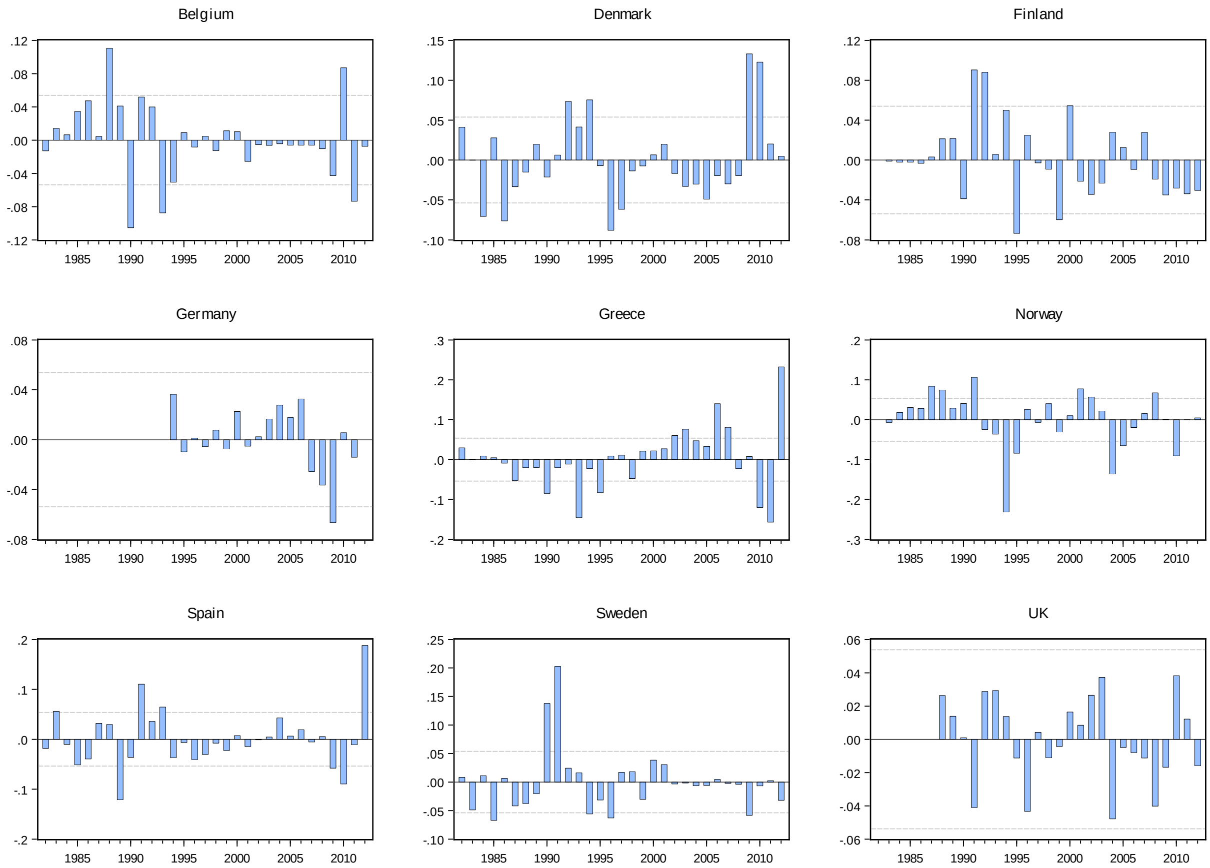
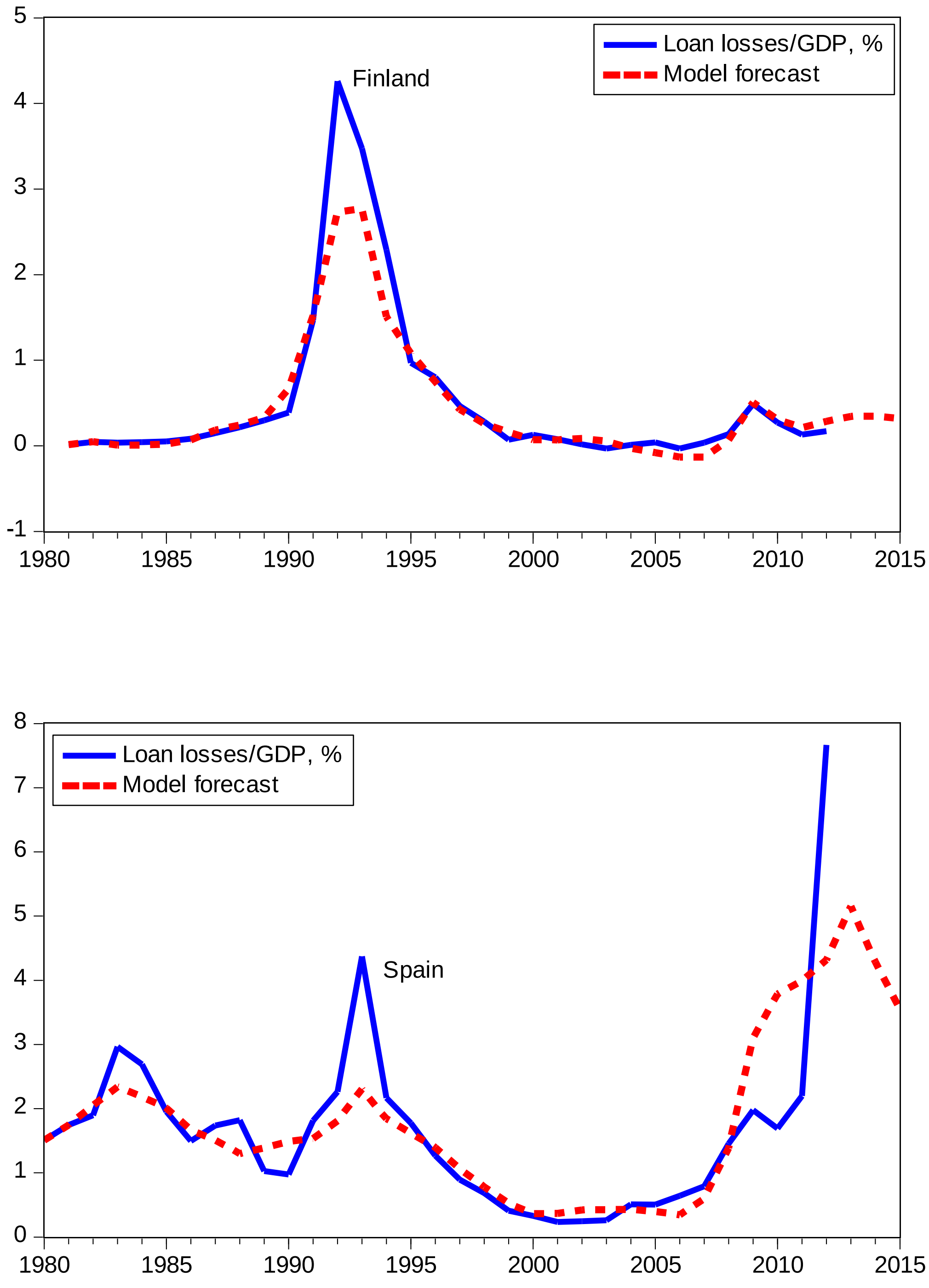
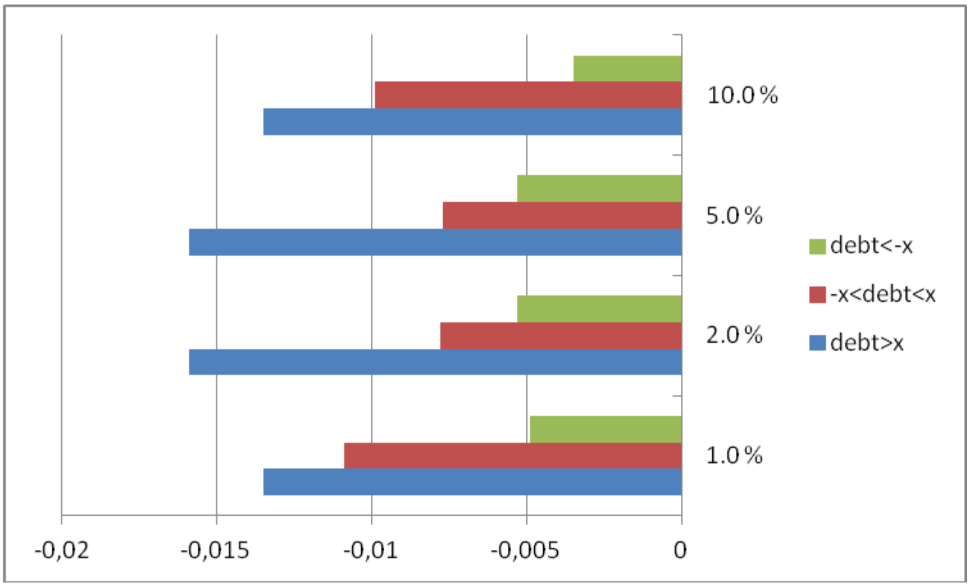


Figure 4. Predicted vs actual loan losses for Finland and Spain



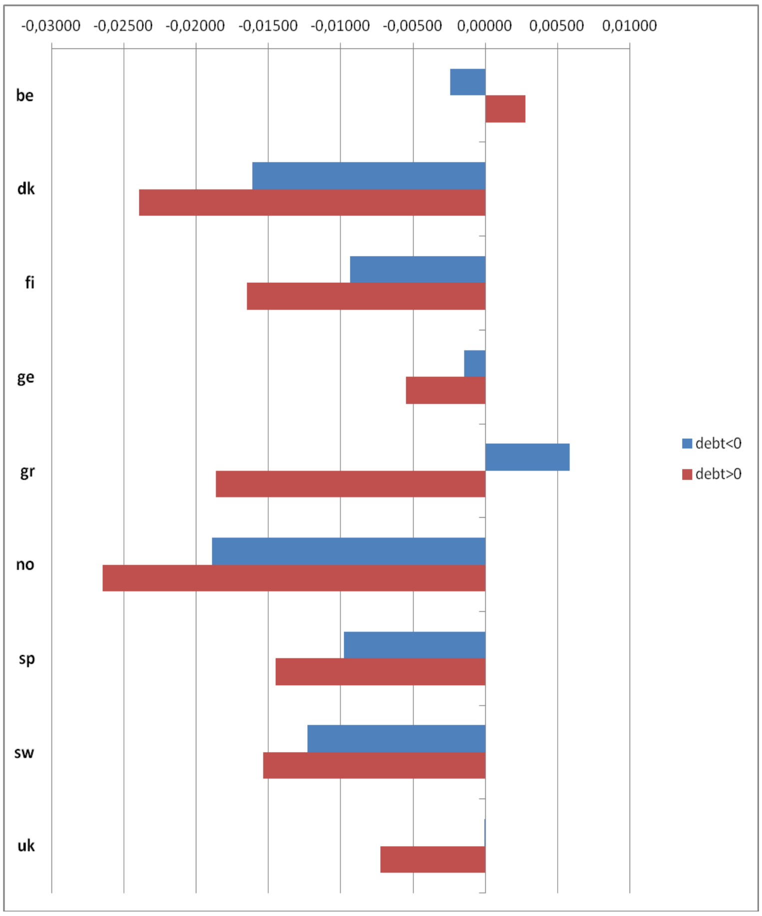
Predictions are based on country-specific coefficients. GDP values for 2012-2015 are based on ECB forecasts

Figure 5. Output growth coefficients from a model with two thresholds



Each set of bars represents three regimes for the output growth coefficient depending on the size of the excessive indebtedness (denoted by “debt”) so that debt<-x, -x<debt<x and debt>x where x is either 1, 2, 5 or 10%.

Figure 6. Country-specific nonlinear output growth coefficients



The regimes are based on a fixed (zero) threshold of excessive indebtedness.

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