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DNB WORKING PAPER

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

Working Paper No. 251/2010

July 2010

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July 2010

Abstract[†]

This paper estimates the relation between bank profitability and economic downturns using a theoretical model that takes into account the bank's lending history as well as amortization and losses on outstanding loans. We focus on total bank profits and its components: net interest income, other income, and net provisioning plus other costs. Using both aggregate and individual bank panel datasets, our results confirm that pro-cyclicality of bank profits is stronger for deep recessions than during mild ones. Loan-losses are found to be the main driver of this nonlinearity. We find evidence that each percent contraction of real GDP during severe recessions leads to a 0.24 percent decrease in return on bank assets.

JEL code: E32, G21

Keywords: Bank profitability, Business cycle

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† The views expressed in this paper are those of the authors and do not necessarily represent those of De Nederlandsche Bank or the European System of Central Banks. Data assistance was provided by Jack Bekooij and Frans Vermeer. Thanks are due to participants of the lunch seminars at De Nederlandsche Bank (2010) and the 16th International Conference on Panel Data (Amsterdam).

1. Introduction

The latest recession, initiated by the banking crisis of 2008, revives the issue of how sensitive bank profits are to the business cycle. The banking crisis melted down a large part of the value of bank assets all over the world. This meltdown started with poisoned assets, notably subprime mortgages of US banks, but quickly spread to bank assets in other countries and a crash of global stock markets. The bank credit crunch that followed affected the global real economy which suffered from the deepest recession since the Great Depression of the 1930s. The big question now is whether this recession will cause a new wave of bank losses, which would come on top of the losses already incurred by the meltdown of bank assets.

Several studies demonstrate the existence of a significant relation between the business cycle and bank profitability. Demirgüç-Kunt and Huizinga (1999) were among the first to relate bank profits to macro-economic indicators such as real GDP per capita. Based on aggregate data of the banking sector in a number of OECD countries, Bikker and Hu (2002) estimate the relation between bank profitability and real GDP growth. More recently, Albertazzi and Gambacorta (2009) report a significant relation between real GDP growth and bank profitability. Athanasoglou et al. (2008) find a positive relation between the output gap and the profitability of a panel of Greek banks.

Among the different components which define bank profits, more than one may be responsible for the co-movement with the business cycle. First, procyclicality of bank profits may be caused by the procyclical nature of lending to the private sector. In most empirical studies, bank lending to the private sector is found to depend strongly on GDP (e.g., Calza et al., 2006, Sørensen et al., 2009, Jiménez et al., 2009). Second, loan losses may increase during economic declines. This is confirmed by Laeven and Majnoni (2003), Bikker and Metzmakers (2005) and Bouvatier and Lepetit (2008), who report the negative co-movement of loan loss provisions with the business cycle in a large panel of individual banks. The negative co-movement of loan loss provisions is confirmed by Quagliariello (2007), who also detects a positive relation between real GDP growth and the flow of new bad debt in a panel of Italian banks. This result is supported by Salas and Saurina (2002), who investigate the effect of real GDP growth on the amount of problem loans faced by Spanish banks. Besides

measuring the effect of macroeconomic variables on problem loans faced by banks, a rich literature shows that macroeconomic variables explain part of the variation in default rates.¹

Marcucci and Quagliariello (2009) stress that researchers have not explored the possibility of asymmetric effects of bank credit risk during the business cycle. They fill this gap by means of a dataset with Italian banks' borrowers' default rates. They find evidence that the relation of the output gap and default rates is subject to a regime switch, such that the effect of the business cycle on the probability of default on bank loans is significantly more pronounced during severe economic downturns.

Our paper contributes to this literature in four different respects. First, we derive a theoretical model for bank profits, that takes into account that the composition of all outstanding loans at the current period results from the accumulation of loans extended in previous periods, on the one hand, and the survivor rate of these loans (depending on both amortization and loan losses), on the other. Second, we do not only estimate the pro-cyclicality of total profits but also of the three components that define it: net interest income, other income, and net provisioning plus other costs. Third, we test this relationship using two types of panel data: aggregate bank data for 17 countries over three decades and individual bank data for 19 countries over a period of 18 years, respectively. Fourth, we assess whether the degree of pro-cyclicality of bank profitability is stronger for deep recessions than for mild ones.

Our results confirm that bank profits are pro-cyclical and find that this pro-cyclicality is stronger for deep recessions than for mild ones. This asymmetric effect is found for aggregate and bank specific data. Among the different components of bank profits, net provisioning is the driver behind this asymmetry. We find evidence that each percent contraction of real GDP during severe recessions leads to a 0.24 percent decrease in return on bank assets. Also, severe recessions are found to have a persistent negative effect on bank profitability for aggregate bank data.

The setup of the paper is as follows. First, data and some stylized facts are discussed in Section 2. Section 3 presents our model. Section 4 presents the estimation results, both for the

¹ See for examples of empirical studies Jacobson et al (2005), Castrén et al (2010) and Duffie et al (2007). See Pesaran et al (2006) for an implementation of macro variables in a credit loss model.

aggregate data and the individual bank data. Section 5 gives an interpretation of the findings in terms of the pro-cyclicality of bank profits, after which Section 6 concludes.

2. Data and stylized facts

Two types of bank data are used in the empirical part of this paper: aggregate bank data and individual bank data, respectively. The aggregate bank data are from the OECD and comprise 17 countries.² This is an unbalanced panel dataset over three decades 1979-2007. The number of observations ranges from 13 for Australia to 28 for Germany, Netherlands, Spain and Switzerland (Table 1a). Figure 1 shows bank profitability³ for the eight countries for which data are available for at least 21 observations, as well as a decomposition⁴. This figure indicates that the component net provisioning and other costs is an important driver of the variability in profitability, though this does not hold for all countries. The contribution of net interest income shows a downward trend, indicating a shift to other banking activities.

[insert Table 1a and Figure 1]

The individual bank data are from BankScope. We selected large commercial banks, saving banks, cooperative banks, real/mortgage banks and investment banks, leaving out bank holdings to avoid double counting. Profits before tax, net interest income and other income (both scaled by total assets) were trimmed at the 0.2nd and 99th percentiles to exclude outliers. Next, as the panel data are unbalanced (Figure 2), banks were selected if at least five observations were available for the estimation (this implies that, given the use of one lag of the bank variables in the estimation, at least six consecutive observations had to be available). The selection procedure resulted in an unbalanced panel dataset of 16,453 bank-year observations from 19 different countries (Table 1a). Commercial banks form the bulk of the sample (Table 1b). The median ratio of profit before tax over (the lag of) total assets is 0.76% for the individual bank sample, while it is 0.72% for the aggregate sample (Table 1c).

² Australia, Belgium, Canada, Denmark, Germany, Finland, France, Italy, Japan, Netherlands, New Zealand, Norway, Austria, Spain, United States, Sweden and Switzerland. Appendix B gives detailed data sources and definitions.

³ Return on assets, defined as net income before tax over total assets.

⁴ Although data were available for the whole sample, Sweden has been excluded from this figure because of obscure observations for net provisions in the OECD database from 1991 to 2001.

[insert Figure 2, Table 1b, Table 1c]

Figure 3 shows the stylized bank balance sheet which is the starting point in our analysis. On the asset side we have loans and non-interest earning assets. The bank is funded by deposits and bank capital. In order to account for deviations from this classical type of bank business, we include the term ‘other (net) interest bearing liabilities’, which encompasses components such as net borrowing from banks, the central bank and (net) securities holdings.

[Insert Figure 3]

The correlation matrix (Table 1d) shows that the variables that are most strongly correlated in the aggregate bank dataset are not the same variables that are mostly correlated in the individual bank dataset. For example, deposits and loans are strongly correlated in the aggregate data (0.865), while they are not (-0.057) in the individual data. This is due to the different level of aggregation of the data. Individual banks may lend surplus deposits to other banks, without affecting the former’s lending activities to non-banks. However, at the aggregate level, lending activities to non-banks must be correlated to the availability of deposits. In accordance with this explanation, the correlation between deposits (loans) and other net interest bearing liabilities is negative (positive) for the individual bank data, but close to zero for the aggregate bank data.

[Table 1d]

The macro economic data and interest rates are from the OECD database. Detailed information on the exact source of the individual series and the definitions of the variables is given in the overview in appendix B.

3. The model

Our starting point of the analysis is the bank’s income statement and a simple bank balance sheet. Omitting any subscripts for individual banks in our notation throughout the paper, we may write for the bank’s profit (before taxes):

$$(1) \quad \Pi_t = NII_t - BL_t + OI_t - OC_t$$

where NII denotes net interest income, BL bad loan losses, OI other income and OC operating costs. Other income (OI) encompasses net fees and commission income, net trading income, and results from financial transactions.

In correspondence with earlier research we scale equation (1) by total assets. However, the amount of total assets is very likely to be affected by macro-economic and financial variables. For example, Adrian and Shin (2010) observe that banks tend to actively manage the amount of total assets on their balance sheets. In order to prevent the change in total assets from obscuring the estimation results we scale by total assets at the beginning of the period (A_{t-1}).

In the remainder of this section, we discuss our assumptions for the different profit components.

3.1 Net Interest Income

Net interest income is given by interest income minus interest expenses:

$$(2) \quad NII_t = r_{L,t}L_t - r_{D,t}D_t,$$

where L_t and D_t denote the outstanding amounts of loans and deposits on the balance sheet.

We assume that the maturity of deposits is short, such that the interest rate paid on deposits (r_D) depends on the current interest rate only. Profit-maximizing banks set their deposit rate at a level equal to the short-term risk-free rate r_s minus a reduction for the marginal operating costs of managing deposits, c_D :

$$(3) \quad r_{d,t} = r_{s,t} - c_D.$$

In contrast to the rate paid to deposit holders, the rate received on the loan portfolio (r_L) is a weighted average of lending rates on loans in the current year and preceding years ($r_{l,t}, r_{l,t-1}, \dots$). For a loan in a particular year, the lending rate is assumed to be set as a mark-up over the risk-free capital market rate ($r_{f,t}$), where the mark-up compensates for operating

expenses (c_L), expected default losses (f^e) and risk (k). Hence, following Cavallo and Majnoni (2001), we specify for the lending rate in year t :

$$(4) \quad r_{l,t} = r_{f,t} + c_L + f^e + k.$$

The weights of the lending rates for the different loan vintages ($r_{l,t}, r_{l,t-1}, \dots$) in the average lending rate on the loan portfolio ($r_{L,t}$) depend on the fractions of the different loan vintages in the total loan portfolio ($\omega_{l,t}, \omega_{l,t-1}, \dots$). The fraction of a loan vintage in the total loan portfolio ($\omega_{l,t-i}$) is subject to the current size of the loan portfolio, the amount of loans originated during period $t-i$ and the annual survival rates of those loans.

The survival rates depend on both the natural maturity structure of a bank's loan portfolio, which we assume to be constant over time, and the amount of bad loans that is written off. Thus the survival rate of loans from the preceding year to the current year (λ_{t-1}) can be defined as:

$$(5) \quad \lambda_{t-1} = \bar{\lambda} - \frac{BL_t}{L_{t-1}},$$

where $\bar{\lambda}$ denotes the survival rate if loan-losses do not occur. Assuming the probability of a loan turning into a bad loan to be independent of the loan's maturity, we can write the weight of loans from year $t-i$ in the total current loan portfolio as:

$$(6) \quad \omega_{l,t-i} = \frac{NL_{t-i}}{L_t} \times \prod_{j=1}^i \lambda_{t-j} \quad \text{for } i \in \mathbb{N},$$

where NL_{t-i} denotes the amount of loans originated during period $t-i$. As a special case we have the amount of loans originated during the *current* year as fraction of the total loan portfolio, which is:

$$(7) \quad \omega_{l,t} = \frac{NL_t}{L_t}.$$

However, the interest income from loans in (7) has to be treated differently from the interest income from loans originated during previous periods. If one would assume that the origination of new loans is distributed uniformly over the year, then the expected interest income on new loans is only *half* of the lending rate for the current year⁵. In contrast, the surviving loans from previous periods earn their full lending rates. Thus, after combining (4), (6) and (7) gross interest income on the loan portfolio equals:

$$(8) \quad \begin{aligned} r_{L,t}L_t &= \frac{1}{2}r_{l,t} \cdot \omega_{l,t} \cdot L_t + \sum_{i=1}^{\infty} r_{l,t-i} \cdot \omega_{l,t-i} \cdot L_t \\ &= \frac{1}{2}r_{l,t} (NL_t) + \sum_{i=1}^{\infty} r_{l,t-i} \left(NL_{t-i} \times \prod_{j=1}^i \lambda_{t-j} \right) \end{aligned}$$

where the terms within brackets represent the size of the loan vintages in the current loan portfolio.

In order to relate bank profitability with the stance of the business cycle, we introduce three reduced form equations for loan-losses, new loans and deposits, respectively. As measures of the stance of the business cycle we take current and historical rates of real GDP growth $(y_t, y_{t-1}, \dots, y_{t-i})$ and the current rate of unemployment (u_t) . As the amount of loan losses is likely to increase proportionally with the size of the loan portfolio, we scale loan-losses by the amount of loans at the beginning of the period. We postulate the first reduced form equation as follows:

$$(9) \quad \frac{BL_t}{L_{t-1}} = f_t(y_t, y_{t-1}, \dots, y_{t-i}, u_t).$$

Since firms' profitability declines during recessions we expect more defaults on business loans for lower real GDP growth rates. Also, lower income growth rates and higher unemployment increases the number of defaults on consumer loans. Thus the expected signs

⁵ Data on the amount of loans and deposits are end-of-period figures.

for real GDP growth rates are negative and the expected sign for the unemployment rate is positive.

The second reduced form equation describes the rate of new loan origination as a function of economic growth y_t and the slope of the yield curve s_t , defined as the difference between the long-term interest rate and the short-term interest rate ($r_f - r_s$).

$$(10) \quad \frac{NL_t}{L_{t-1}} = g_t(y_t, s_t)$$

For real GDP growth a positive sign is expected. A positive relation between new loan origination and real GDP growth is supported by e.g., Calza et al. (2006), Sørensen et al. (2009), and Jiménez et al. (2009). The slope of the yield curve reflects the relative price of long-term and short-term loans. A priori the sign expectation is ambiguous, as the effects of this relative price on loan demand and supply are counteractive. Assuming that bank lending is mostly long-term, a steep yield curve is expected to slow down loan demand. However, a higher interest rate margin for banks is expected to stimulate loan supply. The net effect is therefore uncertain. Also, the slope of the yield curve is known to be a leading indicator of the business cycle (see e.g. Estrella and Hardouvelis, 1991).

The third reduced form equation writes deposit growth as a function of the short-term interest rate (positive sign) and the inflation rate (i_t).

$$(11) \quad \frac{D_t - D_{t-1}}{D_{t-1}} = h_t(r_{s,t}, i_t)$$

For simplifying purposes we assume a constant loan survival rate (i.e. $\lambda_{t-i}(\cdot) = \lambda = \bar{\lambda} - f^e$ for $i \in \mathbb{N}$). Substituting (8), (10) and (11) into (2) results, after some rewriting, in the following equation for net interest income as a proportion of total assets at the beginning of the period (see appendix A for a derivation):

$$(12) \quad \frac{NII_t}{A_{t-1}} = \frac{L_{t-1}}{A_{t-1}} \times \left\{ \frac{1}{2} g_t \cdot r_{l,t} + \sum_{i=1}^{\infty} \tilde{r}_{l,t-i} \left(g_{t-i} \times \prod_{j=1}^i \frac{\lambda}{g_{t-j} + \lambda} \right) \right\} - \frac{D_{t-1}}{A_{t-1}} \times \left\{ \left(1 + \frac{1}{2} h_t \right) r_{d,t} \right\}$$

Equation (12) gives three important insights. First, the influence of a change in the short-term interest rate is likely to have a higher impact on the current net interest income than a change in the long-term interest rate. The current short-term rate affects the rate paid to both old and new deposit holders. The current long-term rate only affects the rate received on new loans originated during the current period. Second, the current long-term rate has a more persistent effect on net interest income: a drop in the current long-term rate will depress net interest income as long as loans originated during the current period are part of the bank's loan portfolio. Third, as a consequence of scaling net interest income by total assets, the coefficients of the macro-economic variables are also weighted by loans and deposits over total assets.

3.2 Loan Losses

Rescaling equation (9) by total assets results in the following relation between loan losses and the business cycle:

$$(13) \quad \frac{BL_t}{A_{t-1}} = \frac{L_{t-1}}{A_{t-1}} f(y_t, y_{t-1}, \dots, y_{t-i}, u_t).$$

3.3 Other income

As other income typically comprehends fees and income from trading on financial market, we assume it to be a function of local stock market returns and current long and short-term interest rates. In addition to stock market growth, we also add stock market volatility, which positively affects trading volumes. Finally, high economic growth is expected to be favourable for other income:

$$(14) \quad \frac{OI_t}{A_{t-1}} = O\left(r_{m,t}, \sigma_{m,t}, r_{f,t}, r_{s,t}, y_t, y_{t-1}\right),$$

where $r_{m,t}$ is the return on the local stock market index (excluding dividends) and $\sigma_{m,t}$ the coefficient of the monthly variation in stock returns.

3.4 Operating costs

From equation (3) and (4) we have that operating expenses increase with the amount of deposits and loans due to the costs of managing deposits (c_D) and loans (c_L). However, the effect of macro economic conditions on operating costs is ambiguous. For example, unfavourable economic conditions may raise the costs of collecting payments on loans, but then also fewer new loans will be originated (equation 10). This is why we refrain from modelling the effect of economic conditions on operating costs. On the other hand it would be to restrictive to presume that none of the variables having a relation with new loan origination, loan losses and other income has any relation with operating costs. Therefore, we estimate an empirical relation between these variables and operating costs, without any sign predictions. Again, we scale operating cost by bank assets.

$$(15) \quad \frac{OC_t}{A_{t-1}} = C \left(\frac{L_{t-1}}{A_{t-1}}, \frac{L_{t-1}}{A_{t-1}} y_t, (\dots), \frac{L_{t-1}}{A_{t-1}} y_{t-i}, \frac{L_{t-1}}{A_{t-1}} u_t, \frac{D_{t-1}}{A_{t-1}}, y_t, i_t, r_{f,t}, r_{s,t}, r_{m,t}, \sigma_{m,t} \right)$$

3.5 Empirical specifications

For the empirical estimation we further assume several linear approximations for the functions introduced above. In order to obtain a first order approximation of the model for *net*

interest income we deviate from model (12) by replacing the product term $\prod_{j=1}^i \lambda / (g_{t-j} + \lambda)$

by C^i , with C some constant. This means that we neglect the ‘indirect effect’ that high loan growth in period $t-1$ decreases the fraction of loans originated during period $t-2$ in terms of the loan portfolio in period $t-1$. However, the ‘direct effect’ of the business cycle on new loan origination is kept intact, since $g_t(\cdot)$ and $g_{t-i}(\cdot)$ are still allowed to vary through the business cycle.⁶ Taking first order approximations for $g_{t-i}(\cdot)$ and $h_t(\cdot)$ in (12) and setting $i \in 1, 2, 3, 4$ yields the following model (see appendix A for more details):

⁶ Although abstracting from the indirect effect is obviously a simplification, the impact of this simplification should not be overemphasized. Since bank loans have on average a long maturity, the size of $g_{t-j}(\cdot)$ is small relatively to the survival rate λ , which is the other term in the denominator in (12).

$$\begin{aligned}
(16) \quad \frac{NII_t}{A_{t-1}} = & \left[1 \quad \frac{L_{t-1}}{A_{t-1}} \quad \frac{D_{t-1}}{A_{t-1}} \quad \frac{R_{t-1}}{A_{t-1}} \right] \beta_0 + \\
& + \frac{L_{t-1}}{A_{t-1}} \times \sum_{i=0}^4 \left[r_{f,t-i} \quad y_{t-i} \quad s_{t-i} \quad r_{f,t-i} \cdot y_{t-i} \quad r_{f,t-i} \cdot s_{t-i} \right] \beta_{i+1} + \\
& + \frac{D_{t-1}}{A_{t-1}} \times \left[r_{s,t} \quad r_{s,t}^2 \quad r_{s,t} \cdot i_t \right] \beta_6 + \frac{R_{t-1}}{A_{t-1}} \times \left[r_{s,t} \right] \beta_7 + \varepsilon_t
\end{aligned}$$

where R_{t-1} is added to correct for ‘other interest-earning bank liabilities’. Vector β_1 is part of a linear approximation of reduced form equation (10) multiplied by the lending rate in equation (4). For the fourth and the fifth elements in β_1 we expect a positive and negative sign, respectively, since economic growth and the slope of the yield curve are (according to (10)) expected to have, respectively, a positive and negative relation with new loan origination. The second and third element in vector β_1 are expected to have signs equal to the signs of the fourth and the fifth element as the difference between the lending rate and the long term rate is positive (i.e., $c_L + f^e + k$ in (4)). The sign of the first element in vector β_1 is positive if the number of loans originated, given a zero real GDP growth and a flat yield curve, is positive (i.e., equation (10) with $y_t, s_t = 0$). Vectors β_2, \dots, β_5 refer to similar approximations after multiplying with the loan survival rate(s). We expect these vectors’ elements to have signs equal to those of vector β_1 ; the absolute values of these elements are expected to decline relative to the elements in vector β_1 . Vector β_6 is part of a linear approximation of equation (11).⁷ For both the first element in β_6 and the (single) element in β_7 we expect a negative sign. For the remaining elements the a priori signs are not determined as they depend on the relative financing cost of deposits and other finance.

The empirical specification for *other income* is a linear approximation of equation (14):

$$(17) \quad \frac{OI_t}{L_{t-1}} = \delta_0 + \left[y_t \quad r_{f,t} \quad r_{s,t} \quad r_{m,t} \quad \sigma_{m,t} \right] \delta_1 + \xi_t.$$

⁷ The interpretation of these coefficients is not straightforward due to the inclusion of R_{t-1} in the estimated equation.

In contrast to net interest income and other income, losses on bad loans are generally not observed directly from the income statement. Instead of losses on bad loans, we observe net provisions. However, in bad economic situations provisions fall short of loan losses (e.g. Laeven and Majnoni, 2003) and hence, part of these losses are incurred directly as costs on the income statement. It is thus likely to be a serious shortcoming if one estimates the effect of severe recessions on loan losses while using net provisions only. In order to include (most of the) loan losses that occur during severe recession periods we therefore consider the sum of *loan losses* and *operating costs*, equations (13) and (15), for the empirical specification. Moreover, we allow for non-linearity in the relation between loan losses and the business cycle. Marcucci and Quagliariello (2009) report a more pronounced relation between the business cycle and credit risk during severe economic downturns. Incorporating this important finding, we allow for an asymmetric relation in the following equation for the sum of loan losses and other cost:

$$(18) \quad \frac{BL_t + OC_t}{A_{t-1}} = \left[1 \quad \frac{L_{t-1}}{A_{t-1}} \quad \frac{D_{t-1}}{A_{t-1}} \right] \gamma_0 + \frac{L_{t-1}}{A_{t-1}} \times \sum_{i=0}^2 [y_{t-i} \quad I \cdot (y_{t-i} - a)] \gamma_{1+i} \\ + \frac{L_{t-1}}{A_{t-1}} \times u_t \gamma_4 + \left[y_t \quad r_{f,t} \quad r_{s,t} \quad r_{m,t} \quad CV_{m,t} \quad i_t \right] \gamma_5 + v_t$$

where I is an indicator function for severe recessions, which equals 1 if $y_{t-i} < a$ and 0 otherwise⁸. In this relation the elements of vectors $\gamma_1, \dots, \gamma_4$ represent the cyclical and possibly asymmetric effects on loan losses. These coefficients are a linear approximation of equation (9). Vectors $\gamma_1, \dots, \gamma_3$ each contain two elements: the first element represents the standard effect of a ‘normal’ business cycle and the second element the additional effect of a severe recession on loan-losses. Therefore, we will refer to the second elements in $\gamma_1, \dots, \gamma_3$ as ‘recession slope dummies’. For both elements of $\gamma_1, \dots, \gamma_3$ we expect a negative sign. For the (single) element in vector γ_4 the expected sign is positive since we expect a higher unemployment rate to increase loan-losses. The (six) elements in vector γ_5 stand for the cyclical effect on operational costs, for which we refrain from any sign predictions.

⁸ This is the standard method to include slope dummies, see e.g. Greene (2003), Heij et al. (2004).

The relation for total profit before tax is by definition a combination of relations (16), (17) and (18). The resulting relation (not written out for reasons of space) is probably a ‘noisier’ one than the three distinct equations. Thus, when estimating this relation one may expect larger standard errors.

4. Estimation results

The first and second columns of Table 2 present the estimates for net interest income (i.e. equation (16)) for aggregate and individual bank data, respectively. Tables 3 and 4 present the estimates for (i) other income (i.e. equations (17)), (ii) loan-losses plus cost (equation (18)) and (iii) the sum of the three profit components, profit before tax. Table 3 is for the aggregate bank data, Table 4 for the individual bank data.

We selected variables using a variant of backward elimination with the following rules. Insignificant variables were removed. However, insignificant variables were retained if their lag(s) was (were) significant. Also, since our specific interest is in the recession slope, all (three) recession slope dummy variables were retained irrespective of their significance. Obviously, their corresponding real GDP growth variables had to be retained as well.

For the aggregate bank data (17 countries over 3 decades) we apply generalized least squares (GLS), allowing for the presence of panel specific autocorrelation in the error terms and heteroskedasticity across panels. For the individual bank dataset, for which the number of individuals is large and the number of observations per individual relatively small, the within estimator is used allowing for first order autocorrelation in the disturbances.⁹

[insert Table 2, Table 3 and Table 4]

In the following we discuss the results, first for the three profit components (Table 2, 3 and 4, columns 1 and 2), next for total profits (Table 3 and 4, column 3). Aggregate and individual

⁹ The Baltagi-Wu LBI statistics are around 1.4 indicating significant serial correlation in the residuals for the individual bank data. This is why we apply the estimation technique from Baltagi and Wu (1999) for unequally spaced panel data with AR(1) disturbances. Experiments show that our results are not very sensitive to this correction for autocorrelation.

bank data results are thereby discussed simultaneously, as the findings should corroborate each other.

4.1 *Net Interest Income*

Considering the heterogeneity between individual banks (Table 1c), the fit of the model for interest income is relatively good, with an overall R^2 of 0.21. The coefficients for the long-term interest rate (multiplied by loans over assets) are significantly positive with declining magnitudes, which is more pronounced for the individual data than for the aggregate data. The declining magnitudes corroborate our theoretical specification in (8) in which the long-term interest rate effect on net interest income declines in time due to repayments of loans (as well as the growth of the loan portfolio through time). GDP growth is found to have an important effect on the quantity of new loans and therefore on the significance of the long-term interest rate in that particular year, which confirms our theoretical expectations (see Figure 4). The slope of the yield curve is found to have a negative effect on the quantity of new bank loans and therefore restrains the positive effect of higher long term rates on interest income (see Figure 5).

[insert Figure 4]

[insert Figure 5]

Contrary to our expectations with respect to equation (16), real GDP growth and the slope of the yield curve are found to have opposite signs to their interaction terms with the lending rate. This may be due to linearization of the reduced form equations.

The short-term interest rate has a negative effect on net interest income, as expected. For the squared short-term interest rate (equation 16) we find a positive coefficient in the micro data sample.

4.2 *Other Income*

For this rather heterogeneous profit component the fit of the model (eq. 17) is weak, both for the macro as the micro data sample. However, in both samples, the coefficient of the local stock market index is significant and positive. This confirms that other income, which partly

consists of investment banking fees, moves with the tide of stock market movements. Further, a positive effect of (lagged) economic growth is found.

4.3 *Loan losses and operational costs*

Before we can estimate equation (18) for loan losses and operational cost, which - as has been mentioned before - have been taken together, we first have to define the ‘severe recession dummy’ I which has a value of 1 for $y_{t-i} < a$ and 0 otherwise. We determine the optimal breakpoint a as follows. First we use a rolling version of a ‘modified’ Chow break test in the aggregate data: we calculate test statistics for the null hypothesis that severe recessions do not have any additional impact or, more formally, we test whether the *sum* of the coefficients of the recession slope dummies equals zero. Following Zeileis et al. (2003) we then choose the optimal breakpoint a that maximizes the test statistic from the break test. The maximum test statistic occurs at $a = -1.5\%$. However, for this value we only have six ‘severe recession’ observations as recessions of that kind are rare. To conserve as many observations as possible, which is necessary for a sensible statistical analysis, we choose $a = -0.5\%$ for which we have 22 observations and the test statistic is nearly as high as the maximum (see Figure 6).

[insert Figure 6]

The recession slope dummy variables turn out to be highly significant in both samples, giving support to the notion of asymmetric business cycle effects on loan-losses. Severe recessions increase net provisioning and cost more than moderate ones. Further, in line with our expectations, loan losses are significantly increased by unemployment.

We note that the timing of the asymmetric effect is different for the individual and the aggregate data. According to the aggregate data estimates, the asymmetric effect is strongest in the first year *after* the recession, while the individual data estimates put emphasis on the asymmetric effect during the current period. Also the size, measured by the sums of the asymmetric effects over three years, is different for the micro and macro samples: calculations suggest that each additional percentage-point of real GDP decline during a severe recession

results in an additional loan loss of 0.9% or 0.3% of the current loan portfolio according to the aggregate and individual data, respectively.¹⁰

It may be argued that individual bank samples in particular may suffer from survivorship bias as a result of the fact that failing banks drop out of such samples in quite an early stage of the bankruptcy process. Assuming that some survivorship bias is present in our dataset, it can be expected to lead to an underestimation of the asymmetric effect of recessions on profits, because especially banks with strongly negative profits (being the reason of failure) are underrepresented. Hence, the presence of any survivorship bias makes our finding of a significant asymmetric business cycle effect the more robust.

4.4 *Profit before tax*

As expected, estimation of the relation for the sum of the above mentioned three profit components, i.e. total profits before tax, results in relatively large standard errors. Indeed, most long-term interest rate variables, which were significant in the net interest income equation, lose their significance. Also, economic growth loses its significance. The short-term interest rate retains its significance in the micro data sample, though. The R^2 of the model for profit before tax is quite low, if compared to the R^2 of the model for interest income (0.04 versus 0.20 for the individual bank data). This is because profit includes the components other income and operating costs, which are very weakly explained by our model. It should be stressed, however, that our main goal is not to achieve the best possible fit for the cross section of individual bank profits, but to assess business cycle effects on bank profitability.

The recession slope dummy is significant for current real GDP growth. The coefficient is similar for both data samples and amounts to around 0.4. Hence, the fall in return on assets due to an additional percentage-point decline in the current real GDP growth rate during a recession is about 0.4 percentage-point multiplied by the loan-to-assets ratio. For illustration purposes we choose a loan-to-assets ratio of 0.40 and present the asymmetric effect of mild versus severe recessions on bank profitability in Figure 7, which is based on the aggregate data estimations.¹¹ The figure shows a kinked line, suggesting that the negative effect of

¹⁰ For the aggregate data the additional effect during severe recessions equals $-0.184 - 0.440 - 0.248 \approx -0.87$ and for the individual data the effect equals $-0.387 + 0.119 - 0.0630 \approx -0.33$.

¹¹ While the coefficient (0.4) is equal for all countries, the loan-to-assets ratio differs between countries.

recessions on profits is stronger for ‘severe’ recessions (i.e., a GDP growth less than -0.5%) than for ‘mild’ ones.

Finally, we should note that the figure gives a rather ‘optimistic view’ for two reasons. First, if one would rely on the estimations with the aggregate bank data, the greatest impact would occur in the years *after* the recession. However, this finding is not robust for the use of individual bank data. Second, the assumed loan-to-assets ratio underlying the calculations for the figure is rather low, which leads to some underestimation of the effect of the business cycle for countries with higher loan-to-assets ratios.

[insert Figure 7]

5. Conclusion

The current banking crisis and the concurrent severe recession revive the interest in the issue of pro-cyclicality of bank profitability. This paper contributes to extant research into this topic in four different respects. First, we derive a theoretical model for bank profits, that takes into account that the composition of all outstanding loans at the current period results from the accumulation of loans extended in previous periods, on the one hand, and the survivor rate of these loans (depending on both amortization and loan losses), on the other. Second, we do not only estimate the pro-cyclicality of total profits, but also of the three components that define it: net interest income, other income, and net provisioning plus operational costs. Third, we test this relationship using both aggregate and individual bank data. Fourth, we assess whether the degree of pro-cyclicality of bank profitability is stronger for deep recessions than for mild ones.

This approach yields two main empirical results:

First, we find evidence for our theoretical prediction that a bank’s lending history should also be taken into account when explaining its current net interest income. Specifically, long-term interest rates from previous years are found to be important determinants, especially when economic growth (and hence, lending activity) was relatively high at the time.

Second, we find evidence that bank profits behave pro-cyclically and that this co-movement is especially strong during severe recessions. Among the different profit components loan-loss provisioning is found to be the driver of this asymmetry. We find evidence that each percent contraction of real GDP during severe recessions leads to a 0.24 percent decrease in return on bank assets¹². Also, severe recessions are found to have a persistent negative effect on bank profitability for aggregate bank data.

¹² Estimated effect from the individual bank data set in table 4: $-0.01 \cdot (0.5789) \cdot (0.005 + 0.413) \approx 0.0024$.

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Appendix A – Derivation of equation (12) and (16).

Dividing (8) by L_{t-1} gives:

$$\frac{r_{L,t}L_t}{L_{t-1}} = \left(\frac{1}{2} \frac{NL_t}{L_{t-1}} \right) \eta_{l,t} + \sum_{i=1}^{\infty} \eta_{l,t-i} \left(\frac{NL_{t-i}}{L_{t-1}} \times \prod_{j=1}^i \lambda_{t-j} \right)$$

Rewriting $\frac{1}{L_{t-1}}$ to $\frac{1}{L_{t-i-1}} \prod_{j=1}^i \frac{L_{t-j-1}}{L_{t-j}}$ gives:

$$\frac{r_{L,t}L_t}{L_{t-1}} = \left(\frac{1}{2} \frac{NL_t}{L_{t-1}} \right) \eta_{l,t} + \sum_{i=1}^{\infty} \eta_{l,t-i} \left(\frac{NL_{t-i}}{L_{t-i-1}} \times \prod_{j=1}^i \lambda_{t-j} \frac{L_{t-j-1}}{L_{t-j}} \right)$$

Substituting $L_{t-j} = NL_{t-j} + \lambda_{t-j-1}L_{t-j-1}$ into the product term results in:

$$\frac{r_{L,t}L_t}{L_{t-1}} = \left(\frac{1}{2} \frac{NL_t}{L_{t-1}} \right) \eta_{l,t} + \sum_{i=1}^{\infty} \eta_{l,t-i} \left(\frac{NL_{t-i}}{L_{t-i-1}} \times \prod_{j=1}^i \frac{\lambda_{t-j}L_{t-j-1}}{NL_{t-j} + \lambda_{t-j-1}L_{t-j-1}} \right)$$

Dividing the numerator and denominator of the fraction in the product term by L_{t-j-1} :

$$\frac{r_{L,t}L_t}{L_{t-1}} = \left(\frac{1}{2} \frac{NL_t}{L_{t-1}} \right) \eta_{l,t} + \sum_{i=1}^{\infty} \eta_{l,t-i} \left(\frac{NL_{t-i}}{L_{t-i-1}} \times \prod_{j=1}^i \frac{\lambda_{t-j}}{\frac{NL_{t-j}}{L_{t-j-1}} + \lambda_{t-j-1}} \right)$$

Subsequently substitute (5), (9) and (10) into the result above. Also derive an expression for interest expenses with reduced form equation (11). Assume that the increase in deposits within a period is realized uniformly over time. Subsequently rescale both the interest income and interest expenses to A_{t-1} . Substituting both expressions into (2) yields:

$$\frac{NII_t}{A_{t-1}} = \frac{L_{t-1}}{A_{t-1}} \times \left\{ \frac{1}{2} g_t \cdot \eta_{l,t} + \sum_{i=1}^{\infty} \eta_{l,t-i} \left(g_{t-i} \times \prod_{j=1}^i \frac{\bar{\lambda} - f_{t-j}}{g_{t-j} + \bar{\lambda} - f_{t-j-1}} \right) \right\} - \frac{D_{t-1}}{A_{t-1}} \times \left\{ \left(1 + \frac{1}{2} h_t \right) r_{D,t} \right\}$$

Assume $\lambda_{t-i}(\cdot) = \lambda = \bar{\lambda} - f^e$ gives (12):

$$\frac{NII_t}{A_{t-1}} = \frac{L_{t-1}}{A_{t-1}} \times \left\{ \frac{1}{2} g_t \cdot \eta_{l,t} + \sum_{i=1}^{\infty} \eta_{l,t-i} \left(g_{t-i} \times \prod_{j=1}^i \frac{\lambda}{g_{t-j} + \lambda} \right) \right\} - \frac{D_{t-1}}{A_{t-1}} \times \left\{ \left(1 + \frac{1}{2} h_t \right) r_{D,t} \right\}$$

Impose the restriction $g_{t-j}(\cdot) = g^*$ on (12):

$$\frac{NII_t}{A_{t-1}} = \frac{L_{t-1}}{A_{t-1}} \times \left\{ \frac{1}{2} g_t \cdot \eta_{l,t} + \sum_{i=1}^{\infty} \eta_{l,t-i} g_{t-i} \left(\frac{\lambda}{g^* + \lambda} \right)^i \right\} - \frac{D_{t-1}}{A_{t-1}} \times \left\{ \left(1 + \frac{1}{2} h_t \right) r_{D,t} \right\}$$

Add the ‘other net interest bearing liabilities’ term R_{t-1} to the equation in order to correct for deviations from the theoretical model in the bank balance sheet data (see appendix B for details on R_{t-1}).

$$\frac{NII_t}{A_{t-1}} = \frac{L_{t-1}}{A_{t-1}} \times \left\{ \frac{1}{2} g_t \cdot \eta_{t,t} + \sum_{i=1}^{\infty} \eta_{t,t-i} g_{t-i} \left(\frac{\lambda}{g^* + \lambda} \right)^i \right\} - \frac{D_{t-1}}{A_{t-1}} \times \left\{ \left(1 + \frac{1}{2} h_t \right) r_{D,t} \right\} - \frac{R_{t-1}}{A_{t-1}} \{ r_{R,t} \}$$

Take a first order approximation for $g_{t-i} \approx a_0 + a_1 \cdot y_{t-i} + a_2 \cdot s_{t-i}$ and $h_t \approx b_0 + b_1 r_{s,t} + b_2 i_t$:

$$\begin{aligned} \frac{NII_t}{A_{t-1}} \approx \frac{L_{t-1}}{A_{t-1}} \times & \left\{ \frac{1}{2} [a_0 + a_1 \cdot y_t + a_2 \cdot s_t] \cdot \eta_{t,t} + \sum_{i=1}^{\infty} r_{f,t-i} [a_0 + a_1 \cdot y_{t-i} + a_2 \cdot s_{t-i}] \left(\frac{\lambda}{g^* + \lambda} \right)^i \right\} \\ & - \frac{D_{t-1}}{A_{t-1}} \times \left\{ \left(1 + \frac{1}{2} [b_0 + b_1 r_{s,t} + b_2 i_t] \right) r_{D,t} \right\} - \frac{R_{t-1}}{A_{t-1}} \{ r_{R,t} \} \end{aligned}$$

Assume that the financing rate for ‘other net interest bearing liabilities’ (R_{t-1}) is given by some linear function of the short term rate ($r_{R,t} = d_0 + d_1 \cdot r_{s,t}$). Substitute (3) and (4) for $r_{l,t-i}$ and $r_{D,t}$:

$$\begin{aligned} \frac{NII_t}{A_{t-1}} \approx \frac{L_{t-1}}{A_{t-1}} \times & \left\{ \frac{1}{2} [a_0 + a_1 \cdot y_t + a_2 \cdot s_t] \cdot [r_{f,t} + k + c_L + f^e] + (\dots) \right. \\ & \left. (\dots) + \sum_{i=1}^{\infty} [r_{f,t-i} + k + c_L + f^e] [a_0 + a_1 \cdot y_{t-i} + a_2 \cdot s_{t-i}] \left(\frac{\lambda}{g^* + \lambda} \right)^i \right\} \\ & - \frac{D_{t-1}}{A_{t-1}} \times \left\{ \left(1 + \frac{1}{2} [b_0 + b_1 r_{s,t} + b_2 i_t] \right) [r_{s,t} - c_D] \right\} \\ & - \frac{R_{t-1}}{A_{t-1}} \{ d_0 + d_1 \cdot r_{s,t} \} \end{aligned}$$

Rewrite and restrict $i \in 1, 2, 3, 4$:

$$\begin{aligned} \frac{NII_t}{A_{t-1}} \approx & \left[\frac{L_{t-1}}{A_{t-1}} \right] \times \left\{ \left(\frac{1}{2} a_0 + \sum_{i=1}^4 a_0 \right) (k + c_L + f^e) \right\} + \sum_{i=0}^4 \left[\frac{L_{t-1}}{A_{t-1}} r_{f,t-i} \right] \left\{ a_0 \cdot \left(\frac{\lambda}{g^* + \lambda} \right)^i \right\} + \\ & + \sum_{i=0}^4 \left[\frac{L_{t-1}}{A_{t-1}} y_{t-i} \right] \left\{ a_1 \cdot (k + c_L + f^e) \cdot \left(\frac{\lambda}{g^* + \lambda} \right)^i \right\} + \sum_{i=0}^4 \left[\frac{L_{t-1}}{A_{t-1}} s_{t-i} \right] \left\{ a_2 \cdot (k + c_L + f^e) \cdot \left(\frac{\lambda}{g^* + \lambda} \right)^i \right\} + \\ & + \sum_{i=0}^4 \left[\frac{L_{t-1}}{A_{t-1}} r_{f,t-i} y_{t-i} \right] \left\{ a_1 \cdot \left(\frac{\lambda}{g^* + \lambda} \right)^i \right\} + \sum_{i=0}^4 \left[\frac{L_{t-1}}{A_{t-1}} r_{f,t-i} s_{t-i} \right] \left\{ a_2 \cdot \left(\frac{\lambda}{g^* + \lambda} \right)^i \right\} + \\ & - \left[\frac{D_{t-1}}{A_{t-1}} r_{s,t} \right] \left\{ 1 + \frac{1}{2} b_0 \right\} - \left[\frac{D_{t-1}}{A_{t-1}} (r_{s,t}^2) \right] \left\{ \frac{1}{2} b_1 \right\} - \left[\frac{D_{t-1}}{A_{t-1}} (r_{s,t} i_t) \right] \left\{ \frac{1}{2} b_2 \right\} - \left[\frac{R_{t-1}}{A_{t-1}} \right] \{ d_0 \} - \left[\frac{R_{t-1}}{A_{t-1}} r_{s,t} \right] \{ d_1 \} \end{aligned}$$

Collecting terms into vectors and adding a constant and an error term gives the model in (16), where the terms between curly brackets represent the unknown parameters in the model.

Appendix B – Data Items

| VARIABLE | | DEFINITION | SOURCE ¹³ |
|--|----------------|---|----------------------|
| <i>Macro data:</i> | | | |
| Real GDP growth | y_t | $\log(\text{GDP}_{t,\text{constant prices, local currency}}) - \log(\text{GDP}_{t-1,\text{constant prices, local currency}})$ | OECD MEI |
| Inflation | i_t | $\log \text{ GDP growth}_{t,\text{current prices, local currency}} + \dots - \log \text{ GDP growth}_{t-1,\text{constant prices, local currency}}$ | OECD MEI |
| Long term rate | $r_{f,t}$ | Long-term interest rate _t | OECD MEI |
| Short term rate | $r_{s,t}$ | Short-term interest rate _t | OECD MEI |
| Market index growth | $r_{m,t}$ | $(\text{Stock market index}_t - \text{Stock market index}_{t-1}) / \text{Stock market index}_{t-1}$ | OECD MEI |
| Local stock market C.V. | $\sigma_{m,t}$ | $\frac{\text{s.d.}(\text{Monthly Stock market index}_t)}{\text{mean}(\text{Monthly Stock market index}_t)}$ | OECD MEI |
| Unemployment | u_t | Total unemployment _t / (Total unemployment _t + Total employment _t) | OECD MEI |
| Slope of the yield curve | s_t | Long-term interest rate _t – Short-term interest rate _t | OECD MEI |
| <i>Aggregated data:</i> | | | |
| Profit before tax | Π_t | Income before tax _t (9) | OECD BPS |
| Net interest income | NII_t | Net interest income _t (3) | OECD BPS |
| Other income | OI_t | Net non interest income _t (4) | OECD BPS |
| Loan losses and costs | $BL_t + OC_t$ | Operating expenses _t (6) + Net provisions _t (8) [i.e. (9)-(3)-(4)] | OECD BPS |
| Loans | L_{t-1} | Loans _{t-1} (16) – Bonds _{t-1} (23) | OECD BPS |
| Deposits | D_{t-1} | Customer deposits _{t-1} (22) | OECD BPS |
| Other net interest bearing liabilities | R_{t-1} | Borrowing from c.b. _{t-1} (18) + Interbank deposits _{t-1} (19, [L]) + ... – Cash and balance with c.b. _{t-1} (14) + ... – Interbank deposits _{t-1} (15, [A]) – Securities _{t-1} (17) | OECD BPS |
| Assets | A_{t-1} | Balance sheet total, end year total _{t-1} (25) | OECD BPS |
| <i>Individual data:</i> | | | |
| Profit before tax | Π_t | Profit before tax _t | BankScope |
| Net interest income | NII_t | Net Interest Revenue _t | BankScope |
| Other income | OI_t | Other Income _t | BankScope |
| Loan losses and costs | $BL_t + OC_t$ | Profit before tax _t – Net Interest Revenue _t – Other Income _t | BankScope |
| Loans | L_{t-1} | Loans _{t-1} | BankScope |
| Deposits | D_{t-1} | Deposits and Short term funding _{t-1} | BankScope |
| Other net interest bearing liabilities | R_{t-1} | Other funding _{t-1} – Other earning assets _{t-1} | BankScope |
| Assets | A_{t-1} | Total Assets _{t-1} | BankScope |

¹³ MEI refers to Main Economic Indicators, BPS refers to Bank Profitability Statistics.

TABLES

Table 1a Distribution over country

| COUNTRY | N | |
|----------------|-------------------|--------------------|
| | <i>Aggregate:</i> | <i>Individual:</i> |
| Australia | 13 | 313 |
| Austria | 18 | 320 |
| Belgium | 26 | 345 |
| Canada | 19 | 312 |
| Denmark | 21 | 260 |
| Finland | 20 | 58 |
| France | 19 | 1,864 |
| Germany | 28 | 3,089 |
| Italy | 16 | 1,277 |
| Japan | 14 | 2,086 |
| Netherlands | 28 | 349 |
| New Zealand | 17 | 99 |
| Norway | 23 | 200 |
| Portugal | 0 | 199 |
| Spain | 28 | 991 |
| Sweden | 10 | 236 |
| Switzerland | 28 | 354 |
| United Kingdom | 0 | 1,267 |
| United States | 27 | 3,232 |
| Total: | 355 | 16,851 |

Table 1b Distribution over bank type

| BANK TYPE | N |
|-------------------------|--------|
| <i>Individual data:</i> | |
| Commercial Banks | 8,911 |
| Cooperative Bank | 2,213 |
| Investment Banks | 790 |
| Real Estate / Mo | 1,360 |
| Savings Bank | 3,577 |
| Total: | 16,851 |

Table 1c Summary Statistics

| VARIABLE | | MEAN | MEDIAN | ST.DEV | N |
|--|---------------------------|---------|---------|--------|-------|
| <i>Aggregate data:</i> | | | | | |
| Profit before Tax | Π_t / A_{t-1} | 0.0076 | 0.0072 | 0.0065 | 355 |
| Net Interest Income | NII_t / A_{t-1} | 0.0214 | 0.0201 | 0.0090 | 366 |
| Other Income | OI_t / A_{t-1} | 0.0116 | 0.0110 | 0.0062 | 366 |
| Loan losses and costs | $(BL_t + OC_t) / A_{t-1}$ | 0.0252 | 0.0229 | 0.0101 | 355 |
| Loans | L_{t-1} / A_{t-1} | 0.4462 | 0.4417 | 0.1541 | 368 |
| Deposits | D_{t-1} / A_{t-1} | 0.5097 | 0.5039 | 0.1430 | 368 |
| Other Net Interest bearing liabilities | R_{t-1} / A_{t-1} | -0.2047 | -0.2007 | 0.1037 | 368 |
| <i>Individual data:</i> | | | | | |
| Profit before Tax | Π_t / A_{t-1} | 0.0097 | 0.0076 | 0.0113 | 16523 |
| Net Interest Income | NII_t / A_{t-1} | 0.0239 | 0.0220 | 0.0139 | 16406 |
| Other Income | OI_t / A_{t-1} | 0.0138 | 0.0084 | 0.0198 | 16453 |
| Loan losses and costs | $(BL_t + OC_t) / A_{t-1}$ | 0.0273 | 0.0246 | 0.0199 | 16219 |
| Loans | L_{t-1} / A_{t-1} | 0.5789 | 0.6138 | 0.2170 | 16737 |
| Deposits | D_{t-1} / A_{t-1} | 0.7676 | 0.8436 | 0.2077 | 16737 |
| Other Net Interest bearing liabilities | R_{t-1} / A_{t-1} | -0.2318 | -0.2444 | 0.2986 | 16544 |

All variables are scaled by (lagged) total assets.

Table 1d Correlation Matrix

| VARIABLE | $\frac{\Pi_t}{A_{t-1}}$ | $\frac{NII_t}{A_{t-1}}$ | $\frac{OI_t}{A_{t-1}}$ | $\frac{BL_t + OC_t}{A_{t-1}}$ | $\frac{L_{t-1}}{A_{t-1}}$ | $\frac{D_{t-1}}{A_{t-1}}$ | $\frac{R_{t-1}}{A_{t-1}}$ |
|---------------------------|-------------------------|-------------------------|------------------------|-------------------------------|---------------------------|---------------------------|---------------------------|
| <i>Aggregate data:</i> | | | | | | | |
| Π_t / A_{t-1} | 1 | | | | | | |
| NII_t / A_{t-1} | 0.322 | 1 | | | | | |
| OI_t / A_{t-1} | 0.568 | 0.215 | 1 | | | | |
| $(BL_t + OC_t) / A_{t-1}$ | -0.009 | 0.821 | 0.430 | 1 | | | |
| L_{t-1} / A_{t-1} | 0.224 | 0.548 | 0.264 | 0.506 | 1 | | |
| D_{t-1} / A_{t-1} | 0.179 | 0.500 | 0.143 | 0.419 | 0.865 | 1 | |
| R_{t-1} / A_{t-1} | -0.0675 | 0.1181 | -0.1614 | 0.0522 | 0.1232 | -0.0352 | 1 |
| <i>Individual data:</i> | | | | | | | |
| Π_t / A_{t-1} | 1 | | | | | | |
| NII_t / A_{t-1} | 0.521 | 1 | | | | | |
| OI_t / A_{t-1} | 0.400 | 0.145 | 1 | | | | |
| $(BL_t + OC_t) / A_{t-1}$ | 0.181 | 0.543 | 0.792 | 1 | | | |
| L_{t-1} / A_{t-1} | 0.113 | 0.322 | -0.186 | -0.007 | 1 | | |
| D_{t-1} / A_{t-1} | 0.013 | 0.266 | -0.067 | 0.118 | -0.057 | 1 | |
| R_{t-1} / A_{t-1} | 0.051 | 0.058 | -0.106 | -0.083 | 0.750 | -0.663 | 1 |

Table 2 Net interest income and macro economic variables: estimation results

| DATASET: | <i>Aggregate data:</i> | | <i>Individual data:</i> | |
|--|---|----------|---|------------|
| | (1) | | (2) | |
| | <u>Net Interest Income_t</u> Assets _{t-1} | s.e. | <u>Net Interest Income_t</u> Assets _{t-1} | s.e. |
| [L _{t-1} /A _{t-1}] * (Long term rate) _t | -0.0204 | (0.0334) | 0.0661 | (0.0529) |
| [L _{t-1} /A _{t-1}] * (Long term rate) _{t-1} | 0.0988*** | (0.0294) | 0.0762*** | (0.0221) |
| [L _{t-1} /A _{t-1}] * (Long term rate) _{t-2} | 0.0607** | (0.0298) | 0.0421** | (0.0204) |
| [L _{t-1} /A _{t-1}] * (Long term rate) _{t-3} | 0.0650** | (0.0262) | 0.0686*** | (0.0187) |
| [L _{t-1} /A _{t-1}] * (Long term rate) _{t-4} | | | 0.0266* | (0.0153) |
| [L _{t-1} /A _{t-1}] * (Real GDP growth) _t | -0.153*** | (0.0415) | -0.0753*** | (0.0221) |
| [L _{t-1} /A _{t-1}] * (Real GDP growth) _{t-1} | -0.0327 | (0.0387) | -0.0698*** | (0.0206) |
| [L _{t-1} /A _{t-1}] * (Real GDP growth) _{t-2} | -0.0810** | (0.0374) | -0.0474** | (0.0189) |
| [L _{t-1} /A _{t-1}] * (Real GDP growth) _{t-3} | -0.0433 | (0.0360) | -0.0314* | (0.0162) |
| [L _{t-1} /A _{t-1}] * (Real GDP growth) _{t-4} | | | 0.000981 | (0.0166) |
| [L _{t-1} /A _{t-1}] * (Slope yield curve) _t | | | 0.180** | (0.0718) |
| [L _{t-1} /A _{t-1}] * (Slope yield curve) _{t-1} | | | 0.0890** | (0.0389) |
| [L _{t-1} /A _{t-1}] * (Slope yield curve) _{t-2} | | | 0.0856** | (0.0335) |
| [L _{t-1} /A _{t-1}] * (Slope yield curve) _{t-3} | | | 0.0476 | (0.0318) |
| [L _{t-1} /A _{t-1}] * (Slope yield curve) _{t-4} | | | 0.0151 | (0.0269) |
| [L _{t-1} /A _{t-1}] * (It rate*Real GDP growth) _t | 2.662*** | (0.575) | 1.996*** | (0.413) |
| [L _{t-1} /A _{t-1}] * (It rate*Real GDP growth) _{t-1} | 0.606 | (0.463) | 1.938*** | (0.368) |
| [L _{t-1} /A _{t-1}] * (It rate*Real GDP growth) _{t-2} | 1.267*** | (0.454) | 1.502*** | (0.327) |
| [L _{t-1} /A _{t-1}] * (It rate*Real GDP growth) _{t-3} | 0.536 | (0.420) | 0.584** | (0.279) |
| [L _{t-1} /A _{t-1}] * (It rate*Real GDP growth) _{t-4} | | | 0.0545 | (0.237) |
| [L _{t-1} /A _{t-1}] * (It rate* Slope yield curve) _t | | | -2.547*** | (0.914) |
| [L _{t-1} /A _{t-1}] * (It rate* Slope yield curve) _{t-1} | | | -1.642*** | (0.589) |
| [L _{t-1} /A _{t-1}] * (It rate* Slope yield curve) _{t-2} | | | -1.508*** | (0.457) |
| [L _{t-1} /A _{t-1}] * (It rate* Slope yield curve) _{t-3} | | | -1.165*** | (0.424) |
| [L _{t-1} /A _{t-1}] * (It rate* Slope yield curve) _{t-4} | | | -0.394 | (0.342) |
| [D _{t-1} /A _{t-1}] * (Short term rate) | -0.0444* | (0.0265) | 0.0116 | (0.0554) |
| [D _{t-1} /A _{t-1}] * (Short term rate) ² | | | -0.654*** | (0.250) |
| [D _{t-1} /A _{t-1}] * (Inflation) | | | -0.0665*** | (0.0189) |
| [D _{t-1} /A _{t-1}] * (Short term rate*Inflation) | | | 1.216*** | (0.320) |
| [R _{t-1} /A _{t-1}] * (Short term rate) | -0.0763 | (0.0485) | -0.0749 | (0.0508) |
| [L _{t-1} /A _{t-1}] | 0.00153 | (0.0050) | 0.0137*** | (0.00286) |
| [D _{t-1} /A _{t-1}] | 0.00860** | (0.0037) | -0.0124*** | (0.00241) |
| [R _{t-1} /A _{t-1}] | 0.00787** | (0.0038) | -0.0171*** | (0.00239) |
| Constant | 0.0104*** | (0.0012) | 0.0107*** | (0.000430) |
| Observations | 331 | | 14468 | |
| R ² | 0.576 | | 0.114; 0.205; 0.208 | |
| Wald-Chi ² [d.o.f.] | 414.15*** | [17] | - | |
| Number of countries, banks | 17 | | 1399 | |
| AR coefficient; Baltagi-Wu LBI | - | | 0.457; 1.431 | |

Aggregate data: Generalized least squares with heteroskedastic panels and panel specific auto correlation. R² is the pseudo-R². Individual data: Least Squares with fixed bank effects and an AR(1) error term. R² is given for within, between, and overall, respectively. *** p<0.01, ** p<0.05, * p<0.1

Table 3

Bank profitability and macro economic variables: Estimation results for aggregate data.

| VARIABLES | (1) | | (2) | | (3) | |
|--|---------------------------------------|------------|---|-----------|---|-----------|
| | Other Income Assets _{t-1} | s.e. | Net provisions _t + Costs _t Assets _{t-1} | s.e. | Profit before tax _t Assets _{t-1} | s.e. |
| (Real GDP growth) _t | -0.00129 | (0.00653) | -0.0553** | (0.0234) | ----- | |
| (Real GDP growth) _{t-1} | 0.0152** | (0.00640) | | | ----- | |
| [L _{t-1} /A _{t-1}] * (Real GDP growth) _t | | | 0.0670 | (0.0539) | 0.0820*** | (0.0215) |
| [L _{t-1} /A _{t-1}] * (Real GDP growth) _{t-1} | | | -0.0124 | (0.0236) | 0.0167 | (0.0216) |
| [L _{t-1} /A _{t-1}] * (Real GDP growth) _{t-2} | | | -0.000317 | (0.0215) | 0.0114 | (0.0203) |
| [L _{t-1} /A _{t-1}] * (Recession slope dummy) _t | | | -0.184 | (0.116) | 0.295*** | (0.114) |
| [L _{t-1} /A _{t-1}] * (Recession slope dummy) _{t-1} | | | -0.440*** | (0.123) | 0.535*** | (0.116) |
| [L _{t-1} /A _{t-1}] * (Recession slope dummy) _{t-2} | | | -0.248** | (0.114) | 0.383*** | (0.112) |
| [L _{t-1} /A _{t-1}] * (Unemployment rate) _t | | | 0.101*** | (0.0263) | 0.0477** | (0.0185) |
| Inflation rate | | | -0.00217 | (0.0127) | 0.0186 | (0.0114) |
| Long term rate | -0.0617*** | (0.0147) | 0.0528*** | (0.0193) | -0.0479*** | (0.0167) |
| Short term rate | 0.0189* | (0.00967) | 0.0372*** | (0.0143) | 0.000410 | (0.0127) |
| [L _{t-1} /A _{t-1}] * (Long term rate) _t | | | | | ----- | |
| (...) | | | | | ----- | |
| Local market index return | 0.00167*** | (0.000555) | ----- | | ----- | |
| Local market index volatility | 0.00140 | (0.00217) | ----- | | ----- | |
| [L _{t-1} /A _{t-1}] | | | 0.0213*** | (0.00535) | 0.00849** | (0.00369) |
| [D _{t-1} /A _{t-1}] | | | 9.63e-05 | (0.00506) | -0.00256 | (0.00382) |
| [R _{t-1} /A _{t-1}] | | | | | -0.00583** | (0.00281) |
| Constant | 0.0131*** | (0.000814) | 0.00670*** | (0.00156) | 0.00371*** | (0.00118) |
| Observations | 354 | | 343 | | 343 | |
| Number of countries | 17 | | 17 | | 17 | |
| R ² (pseudo) | 0.001 | | 0.530 | | 0.360 | |
| Wald Chi ² [d.o.f.] | 47.51*** | [6] | 285.50*** | [13] | 146.51*** | [13] |

Generalized least squares with heteroskedastic panels and panel specific auto correlation, *** p<0.01, ** p<0.05, * p<0.1 ----- = removed due to insignificance. Blank: not in model.

Table 4

Bank profitability and macro economic variables with individual bank data: estimation results for individual data

| VARIABLES | (1) | | (2) | | (3) | |
|--|--|------------|---|------------|---|------------|
| | Other Income _t Assets _{t-1} | s.e. | Net provisions _t + Costs _t Assets _{t-1} | s.e. | Profit before tax _t Assets _{t-1} | s.e. |
| (Real GDP growth) _t | -0.00808 | (0.00787) | 0.0158 | (0.0213) | ----- | |
| (Real GDP growth) _{t-1} | 0.0234*** | (0.00696) | | | ----- | |
| [L _{t-1} /A _{t-1}] * (Real GDP growth) _t | | | -0.0357 | (0.0335) | 0.00490 | (0.0134) |
| [L _{t-1} /A _{t-1}] * (Real GDP growth) _{t-1} | | | -0.00390 | (0.0136) | 0.0697*** | (0.0106) |
| [L _{t-1} /A _{t-1}] * (Real GDP growth) _{t-2} | | | 0.0432*** | (0.0117) | -0.00508 | (0.00921) |
| [L _{t-1} /A _{t-1}] * (Recession slope dummy) _t | | | -0.387*** | (0.103) | 0.413*** | (0.0804) |
| [L _{t-1} /A _{t-1}] * (Recession slope dummy) _{t-1} | | | 0.119 | (0.100) | -0.0416 | (0.0783) |
| [L _{t-1} /A _{t-1}] * (Recession slope dummy) _{t-2} | | | -0.0630 | (0.0695) | -0.0388 | (0.0534) |
| [L _{t-1} /A _{t-1}] * (Unemployment rate) _t | | | 0.187*** | (0.0166) | -0.0278** | (0.0122) |
| Inflation rate | | | -0.00926 | (0.00962) | 0.0102 | (0.00741) |
| Long term rate | -0.00636 | (0.0140) | 0.0429*** | (0.0158) | -0.0280 | (0.0259) |
| Short term rate | 0.00390 | (0.00992) | 0.0651*** | (0.0112) | 0.0570** | (0.0244) |
| [L _{t-1} /A _{t-1}] * (Long term rate) _t | | | | | 0.112** | (0.0452) |
| [L _{t-1} /A _{t-1}] * (Long term rate) _{t-1} | | | | | 0.0234 | (0.0171) |
| (...) | | | | | ----- | |
| [D _{t-1} /A _{t-1}] * (Short term rate) | | | | | -0.244*** | (0.0416) |
| [D _{t-1} /A _{t-1}] * (Short term rate) ^{^2} | | | | | 0.696*** | (0.179) |
| [R _{t-1} /A _{t-1}] * (Short term rate) | | | | | -0.112*** | (0.0303) |
| Local market index return | 0.00276*** | (0.000555) | -0.00226*** | (0.000608) | 0.00514*** | (0.000474) |
| Local market index volatility | 0.00429** | (0.00219) | 0.00332 | (0.00233) | 0.00480*** | (0.00183) |
| [L _{t-1} /A _{t-1}] | 0.00337*** | (0.00127) | 0.0226*** | (0.00311) | 0.00767*** | (0.00292) |
| [D _{t-1} /A _{t-1}] | -0.00525*** | (0.00125) | -0.0253*** | (0.00237) | 0.00269 | (0.00226) |
| [R _{t-1} /A _{t-1}] | | | -0.0252*** | (0.00240) | -0.00534*** | (0.00207) |
| Constant | 0.0152*** | (0.000623) | 0.0141*** | (0.000715) | 0.00147 | (0.000922) |
| Observations | 15053 | | 14097 | | 14322 | |
| R ² [within; between; overall] | 0.004; 0.001; 0.000 | | 0.039; 0.003; 0.012 | | 0.025; 0.039; 0.039 | |
| Number of banks | 1398 | | 1394 | | 1402 | |
| AR coefficient; Baltagi-Wu LBI | 0.527; 1.312 | | 0.535; 1.364 | | 0.409; 1.567 | |

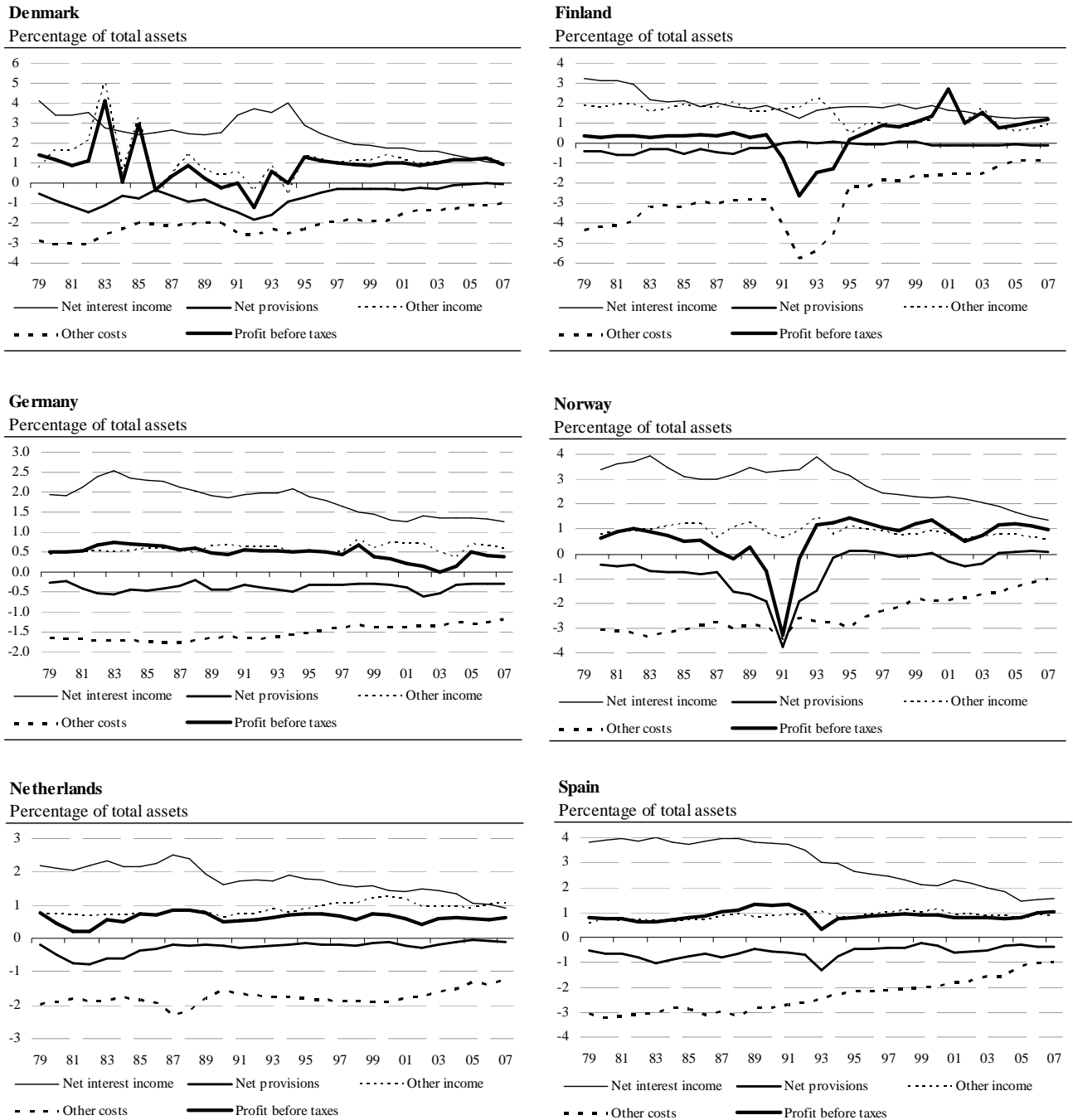
Least Squares with fixed bank effects and an AR(1) error term, standard errors in brackets.

*** p<0.01, ** p<0.05, * p<0.1. ----- = removed due to insignificance. Blank: not in model.

FIGURES

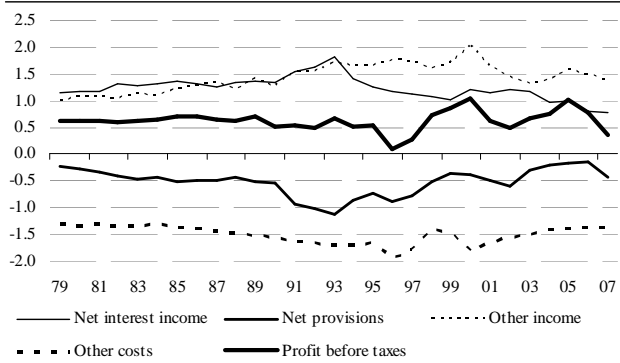
Figure 1

Decomposition bank profitability, per country



Switzerland

Percentage of total assets



United States

Percentage of total assets

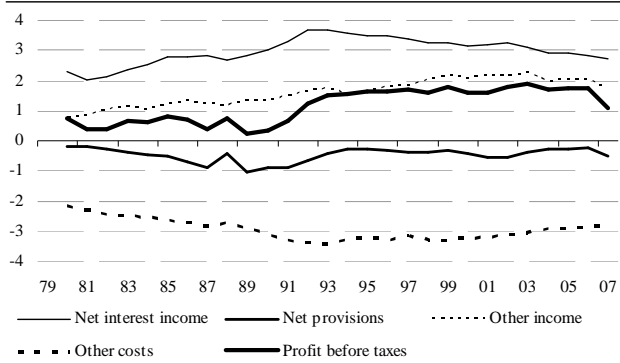


Figure 2

Distribution of observations over time

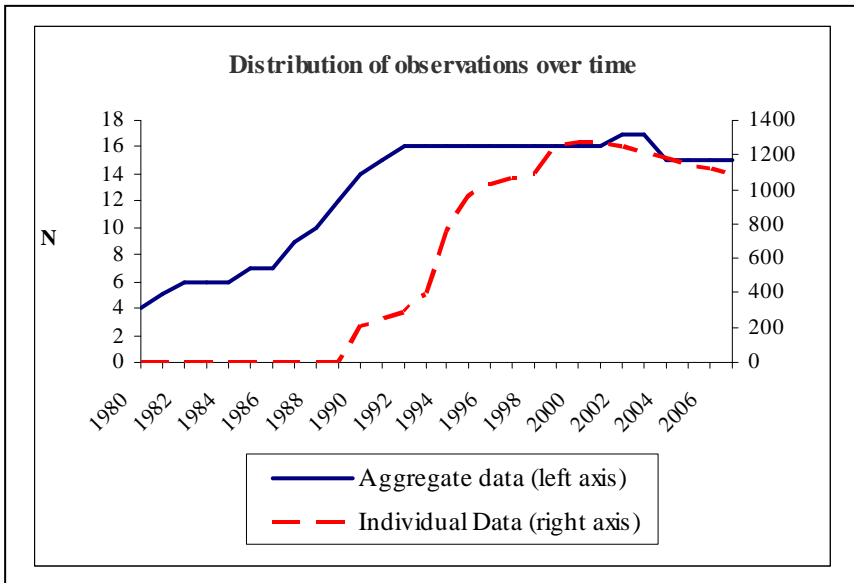


Figure 3

| Stylized Bank Balance Sheet | | | |
|-----------------------------|----------|--|----------|
| Loans | <i>L</i> | Deposits | <i>D</i> |
| Non interest earning assets | | Other (net) interest bearing liabilities | <i>R</i> |
| | | Bank capital | |
| Total assets | <i>A</i> | Total liabilities | <i>A</i> |

Figure 4

Mean marginal effect of the long term rate on interest income in relation to real GDP growth, given a loan-to-asset ratio of 1. As real GDP growth increases, the long term rate becomes more important. The figure is based on individual data. The dotted lines represent the 95% confidence interval.

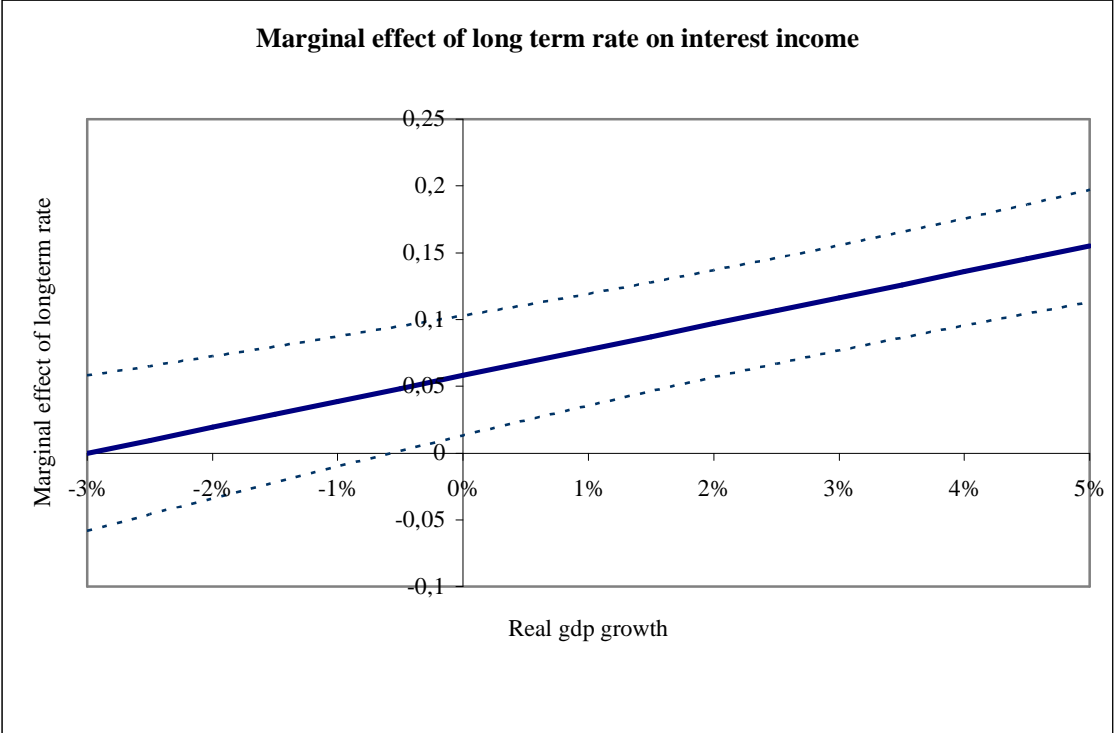


Figure 5

Mean marginal effect of the long term rate on interest income in relation to the slope of the yield curve, given a loan to asset ratio of 1. As the yield curve becomes steeper, the long term rate becomes less important. The figure is based on individual data. The dotted lines represent the 95% confidence interval.

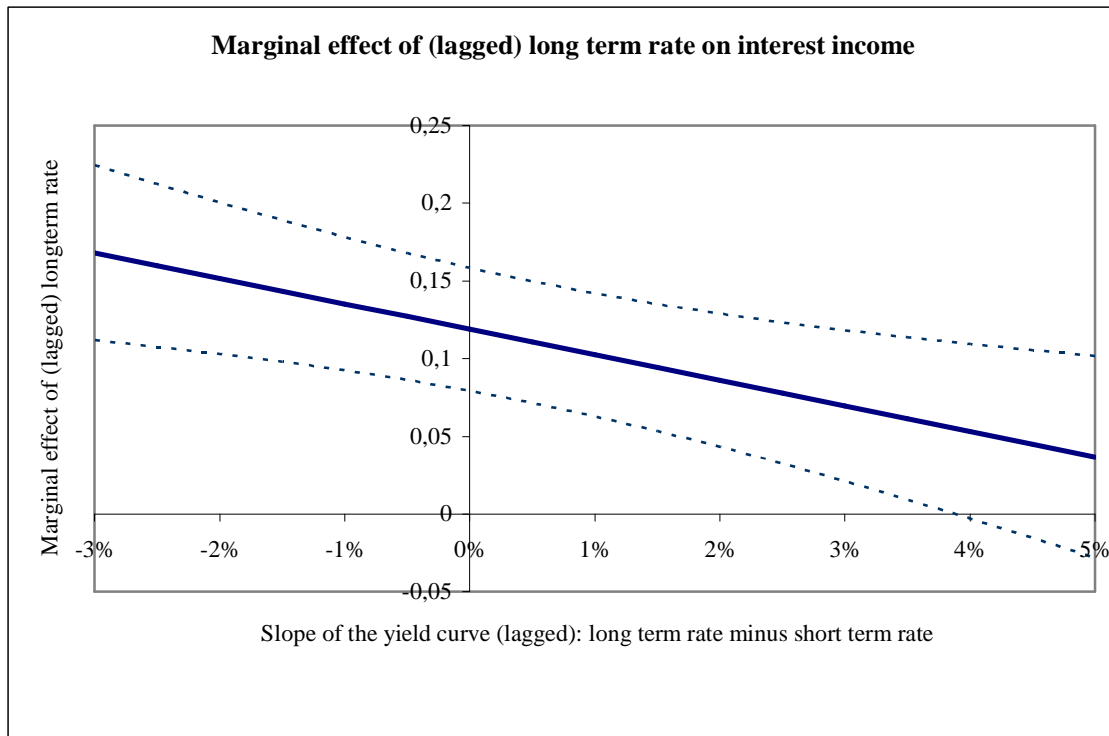


Figure 6

The figure shows the Wald test statistic for the null hypothesis that severe recessions do not have any additional impact on bank profits. The test was performed on the model for return on assets estimated for the aggregate data (Table 3, column 3). The choice of the optimal breakpoint a is based on a trade-off between the size of the test statistic and the number of observations on severe recessions (i.e. real GDP growth smaller than a).

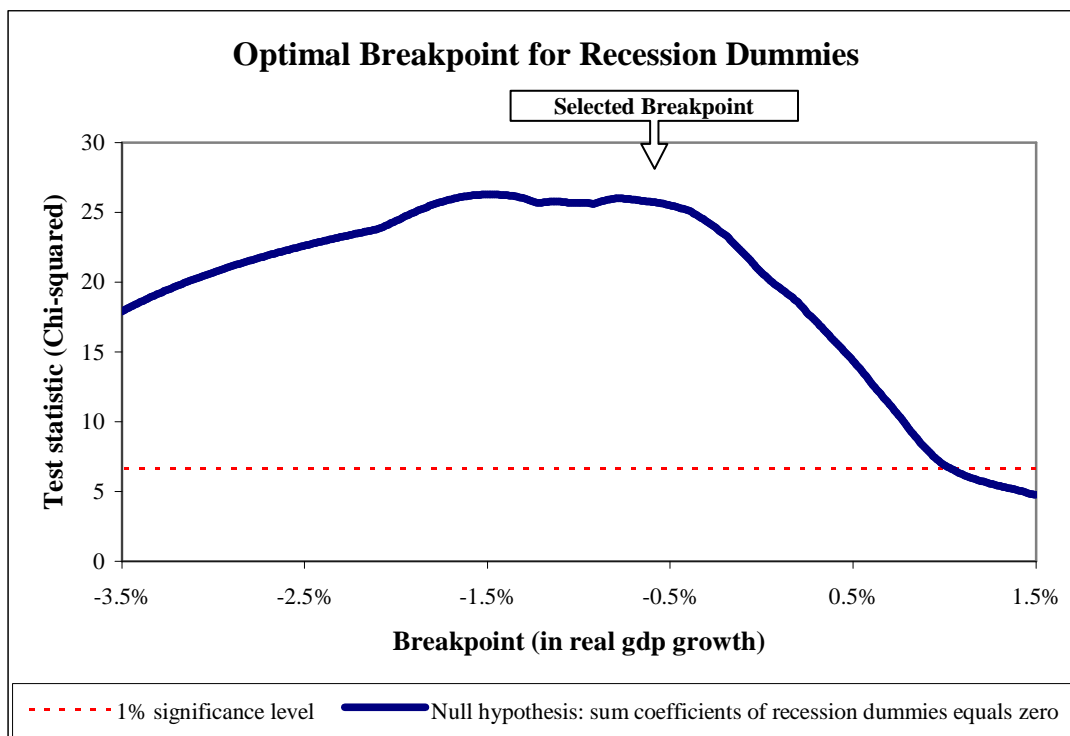
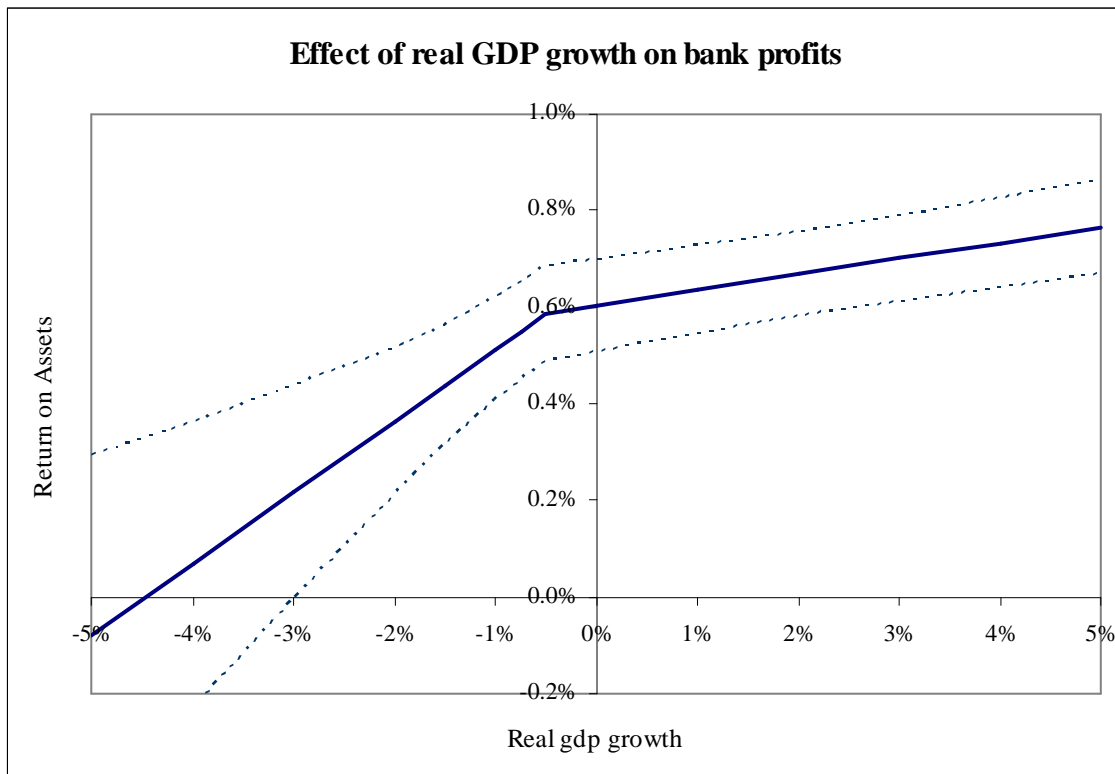


Figure 7

The effect of GDP growth for a representative country with a loan-to-assets ratio of 40%, based on the bank profit model estimated with aggregate data. The dotted lines represent the 95% confidence interval.



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