STAFF MEMO

NO. 2 | 2017

Average risk weights for corporate exposures: what can 30 years of loss data for the Norwegian banking sector tell us?

AUTHORS:
HENRIK ANDERSEN
HANNA WINJE

FINANCIAL STABILITY

NORGES BANK

ISSN 1504-2596 (online only)

ISBN 978-82-7553-962-3 (online only)

Average risk weights for corporate exposures: what can 30 years of loss data for the Norwegian banking sector tell us?

Henrik Andersen and Hanna Winje[1], Financial Stability, Norges Bank

Summary

The cost to society of a banking crisis is high. Higher capital ratios improve banks' loss-absorbing capacity and reduce the risk of crises. Since the financial crisis erupted in 2008, banks have increased their capital ratios considerably in pace with stricter regulatory requirements. Nevertheless, the level of capital held by banks to support their assets is not appreciably higher than after the banking crisis of the 1990s. Banks calculate capital ratios by risk-weighting their exposures to reflect the risk of unexpected losses. Large Norwegian banks' risk weights have decreased over the past decade. In this paper, we examine historical loss data and corporate data back to the 1980s to estimate average risk weights for corporate exposures in the Norwegian banking sector. We cross-check the estimates using calculations that are based on a stress test and other points of reference. Even when we take a number of elements of uncertainty into account, historical loss data indicate higher average corporate risk weights than the current level in the Norwegian banking sector.

[1] We thank Hege Anderson, Sigbjørn Atle Berg, Erlend Magnussen Fleisje, Torbjørn Hægeland, Kjell Bjørn Nordal, Øyvind Lind, Haakon Solheim, Bent Vale, Sindre Weme and other colleagues at Norges Bank for useful input and comments. Special thanks to Ida Nervik Hjelseth for her valuable help in processing corporate data. Any remaining errors or omissions are solely the responsibility of the authors.

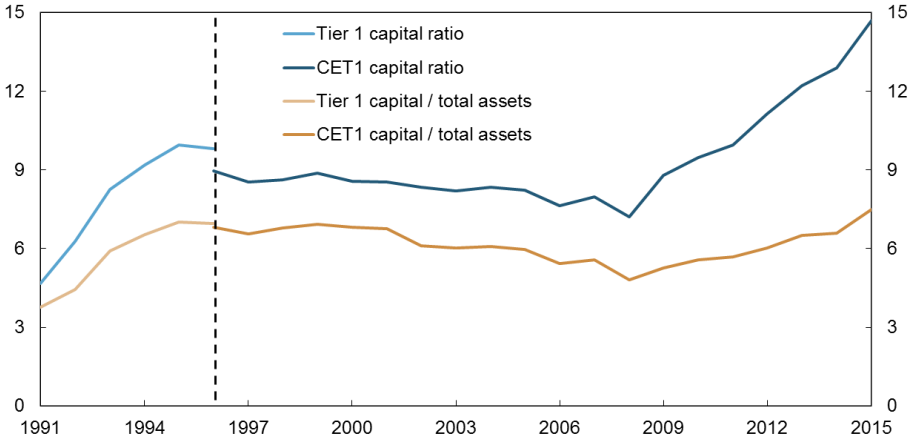
Contents

Average risk weights for corporate exposures: what can 30 years of loss data for the Norwegian banking sector tell us?

1. Introduction

The cost to society of a banking crisis is high. Higher capital ratios improve banks' loss-absorbing capacity and reduce the risk of crises, but at the same time banks' funding costs can rise if banks are required to increase equity funding. Since the financial crisis erupted in 2008, banks have increased their capital ratios considerably in pace with higher regulatory requirements. Nevertheless, the level of capital held by banks to support their assets is not appreciably higher than after the banking crisis in the 1990s (see orange line in Chart 1). One reason is that banks' risk-weighted assets, which banks use to calculate capital ratios, have increased less than their assets.[2]

Chart 1 (Common Equity) Tier 1 capital ratio and (Common Equity) Tier 1 capital as a share of total assets.[1)] Percent. 1991–2015



1) Tier 1 capital before 1996, Common Equity Tier 1 (CET1) capital as from 1996. CET 1 capital ratio with a transitional floor as from 2007.
Source: Finanstilsynet (Financial Supervisory Authority of Norway)

Banks' capital adequacy ratio is calculated as capital as a percentage of risk-weighted assets:

$$Capital\ adequacy\ ratio = \frac{Capital}{Risk\text{–}weighted\ assets}$$

Capital adequacy can be calculated based on different capital variables. The variable most commonly used is Common Equity Tier 1 (CET1) capital[3], which is the capital that is written down first when banks operate at a loss. Banks calculate risk-weighted assets by assigning risk weights to their assets (exposures). The higher the risk of loss on an asset, the higher its risk weight should be. Risk weights are intended to reflect the risk of unexpected losses.[4] Expected losses are reflected in lending margins and are covered by operating income.

New capital standards introduced in 2007 (the Basel II framework) allow banks to use internal risk models to calculate risk weights for their exposures (the IRB approach). The alternative is to apply more general, standardised risk weights set by the authorities (the standardised approach). Since the IRB approach to a greater extent uses bank-specific data, such as historical loss and default data and key figures for banks' borrowers, internal models are often assumed to

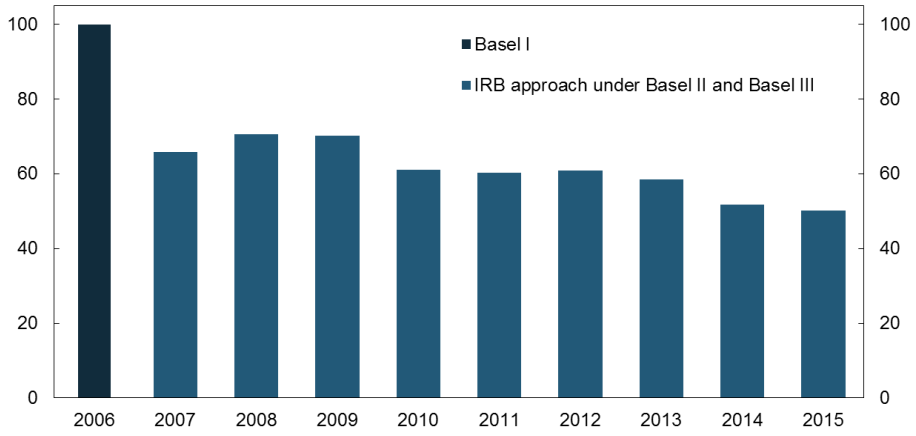
[2] There may be a number of reasons why banks' risk-weighted assets have increased less than their assets. Banks have increased their lending to segments with low risk weights. Assessing the credit risk of existing borrowers as lower may also have contributed to a fall in banks' risk weights. Banks have also implemented new calculation methods that result in lower risk weights.
[3] CET1 capital is a bank's equity capital less immaterial assets such as goodwill and deferred tax assets.
[4] The risk weight functions under the IRB approach produce capital requirements for unexpected losses (see Section 212 in Basel Committee (2006)).

estimate actual risk more accurately than the standardised approach. For both banks and the authorities however, accurately modelling risk is demanding since actual risk is not directly observable. If the different approaches underestimate risk, resulting in risk weights that are too low, the estimated capital adequacy ratio will give the impression that banks' loss-absorbing capacity is better than it actually is.

Corporate exposures account for a little less than one third of Norwegian banks' total loans and slightly more than one third of their total risk-weighted assets. Since the introduction of the Basel II framework, ten of the largest Norwegian banking groups have received supervisory approval to use the IRB approach to calculate risk weights for corporate exposures.[5] At the end of 2015, the IRB approach was used for slightly more than 80 percent of Norwegian banks' total corporate exposures.

Since 2006, IRB banks' average risk weight for corporate exposures has been reduced by half (Chart 2). For smaller banks using the standardised approach, the introduction of Basel II has not resulted in the same decrease in risk weights. Under the standardised approach, corporate exposures without a credit rating and commercial property mortgages are assigned a 100 percent risk weight, as under Basel I.[6] At the end of 2015, the average corporate risk weight for IRB banks was approximately 50 percent, half of the minimum requirement under the standardised approach.

Chart 2 Average risk weight for corporate exposures under Basel I and the IRB approach.[1)]
Weighted average of Norwegian IRB banks. Percent. 2006–2015



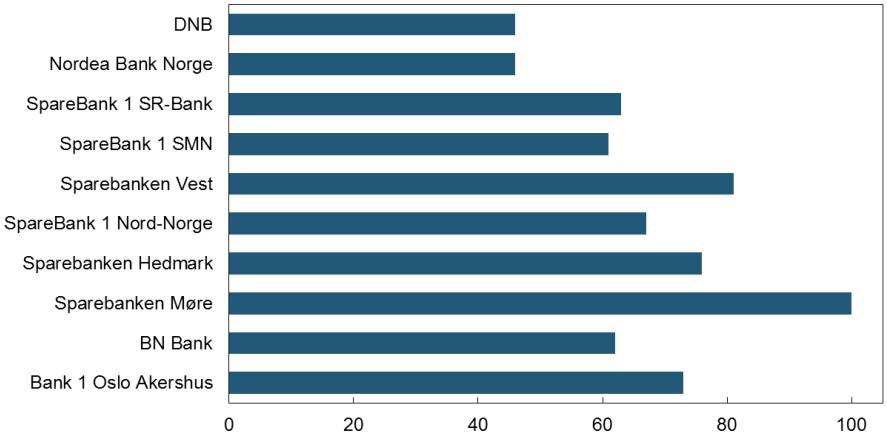
1) The transitional rule from Basel I has not been taken into account.
Source: Banking groups' Pillar 3 reports

Nevertheless, risk weights cannot be assessed without taking account of Basel I transitional rules, which for the time being limit the effect of lower risk weights for IRB banks. Banks bound by the transitional floor use, in reality, a risk weight of about 80 percent for new corporate exposures.[7] The largest banks must therefore hold more equity capital for their corporate exposures than indicated by their IRB models.

[5] DNB, Nordea Bank Norge, SpareBank 1 SR-Bank, SpareBank 1 SMN, Sparebanken Vest, SpareBank 1 Nord-Norge, Sparebanken Hedmark, Sparebanken Møre, BN Bank and Bank 1 Oslo Akershus.
[6] Under the standardised approach, enterprises rated investment grade are assigned a risk weight below 100 percent (see Finanstilsynet (2016b)). Since standardised-approach banks' lending to credit-rated enterprises is limited, the average risk weight for corporate exposures is considered to be 100 percent.
[7] The transitional floor implies that total risk-weighted assets for IRB banks must be at least 80 percent of what they would have been under Basel I. Eighty percent of the Basel I risk weight of 100 percent gives a risk weight of 80 percent.

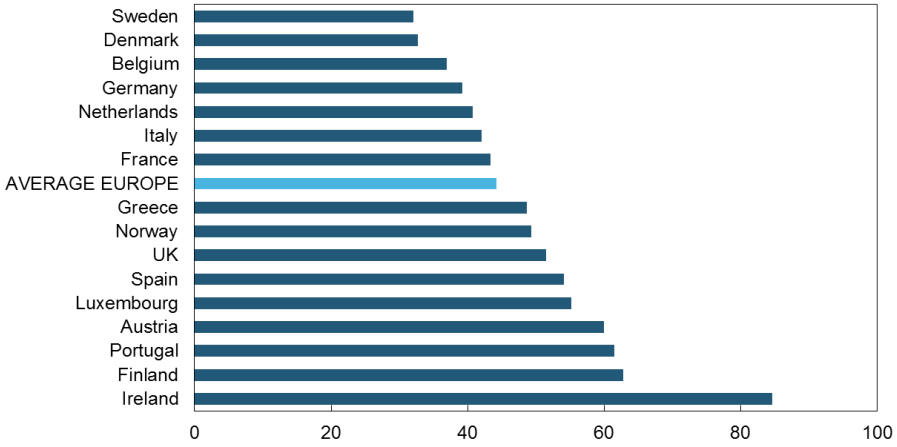
Chart 3 shows that the risk weights used by Norwegian IRB banks to calculate capital requirements for corporate exposures vary substantially from bank to bank. Chart 4 shows that corporate risk weights also vary substantially across countries. Compared with the largest banks in Sweden, the largest banks in Ireland must on average hold more than 2.5 times as much equity capital against each krone in corporate loans.

Chart 3 Average risk weight for corporate exposures under the IRB approach.[1)]
Norwegian IRB banks. Percent. At end-2015



1) The transitional rule under Basel I has not been taken into account.
Source: Banking groups' Pillar 3 reports

Chart 4 Average risk weight for corporate exposures under the IRB approach.[1)]
Weighted average of a sample of selected large European banks.[2)] Percent. At end-2016 Q2



1) Neither the transitional rule under Basel I nor differences in the practical implementation of Pillar 2 requirements across countries have been taken into account.
2) The sample comprises the 71 banks and 16 countries that reported to the European Banking Authority in its 2016 EU-wide transparency exercise (see EBA (2016)).
Source: European Banking Authority (EBA).

A large part of risk weight variability probably reflects real differences in the risk associated with corporate loans. Corporate loans are heterogeneous products. Credit risk on corporate loans can vary considerably, both across industries and across borrowers in the same industry. Banks' exposure to different industries and borrowers also varies. In addition, differences in regulatory frameworks, tax systems, economic policy and bankruptcy legislation create differences in credit risk across countries. Hence, risk weights naturally vary across banks and banking systems. The Basel Committee conducted an analysis of the risk weights of over 100 banks in

2013 (see Basel Committee (2013)). According to the analysis, up to three quarters of the variation in risk weights across banks was attributable to differences in underlying risk.

Risk weights can also vary owing to differences in the risk weights generated by banks' risk models for comparable assets. The Basel Committee explained the remaining quarter of the variation in its analysis by the varying practices and different approaches used by banks and authorities. Reports from the European Banking Authority (EBA) also show that the IRB approaches of a sample of large banks can produce very different risk weights for the same exposure.[8] An important source of differences in IRB risk weights is that the time series used in risk calculations vary in length. The reason may be that data from further back in time are unavailable or deemed to be insufficiently representative of the current risk picture. Risk weights are substantially lower if the time series used do not contain data from downturns (see Andersen (2010)).

Another explanation for the wide variation in corporate risk weights may be that banks apply different IRB approaches. Two of the Norwegian IRB banks calculate corporate risk weights using the foundation IRB approach, while the other IRB banks in Norway use the advanced IRB approach for parts of or their entire corporate lending portfolio. Under the advanced IRB approach, banks apply more bank-specific data to calculate risk weights than under the foundation IRB approach (see Part 2). The advanced IRB approach produces consistently lower risk weights than the foundation IRB approach. According to Finanstilsynet (2016a), the decline in large banks' corporate risk weights in recent years is related to the approval received by these banks to use the advanced IRB approach for a growing share of their corporate exposures. All the IRB banks in the Sparebank 1 Alliance use the advanced IRB approach and the same IRB models, and there is less variation in risk weights across these banks.

The decrease in risk weights since 2006 and the wide differences in risk weights both within and across national borders have prompted the authorities and market participants to question whether risk weights reflect actual credit risk. In recent years, the Basel Committee has published proposed revisions to the regulatory framework for both the IRB and standardised approaches (see Basel Committee 2015 and 2016a)). The aim of the revisions is to reduce the complexity of the IRB approach, improve the comparability of capital ratios and reduce the excessive variation in capital requirements resulting from the different approaches to calculating risk weights. The revisions to the standardised approach are intended to make capital requirements for banks using the standardised approach more risk-sensitive. The Basel Committee also proposes to replace the transitional rule for IRB models, which is currently based on Basel I, with rules based on the new standardised approach.

The aim of this paper is to estimate average risk weights for exposures to Norwegian enterprises where banks' risk associated with these loans is measured using 30 years of historical loss data and corporate data for Norway. We estimate risk weights for exposures to eight different industries. The results are compared with estimates based on a stress test and other points of reference.

[8] According to the EBA (2013 a, 2013b, 2013c and 2015) and the Basel Committee (2013 and 2016b), banks often use different margins of conservatism in calculating risk parameters, different data series lengths, different definitions of default and different assumptions regarding loan recovery. Methods also vary with regard to the calculation of risk estimates to reflect an entire business cycle (PD) or a downturn (LGD). The practical implementation of Pillar 2 requirements, under which supervisory authorities can impose extra capital requirements on banks if risk weights do not adequately reflect actual risk, also varies across supervisory authorities.

Section 2 discusses those parts of the capital framework that are relevant to the analysis in this paper. Section 3 presents the dataset we use. Section 4 describes developments in corporate loan losses in Norway over the past 30 years, and Section 5 presents the method we use to estimate corporate risk weights. Section 6 describes corporate risk weight estimates based on long time series for bank losses and key figures for Norwegian enterprises. The paper concludes with a comparison of our estimated corporate risk weights with corporate risk weights that are based on a stress test and other points of reference.

2. Capital framework

The capital framework allows banks to use three different approaches for calculating capital requirements for credit risk: the standardised approach, the foundation IRB approach and the advanced IRB approach (see Ministry of Finance (2006)). The capital requirement is calculated by risk-weighting banks' exposures. Under the IRB approach, bank portfolio exposures are divided into seven segments:

- *Corporate*
- *Retail*
- *Sovereign*
- *Institutional*
- *Equity*
- *Securitisation*
- *Other assets without credit risk*

Corporate exposures can be included in the *Corporate* and *Retail* segments. Enterprises with an annual turnover of less than EUR 50m are classified as *small- and medium-sized enterprises* (SMEs). SMEs will normally be included in the *Corporate* segment, but if a bank's total exposure to an enterprise is less than EUR 1m, it may be included in the *Retail* segment. Other non-SME corporate exposures are included in the *Corporate* segment. With the exception of exposures classified under *Retail*, risk weights are calculated for each exposure in the different segments.

IRB banks must use a specific formula (the Basel formula) to calculate risk weights on the basis of historical default and loss rates (see Appendix 1). This formula is a function of several risk parameters:

- exposure at default (**EAD**), which is an estimate of a bank's exposure in the event of default at a future point in time
- probability of default (**PD**), which is an estimate of the probability that an exposure will default in the coming year
- loss given default (**LGD**), which is a loss estimate for an exposure in the event of default
- maturity (**M**), which is an estimate of an exposure's residual maturity
- correlation (**R**) between exposures and a factor for systemic risk, in order to take account of correlation between risk in banks' portfolios and the situation in the wider economy

Banks using the foundation IRB approach must calculate their own estimates of PD and R, while banks using the advanced IRB approach must also estimate EAD, LGD and M.[9] Estimates are to be based on historical experience. Since risk weights are intended to reflect the risk of unexpected losses, a deduction is made in the Basel formula for expected losses.

The EU framework contains a number of guidelines on how banks should estimate the various parameters in the Basel formula. PD and LGD estimates are to be based on a historical observation period of at least five years. Banks with access to longer time series are to use all relevant data. In Norway, risk calculations are required to be based on data that include the banking crisis of the early 1990s.[10] According to the EU Capital Requirements Regulation (CRR), the most recent data may be given more weight than historical data if the former is assessed to be "a better predictor of loss rates".[11] Banks must increase PD and LGD estimates by a margin of conservatism. The margin of conservatism must reflect the expected range of estimation errors and must be larger if the data set and estimation methods are not satisfactory. For *Retail* and *Corporate* exposures, PD may never be set below 0.03 percent. Banks must use LGD estimates that are appropriate for an economic downturn, if these estimates are more conservative than the average for the entire observation period. The annual default rate must be used to weight the LGD average for the observation period. Thus, years with a high default rate are given more weight in the calculation than years with a low default rate.

3. Data

Our calculations of corporate risk weights are based on several data sources. The ORBOF banking statistics[12] contain data on banks' total corporate exposures and loan losses back to 1987, while Norges Bank's historical monetary statistics[13] contain pre-1987 lending data. The banking statistics also contain data on banks' losses by industry back to 1997. Loss rates by industry (losses as a share of loans or total losses) and lending ratios (lending to a given industry as a share of total lending) back to 1986 were published in several issues of Norges Bank's series *Economic Bulletin (PEK)* and in Official Norwegian Report (NOU) 1992:30. Data on banks' risk weights and risk parameters are taken from banks' Pillar 3 reports. Finanstilsynet's corporate data from the Brønnøysund Register[14] contains company accounts for all Norwegian limited companies with bank debt in the period 1988-2015. At the end of 2015, total bank debt for these enterprises accounted for around 93 percent of total lending by Norwegian banks and mortgage companies to Norwegian enterprises.

[9] Under the foundation IRB approach, LGD is as a rule set at 45 percent and M at 2.5 years.
[10] Calculation of the long-term average estimate for PD and the lower floor of the LGD must include the banking crisis years.
[11] The CRR will be incorporated into Norwegian legislation under the EEA Agreement.
[12] See banks' and financial undertakings' financial reporting to the Norwegian authorities (Offentlig regnskapsrapportering for banker og finansieringsforetak (ORBOF)): *https://www.ssb.no/innrapportering/naeringsliv/orbof*. (Norwegian only)
[13] See historical monetary statistics for Norway: http://www.norges-bank.no/en/Statistics/Historical-monetary-statistics/.
[14] Compiled by Bisnode.

Chart 5 Grouping of industrial classes in bank lending and loan loss data. 1986–2015

1986–1995	1996	1997–2008	2009–
Primary industries	Primary industries	Agriculture, forestry and fishing Of which: Operation of fish hatcheries, fish farms	Agriculture, forestry and fishing Of which: Operation of fish hatcheries, fish farms
Petroleum	Petroleum 1)	Extraction of crude petroleum and natural gas	Extraction of crude petroleum and natural gas
Mining and exposed sector manufacturing Sheltered sector manufacturing	Manufacturing and mining	Manufacturing and mining	Manufacturing and mining Of which: Manufacturing Of which: Ship and boat building
Construction, electricity and water supply	Construction, electricity and water supply	Electricity and water supply, construction Of which: Building and civil engineering	Electricity and water supply, construction Of which: Building and civil engineering
Wholesale and retail trade Hotels and restaurants	Retail trade, hotels and restaurants	Retail trade, hotels and restaurants Of which: Wholesale and retail trade Of which: Retail trade Of which: Hotels and restaurants	Retail trade etc accommodation and food service activities Of which: Retail trade and repair of motor vehicles Of which: accommodation and food service activities
Shipping, oil drilling	Shipping and pipeline transport 1)	Shipping and pipeline transport Shipping	Shipping and pipeline transport
Services	Property management services	Commercial services and property management Of which: Property management	Commercial services and property management Of which: Property management Of which: Professional, financial and commercial services
Transport, postal, social and personal services	Other transport, postal services and telecommunications 2) Service activities	Other transport and communications Other service industries	Other transport and communications Other service industries

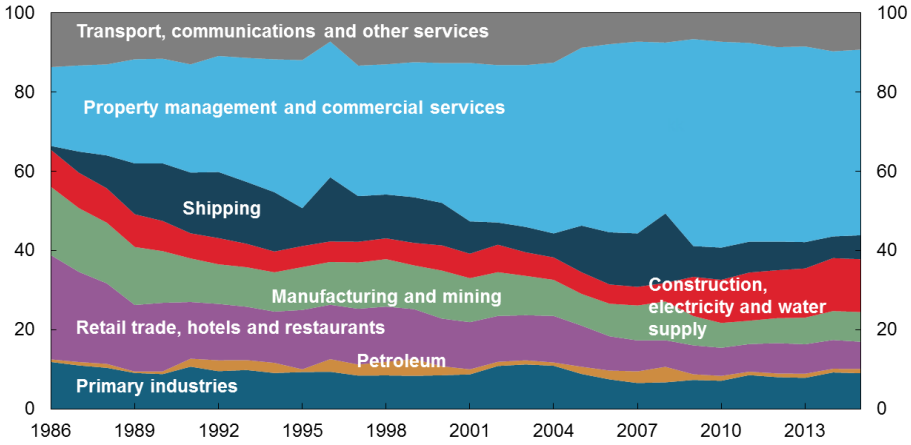
1) Due to changes in industry codes, the petroleum, shipping and pipeline transport industries are treated as one group.
2) Up to end-1995, this industry code also included personal and social services.
Source: Norges Bank

We use several different data sources to construct time series for banks' loan losses by industry back to 1986 (see Appendix 2 for a description of how the time series for loss rates by industry are calculated). On the basis of the different data sources, we calculate loss rates for eight industrial classes:

- Primary
- Petroleum
- Manufacturing and mining
- Construction, electricity and water supply
- Retail trade, hotels and restaurants
- Shipping
- Property management and commercial services
- Transport, communications and other services

The number of industrial classes in our dataset is limited because of changes in industrial classification in recent decades (Chart 5). As some industrial classes were eliminated in 1996 and the content of some classes has changed over time, we have merged certain service industry classes.

Chart 6 Bank[1)] lending shares. Lending to various industrial classes in Norway as a percentage of total corporate lending in Norway. 1986-2015



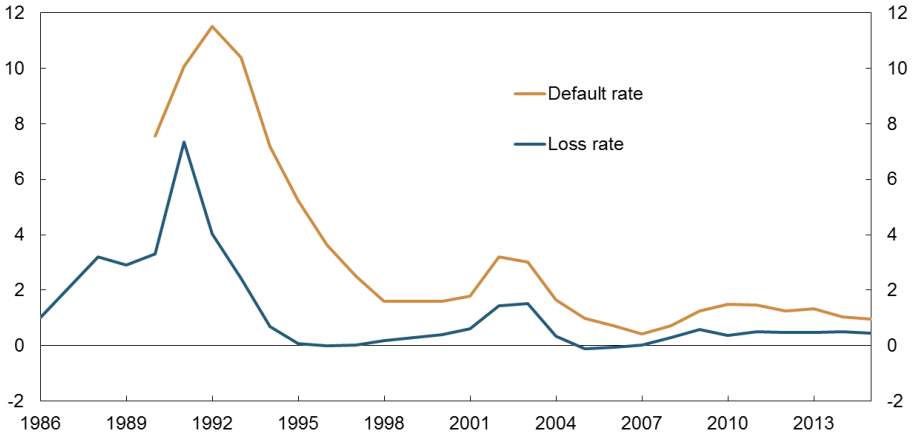
1) All banks in Norway as from 1996. Pre-1996 lending shares are calculated based on data from the largest banks. Due to insufficient data, lending shares for 1987 are calculated as an average of the shares for 1986 and 1988.
Source: Norges Bank

Linking the data series, we find relatively stable developments in banks' shares of lending to the eight industrial classes (Chart 6). Some lending shares show substantial change in certain periods, especially around the financial crisis. This can be attributed to a number of factors. Bank lending to some industries, such as shipping, tends to increase considerably in good times, while in bad times, lending is reduced to the industries with the highest probability of default. Substantial volatility in exchange rates may also have changed the NOK value of Norwegian enterprises' foreign currency loans during the financial crisis. Bank reorganisations may also have resulted in changes in the proportion of lending classified as foreign lending. Our dataset is limited to lending in Norway. A fourth explanation may be that borrowers are not classified in the same industrial classes throughout the time period. Even though we have merged some service industry classes, there may still be groups of borrowers that are not classified in the same class for the entire period. Some industry codes were changed in 1996, especially for petroleum, shipping and pipeline transport. Industry codes were also changed somewhat in 2009, which also led to the reclassification of some non-financial enterprises as financial enterprises. Bank lending to the construction, electricity, gas and water supply industrial class almost doubled in 2009, probably reflecting the inclusion of loans for building project development in this class from 2009. Before 2009, these loans were classified under service industries.

4. Banks' losses on loans to the corporate market

Chart 7 shows banks' overall loan loss and default rates in the corporate market. Both loss and default rates increased sharply when the banking crisis erupted in 1988. The loss rate for loans to the corporate market increased from 2.1 percent in 1987 to 7.3 percent in 1991, falling thereafter to 2.4 percent in 1993. The default rate also increased considerably in the period between 1990 and 1993. The three largest commercial banks (Fokus Bank, Christiania Bank og Kreditkasse and Den Norske Bank) were forced to apply for government capital injections in 1991 (see Moe et al. (2004)). To assess their need for capital, the three banks had to conduct a thorough review of their lending portfolios. The review contributed directly to the recognition of substantial losses by the three banks (see NOU (1992)). Our calculations show that these commercial banks had an overall loss rate for loans to the corporate market of 9.7 percent in 1991.

Chart 7 Banks'[1] losses[2] and defaults on corporate exposures as a share of gross loans to the corporate market. Percent. 1986–2015[3]



1) All banks in Norway as from 1996. Pre-1996 loss rates are calculated based on data from the largest banks.
2) Recognised losses, excluding changes in collective impairment losses/unspecified loss provisions.
3) Default figures back to the end of the second half of 1990. Average for the second half of 1990.
Sources: NOU 1992:30 and Norges Bank

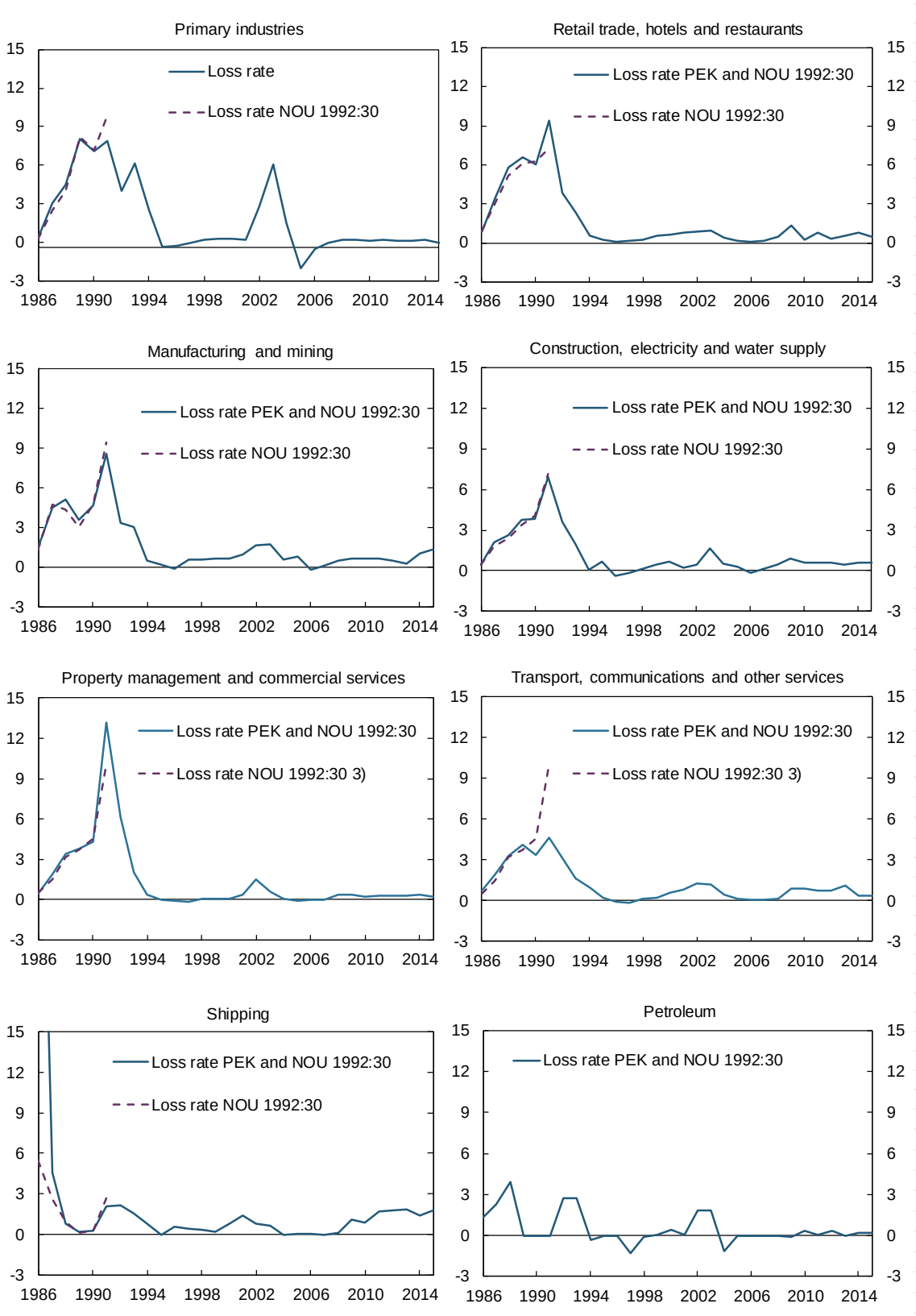
Following the banking crisis, the loss rate for loans to the corporate market fell to very low levels. In 1996, the reversal of previously recognised losses resulted in a negative loss rate. The loss rate rose to 1.5 percent during the 2002-2003 downturn, falling again thereafter until the onset of the financial crisis. In the years following the financial crisis, the loss rate was approximately 0.5 percent.

Chart 8 shows loss rates for the eight industrial classes in the period 1986-2015. Over the three decades, the classes that have accounted for the highest loss rates have varied considerably. Loss rates increased sharply in all eight classes during the banking crisis, but particularly in property management. Rapid output growth and an ample supply of credit resulted in substantial commercial property investment before the banking crisis (see NOU (1992) and Kragh-Sørensen and Solheim (2014)). Building completions peaked in 1988 as the economy began to turn down and the number of corporate bankruptcies increased. This resulted in a considerable rise in commercial property vacancy rates. Banks' collateral values quickly fell below loan values. Banks were also left with a large stock of real estate on their own balance sheets as customers became unable to service their loans, and in 1991 several large commercial banks had to write down the value of these assets.

Losses on loans to primary industries also increased considerably during the financial crisis, primarily as a result of severe problems in the fish farming industry (see NOU, 1992). Fish farming was a new industry that exhibited strong growth in the 1980s, but overcapacity and trade restrictions contributed to a sharp increase in the number of bankruptcies in the industry during the banking crisis. Overcapacity and declining demand also contributed to large losses on banks' loans to retail trade and the hotel and restaurant industry.

After the banking crisis, loss rates fell across all industrial classes before rising again during the 2002-2003 downturn. With increased losses on loans to fish farming, the loss rate for primary industries rose sharply, to more than 6 percent, while the loss rate for petroleum, shipping, manufacturing and mining, construction, and electricity and water supply remained between 1.5 percent and 2 percent.

Chart 8 Banks'[1] losses[2] on loans as a share of total loans to the different industrial classes in Norway. Percent. 1986–2015



1) All banks in Norway as from 1996. Pre-1996 losses are calculated based on data for the largest banks.
2) Recognised losses, excluding changes in collective impairment losses/unspecified loss provisions. Due to insufficient data on lending by industry in 1987, loss rates for 1987 are weighted by average lending by industry in 1986 and 1988.
3) Loss rates in NOU 1992:30 refer to property management and all other services.
Sources: NOU 1992:30 and Norges Bank

Loss rates also increased during the financial crisis, but by less than in 2002-2003 and during the banking crisis. Loss rates during the financial crisis were highest in shipping, retail trade, and the hotel and restaurant industry. The loss rate on loans to shipping has in recent years remained at approximately the same level as during the financial crisis, while the loss rate for the manufacturing and mining class has increased slightly since the financial crisis.

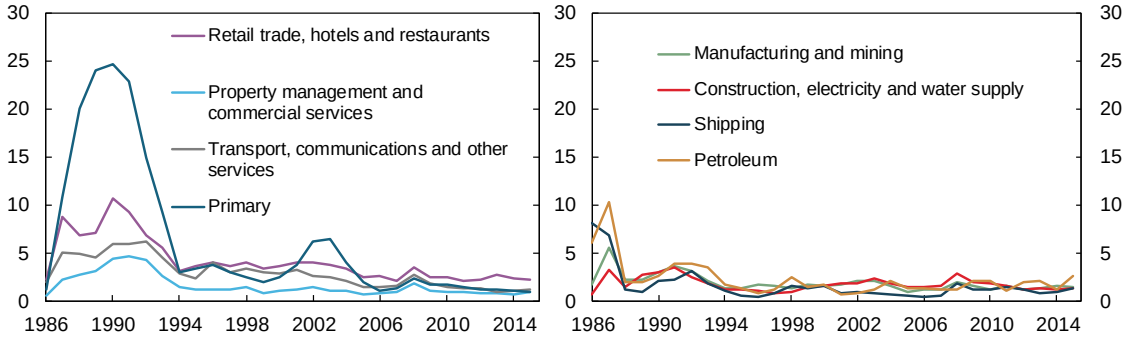
5.1 Method

We employ the advanced IRB approach to calculate risk weights for the eight industrial classes and for Norwegian corporate exposures as a whole. The risk weights thus depend on both the characteristics of the Basel formula and the estimated risk parameters used in the formula.

We apply our own estimates for probability of default (PD) and loss given default (LGD), IRB banks' maturity (M) estimates and the same assumptions regarding correlation (R) and maturity adjustment (b) as in the Capital Requirements Regulation (see Appendix 1). There are a few differences between our method and the method used by IRB banks. We use aggregated time series for the banking sector as a whole, which gives us a longer and wider perspective on bank losses. Banks' data series are generally shorter than our data series.[15] However, our aggregated series provide less information about individual loans. Banks estimate risk parameters based on internal default and loss data for each individual loan. Banks' data series enable them to observe the LGD for each individual loan directly, while our LGDs must be derived from the aggregated figures.

We use Finanstilsynet's and Norges Bank's bankruptcy probability model for Norwegian enterprises (the SEBRA model) to estimate PDs.[16] The SEBRA model applies key figures from an enterprise's accounts (such as earnings, liquidity and solvency) and other data about the enterprise (such as industry, size and age) to estimate the probability of bankruptcy. Bernhardsen and Syversten (2009) find that the probability of default is approximately twice as high as the probability of bankruptcy. On this basis we can derive PDs from bankruptcy probabilities. PDs for each industry are calculated by weighting the PD for individual enterprises in the industry by their debt (Chart 9).

Chart 9 PDs for corporate exposures calculated using the SEBRA model. Percent. 1986[1)]–2015



1) PDs for 1986 and 1987 are estimated using the average ratio between estimated PDs in the corporate sector model and corresponding loss rates for the period between 1988 and 2015.
Sources: Finanstilsynet and Norges Bank

[15] Finanstilsynet requires banks to calibrate IRB models using data from the banking crisis at the beginning of the 1990s. Not all banks report the length of the data series they use to estimate risk parameters. Banks in the SpareBank 1 Alliance estimate PD, LGD and EAD using data for the period 1994-2012 (see SpareBank 1 SR-Bank (2016)). DNB reports that their IRB models are calibrated using data for the period 1988-1993 (see DNB (2016)).

[16] For a more detailed description of the SEBRA model, see Bernhardsen and Larsen (2007).

The SEBRA model has over time proved to be a reliable and stable predictor of Norwegian corporate bankruptcies. PDs estimated by the SEBRA model also correlate closely with bankruptcy probabilities estimated by a new corporate sector model used by Norges Bank for the period between 1999 and 2016 (Hjelseth and Raknerud (2016)).[17] In addition, the SEBRA model estimates bankruptcy probabilities back to 1988. This supports the use of bankruptcy probabilities estimated by the SEBRA model in our calculations. To fully make use of our loss rate data set, we apply the average ratio between PDs estimated by the SEBRA model and corresponding loss rates for the period between 1988 and 2015 to estimate PDs for the years 1986 and 1987.

Our estimated risk weights are to a great extent based on data for banks' loss rates back to 1986. As we do not have loss given default (LGD) data for corporate exposures, we derive LGD from other data series. The expected loss rate for an exposure can be expressed as the product of PD and LGD:

$$(1)\ Expected\ loss\ rate = PD * LGD$$

It follows from (1) that LGD can be approximated by dividing the loss rate by PD. Approximated LGD thus corresponds to recognised losses as a share of expected defaults:

$$(2)\ LGD \approx \frac{Loss\ rate}{PD} = \frac{\left(\frac{Losses}{Lending}\right)}{PD} = \frac{Losses}{PD * Lending} = \frac{Losses}{Expected\ default}$$

We have data for the loss rate that correspond to the product of PD and LGD, and we therefore approximate the LGDs by dividing the loss rates by our estimated PDs.[18] In addition, we assume that LGDs cannot be lower than 0 percent or higher than 100 percent.

As our method is to a great extent based on loss rates, the results are somewhat more robust to errors in PD and LGD estimates. Since the loss rate is known and LGD is approximated on the basis of the loss rate and PD, an overestimation of PD will result in an underestimation of LGD and vice versa. For example, PDs that are reduced by half will result in LGDs that are twice as high. Furthermore, the Basel formula has been designed so that risk weights increase linearly with increases in LGD, while the relationship is concave for increases in PD. (Charts A1 and A2 in Appendix 1). As a result of these characteristics, together with the method for calculating LGD, an underestimation of PD will as a rule produce a somewhat higher risk weight, and vice versa.

We calculate PDs for a total of 24 risk groups. The dataset enables us to estimate PDs for three of the segments within the eight industrial classes: *Corporate*, *SME* and *Retail*.[19] Our loss rate dataset also enables us to calculate LGDs for the eight industrial classes, but we do not have the data needed to estimate LGDs for each of the three segments. We therefore assume LGDs to be the same for the three segments in each of the eight industrial classes.

[17] The SEBRA model PDs are generally higher than the PDs from the new corporate sector model, probably because the new model is estimated over a period that does not include the banking crisis.

[18] According to Article 181 (180) of the CRR, LGD estimates (PD estimates) for retail exposures can be derived from estimates of total losses and appropriate estimates of PDs (LGD estimates).

[19] Here, the segment referred to as *Corporate* in Section 2 is divided into *SMEs* and other enterprises. Other enterprises are referred to as *Corporate* in the remaining text. The *Retail* segment includes SMEs that can be categorised as retail exposures according to the criterion in Section 2.

According to the CRR, PDs and LGDs must be estimated on the basis of a minimum data observation period of five years, but banks are required to use longer observation periods if relevant data is available. We therefore estimate risk weights using average PDs for the entire observation period, ie 1986-2015. According to the CRR, LGD estimates must be appropriate for a downturn. We apply average LGDs for the banking crisis (1988-1993), the 2002-2003 downturn and the financial crisis (2008-2009) in our estimations. The debt ratio for corporate exposures may have changed over the period for which we have loss data. This suggests that LGD estimates should build on data from several downturns. The estimates are also more robust when they are based on a longer time series.

Banks utilising the advanced IRB approach are required to use contractual future payments when measuring the effective maturity (M) of their exposures. M must be no longer than five years and, with the exception of certain short-term exposures, no shorter than one year. Since we do not have data on banks' contractual future payments, we apply the M of IRB banks at end-2015.[20]

We estimate R and b using the CRR formulas (see Appendix 1). In the formulas, R and b only depend on estimated PDs. Different assumptions about R and b can have a considerable impact on risk weight estimates, but this is beyond the scope of this paper, which only estimates average corporate risk weights based on current capital requirement regulations.

5.2 Methodological challenges

This section presents a discussion of factors that could result in risk weight estimates that are too high when our method is used. However, it is worthwhile noting that there are other factors indicating that risk weights estimated using our method are too low. The estimated risk weights would have been higher if we had used loss rates that included collective impairment losses and unspecified loss provisions. In the period 1987–2016, collective impairment losses and unspecified loss provisions accounted for 11 percent of total loan losses in the banking sector. In addition, some of the loss rates reported in Official Norwegian Report (NOU) 1992:30 are higher than the loss rates used in our calculations (Chart 8). Thus, the use of the loss rates in NOU 1992:30 would have resulted in higher risk weights for some industries compared with our estimates. In addition, the CRR requires banks to increase PD and LGD estimates by a margin of conservatism, which will push up risk weights. Our estimates do not include this.

5.2.1 Use of average risk parameters

We estimate average risk weights using average risk parameters in the Basel formula, while banks normally calculate risk weights for each exposure. As we apply average risk parameters for groups of borrowers, our method may overestimate risk weights. This primarily reflects the design of the Basel formula, whereby the risk weight increases concavely with increases in PD, ie that a given increase in an exposure's PD does not result in the same percentage increase in the exposure's risk weight. Thus, the average risk weight calculated by banks by weighting together the risk weights for each exposure will be lower than an average risk weight calculated using average risk parameters in the Basel formula.[21] Our method's overestimation of risk

[20] Not all IRB banks include M for corporate exposures in their reports.

[21] According to the Basel Committee, banks must calculate capital requirements for retail exposures based on average risk parameters for groups of borrowers (see paragraph 232 in Basel Committee (2006)). In our data set, nine percent of corporate exposures are classified as *Retail*, while exposures to the *Corporate* and *SME* segments account for 22 and 69 percent respectively.

weights could be considerable if there are wide differences between PDs in a segment. This will particularly be the case if the distribution of PDs is skewed, for example if the majority of the exposures have a very low PD. The overestimation is greater when PDs are lower as the relationship between PDs and risk weights is flatter when PDs are higher (Chart A1 in Appendix 2).

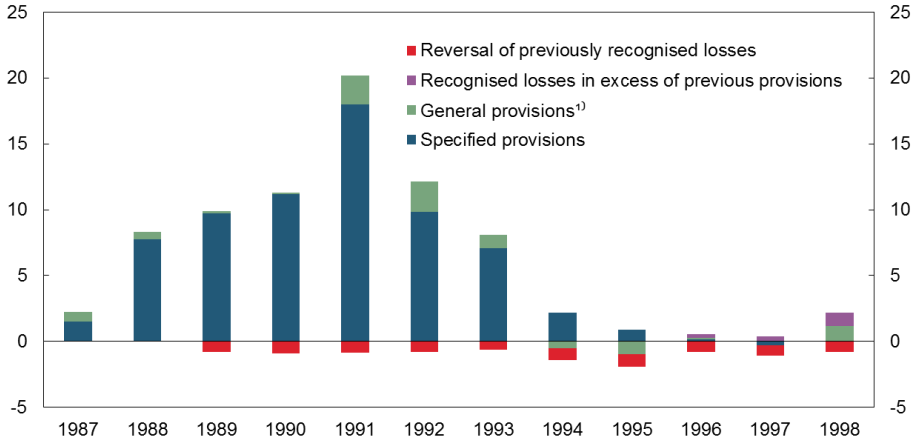
Calculations using IRB banks' average risk parameters indicate that the use of average risk parameters in the Basel formula contributes, in isolation, to an overestimation of IRB banks' risk weights by about 25 percent. To take account of this potential overestimation, the estimated risk weights are revised down by 25 percent in Section 6. The degree of overestimation of risk weights will vary across banks and will not necessarily be the same for IRB banks as for the Norwegian banking sector as a whole. For example, PDs may differ more widely for the banking sector as a whole, which may lead to greater overestimation. At the same time, the PD levels in our analysis are higher than the IRB banks' PD levels. This suggests that the overestimation in our analysis may be smaller than adjusted for here.

The more skewed banks' PD distribution is, the more our method overestimates risk weights. However, very skewed PD distributions do not necessarily reflect the level of underlying credit risk. IRB banks apply logit models to estimate each loan's PD. In a logit model, the relationship between the explanatory variables and the dependent variable (PD) is S-shaped, which often results in a skewed distribution of banks' PDs. Some loans are assigned a very high PD because the explanatory variables have reached a level where PDs increase sharply even with small changes in the explanatory variables. The remaining exposures are often assigned a very low PD. According to King and Zeng (2000), estimations using logit models can to a great extent underestimate the probability of rare events. This will particularly be the case if the dataset is not balanced, ie that the number of events (defaults) is too low compared with the number of non-events (no defaults). The data set can be unbalanced if Norwegian banks have estimated PDs using time series that are too short, particularly if the time series do not contain periods of high default rates on loan types that show very low default rates in normal times. Logit models are probably well-suited to ranking borrowers according to default risk, but their ability to estimate PD levels for performing loans may be more uncertain.

5.2.2 Loss reversals after the banking crisis

Our estimated LGDs do not take account of loss reversals after the banking crisis of 1988–1993 (Chart 10). Although some of the losses recognised during the banking crisis were subsequently reversed, a number of banks were by then already facing a solvency crisis that forced the authorities to recapitalise them. Our calculations are intended to reflect the need for capital that can arise as a result of losses in a downturn. A reasonable prudential requirement would therefore be that a bank's estimated capital requirements should reflect potential loan losses recognised during a banking crisis and not any reversal of losses that might take place after the crisis has passed. In our calculation of risk weights in Section 6, we nonetheless assess the effects of the reversals by including the years 1994–1996 in our calculation of LGDs.

Chart 10 Decomposition of loan losses. In billions of NOK. 1987–1998



1) General loss provisions are not included in our calculations.
Source: Norges Bank

5.2.3 LGDs for defaulted loans

LGD is the estimated share of an exposure that is lost if the borrower defaults. According to EU regulation, LGD estimates should be derived from realised losses.[22] We estimate LGD by dividing recognised losses by expected defaults. Our method may overestimate the average level of LGDs for corporate exposures if LGDs correlated positively with PDs, for example because the value of collateral for defaulted exposures is lower than for other exposures. At the same time, a high positive correlation between PD and LGD will mean that the LGD of an enterprise with a low PD may rise in pace with the PD before the enterprise defaults. The collateral values of enterprises with weak prospects often diminish in the period prior to default. Collateral values in the shipping industry fell sharply during the financial crisis when a higher supply of vessels and lower demand in shipping freight markets resulted in lower freight rates. Similarly, collateral values in the oil service industry have fallen along with the fall in oil prices since autumn 2014.

5.2.4 Changes in accounting rules for recognising bank losses

Bank loan losses in the period 1986–2015 may have been affected by changes in accounting rules (Appendix 3). However, the changes had less effect on the recognition of banks' specified loss provisions that we use in our calculations. Furthermore, the analyses in this article are based on averages over several years, which are affected to a lesser extent by the point in time when banks were obliged to recognise losses. However, accounting rules that result in larger fluctuations in recognised losses can for short periods increase banks' need for capital.

5.2.5 Correlation between PDs and loss rates

The estimated LGD will vary considerably from one year to the next if the loss rate does not moves in tandem with the corresponding PD. In years when PDs are high and loss rates low, estimated LGDs will be low. Similarly, estimated LGDs can be very high in years when PDs have fallen to low levels and loss rates remain high. If the latter occurs frequently, our estimated LGDs can be too high. Our calculations indicate that our LGD estimates are not dominated by these effects.[23] In our dataset, the correlation between PDs and loss rates is very high, and

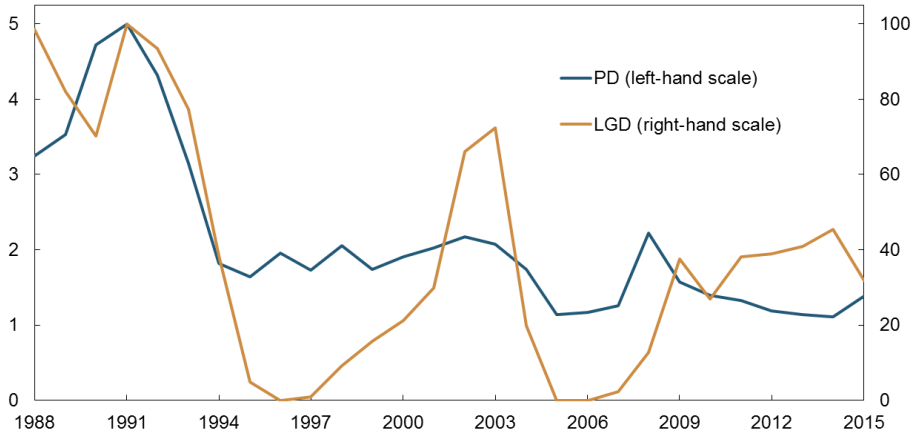
[22] See Article 181 in European Parliament and Council (2013).
[23] We have assessed the importance of such effects in our dataset by, for example, estimating LGDs using average loss rates and PDs. LGDs are then higher than if we estimate annual LGDs using annual loss rates and PDs and then estimate the average of the annual LGDs. This suggests that our estimated LGDs are not dominated by years when loss rates are considerably higher than PDs.

estimated correlations indicate that PDs coincide with loss rates (Table A1 in Appendix 1). Our premise that annual LGDs cannot be higher than 100 percent will at the same time dampen any effects of years when loss rates are higher than PDs. In addition, as our estimated LGDs are based on averages over several years, annual fluctuations in estimated LGDs will be less important.

5.2.6 Changes in corporate credit risk

Our calculations are based on long time series that include events such as the Norwegian banking crisis in its entirety, making the calculations more robust. At the same time, improvements in banks' risk management systems and regulatory and economic policy changes may have reduced credit risk in banks' corporate loan portfolios through the period. In addition, an increasing number of high-risk enterprises have relied on bond market funding over the past ten years, which may have reduced banks' average credit risk. Chart 11 shows that PDs in the SEBRA model and derived LGDs have fallen in recent decades, and calculations based on long time series may then overestimate risk weight levels.

Chart 11 Estimated PDs and LGDs for all corporate loans. Percent. 1988–2015



Sources: Finanstilsynet (Financial Supervisory Authority of Norway) and Norges Bank

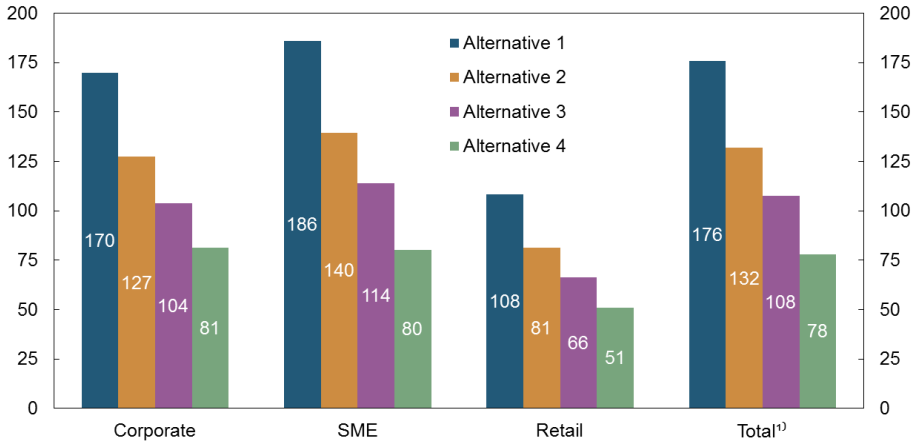
On the other hand, the falling PD and LGD levels in the charts may reflect the Norwegian economy's two golden decades (see Gjedrem, 2010) of solid growth and low losses on corporate loans. Past experience of financial crises shows that imbalances often build up in good times. The structural changes of recent years may also have increased the credit risk on corporate loans (see Section 7). This suggests that long time series that include financial crises should be used. In Section 6, we nonetheless assess the effects of lower credit risk by calculating risk weights that are based on data limited to the period 2001–2015.

6. Calculation of risk weights for corporate exposures based on historical loss figures

Chart 12 below shows our estimated risk weights for an average corporate exposure in the *Corporate*, *Retail* and *Small and Medium-sized Enterprises (SME)* segments. We first calculate risk weights based on loss rates back to 1986 without adjusting for any sources of overestimation (Alternative 1). Then we take account of potential overestimation as a result of using average risk parameters in the Basel formula by revising down all estimated risk weights by 25 percent (Alternative 2). In Alternative 3, we also adjust for any overestimation of LGDs and loss reversals by including the years 1994–1996 in the LGD estimation. In Alternative 4,

we also take account of a possible fall in the credit risk of corporate exposures by calculating risk weights based on data for the period 2001–2015. The risk parameters used in the four alternatives are shown in Table A2 in Appendix 1.

Chart 12 Average risk weight for *Corporate*, *SME*, *Retail* and total corporate sector[1)]. Calculations based on differing assumptions.[2)] Percent



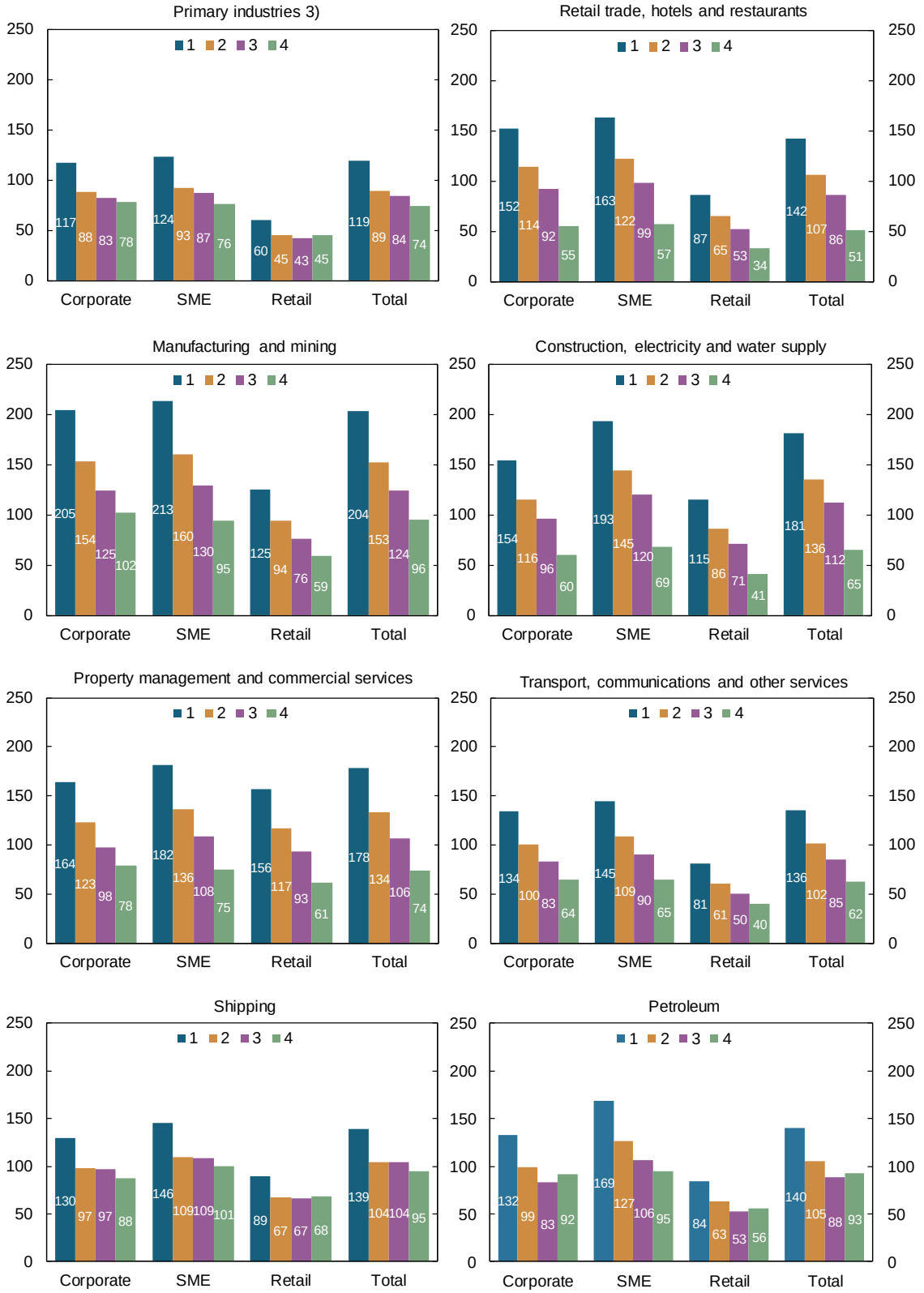
1) Weighted average of *Corporate*, *SME* and *Retail*. The average is weighted by lending figures from the corporate dataset.
2) 1 is unadjusted. 2 is 1 adjusted for possible overestimation resulting from the use of average risk parameters. 3 is 2 except that the LGD estimate is also based on the years 1994–1996 (in addition to 1988–1993, 2002–2003 and 2008–2009). 4 is 3 except that the data used is limited to the period 2001–2015.
Sources: Finanstilsynet (Financial Supervisory Authority of Norway), NOU 1992:30 and Norges Bank

The basic calculation results in an average risk weight of 176 percent for corporate exposures as a whole (Alternative 1). Even when we adjust for several potential sources of overestimation (Alternative 3), the analysis indicates an average corporate weight for the Norwegian banking sector of 108 percent. If we exclude data for the banking crisis of the early 1990s from our calculations (Alternative 4), the estimated average risk weight falls to 78 percent. By comparison, Norwegian banks as a whole have an average corporate weight of below 60 percent.[24]

The estimated risk weights vary across the three segments, with the highest risk weights for the *SME* segment and the lowest for the *Retail* segment. Average PDs are lower for the *Corporate* segment than for the other two segments (Tabell A2 in Appendix 1). In isolation, this pulls down on the risk weight for *Corporate*. On the other hand, the estimated correlation factor and maturity adjustment is higher for *Corporate* than the other two segments, pulling up the risk weight for *Corporate*. The *Retail* segment has the lowest correlation factor. In addition, no maturity adjustment is made in the calculation of risk weights for *Retail*. Owing to this, risk weights for the *Retail* segment are consistently lower than for the two other segments.

[24] Our analysis is based on loss figures for all banks in Norway and accounting figures for all Norwegian limited companies holding bank debt. Reported risk weights for branches of foreign banks in Norway are consistently lower than Norwegian banks' weights. Average reported risk weights for all banks in Norway will thus be lower than the average weight for Norwegian banks of just below 60 percent.

Chart 13 Estimated average risk weight for the *Corporate*, *SME* and *Retail* segments and the corporate sector as a whole[1]. Estimated based on differing assumptions[2]. Percent



1) Weighted average of *Corporate*, *SME* and *Retail*. The average is weighted by lending figures for the corporate dataset.

2) 1 is unadjusted. 2 is 1 adjusted for possible measurement errors resulting from the use of average risk parameters. 3 is 2 except that the LGD estimate is also based on the years 1994–1996 (in addition to 1988–1993, 2002–2003 and 2008–2009). 4 is 3 except that the data used is limited to the period 2001–2015.

3) The *Corporate* segment of our dataset does not include primary industry enterprises in the period 1989–1993. We use average ratios between *Corporate* PDs in primary industries and total PDs in primary industries for the years 1988 and 1994–2015 to estimate PDs for the years 1989–1993.

Sources: Finanstilsynet (Financial Supervisory Authority of Norway), NOU 1992:30 and Norges Bank

Chart 13 shows our estimated risk weights for an average exposure in the eight industrial classes, as distributed across the *Corporate, Retail* and *SME* segments. Risk weights are again highest for Alternative 1 and lowest for Alternative 4, except in the oil sector, where risk weights are somewhat higher under Alternative 4 than under Alternative 3. With the decline in oil prices since 2014, losses on exposures to the oil service industry have increased. Since Alternative 4 is only based on data for the period 2001–2015, the increased losses of recent years in oil-related industries result in higher weights under Alternative 4. For the segments as a whole, the estimated risk weights vary between 84 percent and 124 percent under Alternative 3.

Risk weights by industry are only reported by DNB and Sparebanken Vest. All our calculation alternatives result in higher risk weights for the eight industrial classes than reported by DNB and Sparebanken Vest. The risk weights by industry reported by Sparebanken Vest are about twice as high as the corresponding weights reported by DNB, reflecting the advanced IRB approach used by DNB, while Sparebanken Vest still uses the foundation IRB approach.

Our analysis deals with the Norwegian banking sector as a whole, not with individual banks. Our data does not allow us to distinguish between the various banks' exposures by quality. Some banks have borrowers with lower credit risk, for example because of higher risk aversion or better risk management than other banks. Risk weights for these banks may be lower than our estimated risk weights for an average exposure in the different industrial classes. Similarly, other banks' risk weights may be higher.

7. Calculation of risk weights for corporate exposures based on Norges Bank's stress test

The calculations of risk weights in Section 6 are based on historical data. Historical data do not necessarily reflect the risk associated with banks' corporate exposures today. Banks' customer base may have changed considerably. New borrowers may have a different risk profile, and the credit risk associated with existing borrowers may also have changed. The Norwegian economy has undergone substantial structural changes in the past few decades. A falling interest rate level and rising oil prices contributed to solid growth in the Norwegian economy and low losses on exposures to the corporate sector in the period to 2014. With the decline in oil prices since 2014, losses have increased on exposures to the oil service sector, a sector where loss levels were previously very low (Chart 8). The structural changes may also generate spillovers to other industries.

Stress tests can often, in a different way from historical data, shed light on vulnerabilities facing banks today. Stress tests are often used to estimate banks' vulnerability to shocks that have a low probability of occurrence, but potentially serious consequences. Norges Bank's stress tests are based on vulnerabilities in today's financial system that could lead to substantial bank losses should the economy be exposed to negative shocks. Stress tests can therefore be a useful tool for assessing banks' risk associated with corporate exposures today. In this section, we use the Basel formula to calculate corporate weights using risk parameters based on the stress test Norges Bank conducted in 2016 (see Norges Bank (2016)).

The 2016 stress test was based on past experience of financial crises in Norway and other OECD countries, where the results of the stress test depend on the level of financial imbalances. The gap between total credit relative to GDP and an estimated trend, the so-called credit gap, was used as a measure of financial imbalances. The 2016 stress test assessed the effect of two

stress scenarios. Stress scenario 1 was based on the credit gap in 2016. Stress scenario 2 was based on the average credit gap for the past ten years, which produced more severe results than in stress scenario 1. We use stress scenario 1 in our calculations. The calculations will then be based on more information about the risk associated with today's corporate exposures than historical loss data.

In stress scenario 1, mainland GDP falls by 1.4 percent in 2017 and by a further 0.6 percent in 2018. Unemployment increases to over 6 percent, and house prices fall by just below 20 percent. Household credit growth slows markedly and becomes negative in 2018. There is also a substantial fall in credit to non-financial enterprises. With lower household demand, more enterprises encounter debt-servicing problems, and banks' loss rates on corporate exposures increase to more than 4 percent in 2018 and 2019.

We calculate risk weights for corporate exposures as a whole using an LGD of 40 percent. In the 2016 stress test, banks' loan losses were calculated directly from economic variables without assumptions about shares of problem loans or LGDs. LGDs are therefore not available. In the 2015 stress test, an LGD of 40 percent was used (see Norges Bank (2015)). This is in line with the derived LGD for the periods 2002–2003 and 2008–2009.

We derive PDs for the four stress test years by dividing the stress test loss rate by the LGD of 40 percent. Since PDs should be calculated over a period that ideally includes one business cycle, we calculate risk weights using an average of the annual PDs from the SEBRA model for the period 2006–2015 and the derived PDs for the four stress test years.

With these assumptions for PDs and LGDs, our calculations result in a risk weight for corporate exposures as a whole of 112 percent without adjusting for any overestimation (Alternative 1) and a risk weight of 84 percent when the potential overestimation resulting from the use of average risk parameters in the Basel formula is taken into account (Alternative 2).[25] This is at the lower end of the risk weights calculated based on historical data in Section 6.

8. Other reference points

In this section, we compare the estimated risk weights with banks' risk weights in other countries and risk weights used by the credit rating agency Standard & Poor's (S&P) for Norwegian banks (Chart 14).

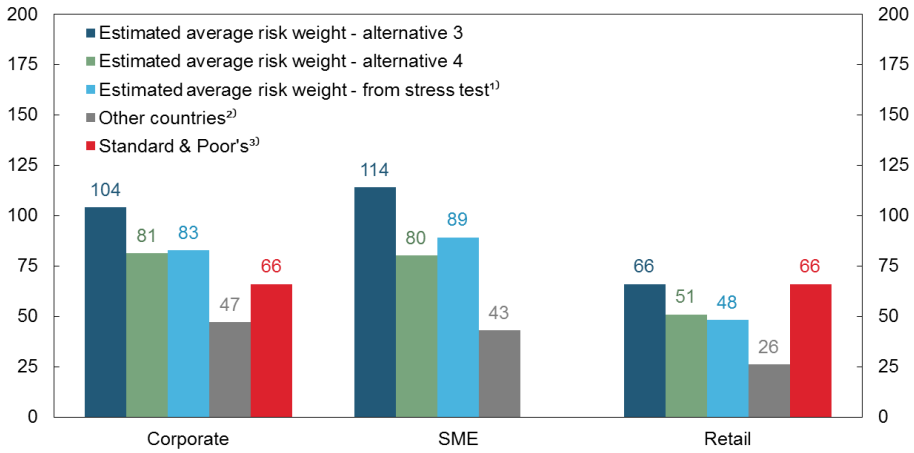
In a number of other countries, average risk weights for corporate exposures are considerably lower than the level indicated by our calculations (Chart 4). For a sample of 71 large European banks, the average risk weight for corporate exposures as a whole is 44 percent. This is lower than both our estimated risk weights and the average for the Norwegian banking sector, but only slightly below the level for the largest Norwegian IRB banks.

It is also useful to compare the estimated risk weights with the market's assessment of risk. Standard & Poor's has developed its own risk-adjusted measure of banks' capital adequacy – Standard & Poor's risk-adjusted capital (RAC) ratio (see Standard & Poor's (2016)). The aim of the RAC ratio is to enhance the rating agency's ability to analyse and compare banks' capital adequacy. Standard & Poor's divides the global banking system into ten economic risk groups,

[25] The other two alternatives are not relevant in the stress test as the calculations do not use pre-2006 data.

with the lowest-risk countries in Group 1 and the highest-risk countries in Group 10. Norway is in Group 2. Standard & Poor's applies a risk weight of 66 percent to corporate exposures in both the *Corporate* and *Retail* segments in Group 2 countries, except exposures to construction and real estate development, which are given a risk weight of 198 percent.[26] The *Corporate* and *Retail* segments are given a risk weight of 60 percent in Group 1 countries and 75 percent in Group 3 countries. This is somewhat higher than the average risk weights in the sample of 71 large European banks.

Chart 14 Average risk weight for corporate exposures using different methods and average risk weight for a sample of large international banks. Percent



1) Adjusted for possible overestimation resulting from the use of average PDs (as in Alternative 2 in Section 6). The distribution of PDs across the *Corporate*, *SME* and *Retail* segments in the SEBRA model are used to calculate the distribution of PDs across the three segments in the stress test.
2) Weighted average for a sample of large European banks at end-2016 Q2. The sample comprises the 71 banks that reported to the European Banking Authority in their 2016 EU-wide Transparency Exercise (see EBA (2016)).
3) S&P does not publish separate risk weights for the *SME* segment.
Sources: Finanstilsynet (Financial Supervisory Authority of Norway), NOU 1992:30, EBA, Standard & Poor's and Norges Bank

These reference points indicate risk weights for corporate exposures as a whole of between 44 and 66 percent. This is lower than the estimated risk weights in Sections 6 and 7.

9. Conclusion

The cost to society of a banking crisis is high. Higher capital ratios improve banks' resilience to losses and reduce the risk of crises. However, having to rely more on equity funding could at the same time push up banks' funding costs. Since the onset of the financial crisis in 2008, banks have increased their capital ratios considerably, in pace with higher requirements set by the authorities. Nonetheless, the level of capital held by banks to support their assets is not much higher today than after the banking crisis in the early 1990s.

Banks calculate capital adequacy by risk-weighting assets to reflect the risk of unexpected losses arising from their exposures. Over the past decade, large Norwegian banks' risk weights have fallen, partly as a result of a new capital adequacy framework, Basel II, which was introduced in 2007. Basel II allowed banks to calculate risk weights using their own risk models (the internal ratings-based approach). The alternative is to apply more general risk weights set by the authorities (the standardised approach). Risk weights calculated using internal models are generally expected to reflect actual risk better than risk weights under the standardised

[26] See Tables 7 and 8 in S&P (2016).

approach. However, precise modelling of risk is demanding, for both banks and the authorities, because actual risk is not directly observable. If the different approaches underestimate risk, resulting in risk weights that are too low, the estimated capital adequacy ratio will give the impression that banks' resilience to losses is better than it actually is. Basel I transitional rules are, for the time being, limiting the effect of lower risk weights for Norwegian IRB banks.

Corporate exposures account for slightly below a third of Norwegian banks' total loans and a little more than a third of their total risk-weighted assets. The average risk weight on a corporate exposure in the Norwegian banking sector fell from 100 percent in 2006 to just below 60 percent in 2015. In this analysis, we examine banks' historical losses and corporate data back to the 1980s to estimate average risk weights for corporate exposures in the Norwegian banking sector. We calculate risk weights for exposures to eight industrial classes. Even when we account for several elements of uncertainty, historical loss data indicate an average corporate weight of around 110 percent. If we exclude data from the banking crisis in the early 1990s, the estimated average risk weight falls to just below 80 percent. This is higher than today's level in the Norwegian banking sector. The estimated weights are in line with stress test calculations, but higher than the other reference points in the analysis.

Our calculations are uncertain. There are a number of factors that could result in risk weight estimates that are too high when our method is used, but other factors suggest that risk weights calculated using our method could be too low. We control for several of these factors in our calculations. Nonetheless, our method poses some challenges that make the calculations uncertain. At the same time, our calculations are based on long time series that include events such as the Norwegian banking crisis in its entirety, making the calculations more robust.

Our analysis deals with the Norwegian banking sector as a whole, not with individual banks. Our data does not allow us to distinguish between borrowers in the different industrial classes by quality. Exposures to enterprises with strong debt-servicing capacity and high collateral values will naturally be assigned risk weights that are lower than our estimated weights. Similarly, corporate exposures to borrowers with weak debt-servicing capacity and low collateral values should be assigned a higher risk weight. Some banks have borrowers with lower credit risk, for example because of higher risk aversion or better risk management than other banks. Risk weights for these banks may be lower than our estimated risk weights.

10. References

Andersen, H. (2010) "Procyclical implications of Basel II: can the cyclicality of capital requirements be contained?". Journal of Financial *Stability*. (Available at http://www.sciencedirect.com/science/article/pii/S1572308910000331)

Basel Committee (2006) "International Convergence of Capital Measures and Capital Standards: A Revised Framework". BIS. (Available at http://www.bis.org/publ/bcbs128.pdf)
Basel Committee (2013) "Regulatory Consistency Assessment Programme (RCAP) – Analysis of risk-weighted assets for credit risk in the banking book". BIS. (Available at http://www.bis.org/publ/bcbs256.pdf)

Basel Committee (2015) "Second consultative document – Revisions to the Standardised Approach for credit risk", BIS. (Available at http://www.bis.org/bcbs/publ/d347.pdf)

Basel Committee (2016a) "Consultative Document – Reducing variation in credit risk-weighted assets – constraints on the use of internal model approaches". BIS. (Available at http://www.bis.org/bcbs/publ/d362.pdf)

Basel Committee (2016b), "Regulatory consistency assessment programme (RCAP) – Analysis of risk-weighted assets for credit risk in the banking book". BIS. (Available at http://www.bis.org/bcbs/publ/d363.pdf)

Bernhardsen, E. and K. Larsen (2007) "Modelling credit risk in the enterprise sector – Further development of the SEBRA model". *Economic Bulletin*, 2/2007, 60–66, Norges Bank. (Available at http://www.norges-bank.no/en/Published/Papers/Economic-Bulletin/Economic-Bulletin-22007/Modelling-credit-risk-in-the-enterprise-sector--further-development-of-the-SEBRA-model//)

Bernhardsen, E. and B. D. Syversten (2009) "Stress Testing the Enterprise Sector's Bank Debt: A Micro Approach", *International Journal of Central Banking*. Vol 5, No 3, pp. 111–138. (Available at http://www.ijcb.org/journal/ijcb09q3a4.pdf)

DNB (2016) "Risk and capital management. Disclosures according to Pillar 3. 2015". DNB. (Available at https://www.dnb.no/portalfront/nedlast/no/om-oss/resultater/2015/pilar3-dnb-2015-engelsk.pdf)

European Banking Authority (2013a) "Interim results of the EBA review of the consistency of risk-weighted assets. Top-down assessment of the banking book". EBA. (Available at https://www.eba.europa.eu/documents/10180/15947/Interim-results-EBA-review-consistency-RWAs_1.pdf)

European Banking Authority (2013b) "Interim results update of the EBA review of the consistency of risk-weighted assets – Low default portfolio analysis". EBA. (Available at https://www.eba.europa.eu/documents/10180/15947/EBA+Report+-+Interim+results+update+of+the+EBA+review+of+the+consistency+of+risk+weighted+assets.pdf)

European Banking Authority (2013c) "Third interim report on the consistency of risk-weighted assets – SME and residential mortgages". EBA. (Available at http://www.eba.europa.eu/documents/10180/15947/20131217+Third+interim+report+on+the+consistency+of+risk-weighted+assets+-+SME+and+residential+mortgages.pdf)

European Banking Authority (2015) "Results from the 2014 low default portfolio (LDP) exercise". EBA. (Available at http://www.eba.europa.eu/documents/10180/950548/EBA+results+from+the+2014+Low+Default+portfolio+%28LDP%29%20exercise.pdf)

European Banking Authority (2016) "2016 EU-wide transparency exercise results". EBA. (Available at https://www.eba.europa.eu/risk-analysis-and-data/eu-wide-transparency-exercise/2016/results)

Eeg, K. and M. Jonassen (1989) "Finansinstitusjonenes drift i 1988". *Economic Bulletin* 2/1989, pp. 63–74, Norges Bank.

Eeg, K. and I. A. Nordal (1992) "Finansinstitusjonenes drift i 1991". *Economic Bulletin* 1/1992, pp. 1–19, Norges Bank.

Erlandsen, T. (1990) "Finansinstitusjonenes drift i 1989". *Economic Bulletin* 2/1990, pp. 87–100, Norges Bank.

Erlandsen, T. and M. Jonassen (1991) "Finansinstitusjonenes drift i 1990". *Economic Bulletin* 1/1991, pp. 1–18, Norges Bank.

European Parliament and Council (2013) "Regulation (EU) No 575/2013 of the European Parliament and of the Council of 26 June 2013 on prudential requirements for credit institutions and investment firms and amending Regulation (EU) No 648/2012". European Parliament and Council (EU regulation, CRR). (Available at http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32013R0575&from=EN).

Norwegian Ministry of Finance "FOR 2006-12-14 nr 1506: Forskrift om kapitalkrav for forretningsbanker, sparebanker, finansieringsforetak, holdingselskaper i finanskonsern, verdipapirforetak og forvaltningsselskaper for verdipapirfond mv." (Kapitalkravsforskriften). [Regulation No. 1506 of 14 December 2006: Regulation relating to capital requirements for commercial banks, savings banks, finance companies, holding companies in a financial group, securities firms and collective investment undertakings etc." (Capital Requirements Regulation)]. (Available in Norwegian only at https://lovdata.no/dokument/SF/forskrift/2006-12-14-1506/*#*).

Finanstilsynet (2016a) *Risk Outlook 2016*, Finanstilsynet. (Available at https://www.finanstilsynet.no/en/news-archive/press-releases/2016/risk-outlook-2016/?id=).

Finanstilsynet (2016b) "Eksterne kredittvurderinger og risikoklasser" [External credit assessment and risk classification]. Circular No 18/2016, Finanstilsynet. (Available in Norwegian only at http://www.finanstilsynet.no/no/Artikkelarkiv/Rundskriv/2016/4_kvartal/Eksterne-kredittvurderinger-og-risikoklasser/).

Gjedrem, S. (2010) "Economic perspectives". Norges Bank. (Available at http://www.norges-bank.no/en/Published/Speeches/2010/Annual-address-11-February-2010/).

Hjelseth, I. N. and A. Raknerud (2016) "A model of credit risk in the corporate sector based on bankruptcy prediction". *Staff Memo* 20/2016, Norges Bank. (Available at http://www.norges-bank.no/en/Published/Papers/Staff-Memo/2016/Staff-Memo-202016/).

Johansen, H (1993) "Finansinstitusjonenes drift i 1992". *Economic Bulletin* 1/1993, pp. 28–48, Norges Bank.

Johansen, H. and R. R. Nilsen (1994) "Finansinstitusjonenes drift i 1993". *Economic Bulletin* 1/1994, pp. 8–32, Norges Bank.

Karlsen, H. and R. R. Nilsen (1996) "Finansinstitusjonenes drift i 1995". *Economic Bulletin* 1/1996, pp. 33–48, Norges Bank.

Karlsen, H., S. Weme and I. A. Nordal. (1997) "Finansinstitusjonenes drift i 1996". *Economic Bulletin* 1/1997, pp. 74–91, Norges Bank.

King, G. and L. Zeng (2000) "Logistic Regression in Rare Events Data". *Political Analysis* 9: 137–163. (Available at http://gking.harvard.edu/files/gking/files/0s.pdf).

Kragh-Sørensen, K. and H. Solheim (2014), "What do banks lose money on during crises?". *Staff Memo* 3/2014, Norges Bank. (Available at http://www.norges-bank.no/en/Published/Papers/Staff-Memo/2014/Staff-Memo-32014/).

Moe, T. G., J. A. Solheim and B. Vale (2004) "The Norwegian banking crisis". *Occasional Papers* No. 33/2004, Norges Bank. (Available at http://www.norges-bank.no/en/Published/Papers/Occasional-Papers/33-The-Norwegian-banking-crisis/).

Nilsen, R. R., S. Evjen and I. A. Nordal (1998) "Finansinstitusjonenes drift i 1997". *Economic Bulletin* 1/1998, pp. 90–105, Norges Bank.

Nordal, I. A. and M. Nærland (1995) "Finansinstitusjonenes drift i 1994". *Economic Bulletin* 1/1995, pp. 21–48, Norges Bank.

Norges Bank (2015) *Financial Stability Report* 2015. (Available at http://www.norges-bank.no/en/Published/Publications/Financial-Stability-report/2015-Financial-stability/).

Norges Bank (2016) *Financial Stability Report* 2016. (Available at http://www.norges-bank.no/en/Published/Publications/Financial-Stability-report/2016-Financial-stability/)

Official Norwegian Reports, NOU (1992) "Bankkrisen" [The banking crisis]. NOU 1992:30 (available in Norwegian only).

SpareBank 1 SR-Bank (2016) "Risiko- og kapitalstyring 2015" [Risk and capital management 2015]. SpareBank 1 SR-Bank konsern. (Available in Norwegian only at https://www.sparebank1.no/content/dam/SB1/bank/sr-bank/om-

oss/Investor/Rapporter/2015/arsrapport/Risiko-%20og%20kapitalstyring%202015%20Pilar%20III.pdf).

Standard & Poor's (2016), "Request For Comment: Bank Capital Methodology And Assumptions", Standard & Poor's.

The Storting (1998) "Rapport til Stortinget fra kommisjonen som ble nedsatt av Stortinget for å gjennomgå ulike årsaksforhold knyttet til bankkrisen" [Report to the Storting from the commission appointed to review the causes of the banking crisis]. The Smith Commission, Document No 17 (1997–98), Oslo. (Available in Norwegian only at https://www.stortinget.no/globalassets/pdf/dokumentserien/1997-1998/dok17-199798.pdf).

Appendix 1 - The Basel formula for the calculation of risk weights

The formula for calculating risk weights for the *Corporate*, *Sovereign*, *Institutional* and *Retail* asset classes is

$$RW = \left[LGD * N\left(\frac{G(PD) + (\sqrt{R} * G(0.999))}{\sqrt{1-R}}\right) - (PD * LGD)\right]\frac{(1 + (M - 2.5)b)}{(1 - 1.5b)} * 12.5 * 1.06$$

where N is the cumulative standard normal distribution and G its inverse. The formula has been calibrated to a solvency margin of 99.9 percent, that is, the estimated probability that a bank's regulatory capital will not cover its losses the following year is less than 0.1 percent. The formula contains a multiplier set at 1.06 based on impact assessments conducted by the Basel Committee on the Basel II framework.

Maturity adjustment (b) is given by:

$$b = [0.11852 - 0.05478 * ln(PD)]^2$$

except for *Retail*, where b is 0. RW increases with M, because risk increases with the maturity of the exposure. In addition, the probability that PD will increase during the term to maturity is greater when PD is low at the outset. Maturity adjustment is therefore a function of PD.

For exposures classified as *Corporate*, the correlation factor (R) is given by:

$$R = 0.12\left(\frac{1 - e^{-50PD}}{1 - e^{-50}}\right) + 0.24\left(1 - \frac{1 - e^{-50PD}}{1 - e^{-50}}\right) - c\left(1 - \frac{S - 5}{45}\right)$$

where c is 0 for all exposures, except for SMEs, where c is 0.04. S is the enterprise's turnover in millions of EUR. For *Retail* exposures that are secured on real estate, the correlation (R) is set at 0.15. For other corporate exposures in *Retail*, R is given by:

$$R = 0.03\left(\frac{1 - e^{-35PD}}{1 - e^{-35}}\right) + 0.16\left(1 - \frac{1 - e^{-35PD}}{1 - e^{-35}}\right)$$

The formula assumes that all idiosyncratic risk can be diversified away. The correlation among the various exposures is ignored. Only the correlation between each exposure and a factor for systemic risk is included. The formula is based on the assumption that small enterprises are less correlated with the factor for systemic risk than large enterprises. A low PD yields a high R because the PD for large enterprises is assumed to be low.

Table A1 Correlation[1)] between PD and loss rate. 1986–2015

	Loss rate leads		Coincide	PD leads	
	-2 years	**-1 year**	**0**	**1 year**	**2 years**
Total	0.56	0.75	0.90	0.85	0.59
Primary	0.51	0.72	0.89	0.85	0.69
Petroleum	0.08	0.18	0.41	0.72	0.30
Manufacturing and mining	0.53	0.50	0.77	0.68	0.40
Construction, electricity and water supply	0.35	0.51	0.76	0.61	0.45
Retail trade, hotels and restaurants	0.70	0.75	0.87	0.84	0.55
Shipping	-0.09	0.63	0.88	0.65	-0.01
Property management and commercial services	0.50	0.76	0.87	0.77	0.49
Transport, communications and other services	0.63	0.72	0.76	0.70	0.50

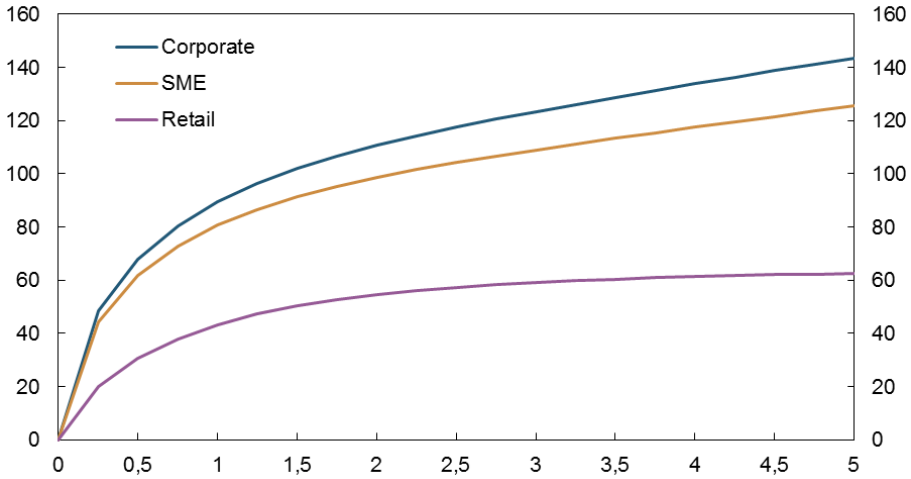
1) The highest correlation for the group is underlined.
Source: Norges Bank

Table A2 PD and LGD used in alternatives 1, 3 and 4[1)]

	Alternative 1		Alternative 3		Alternative 4	
	PD	**LGD**	**PD**	**LGD**	**PD**	**LGD**
Total	2.2	71.0	2.2	58.0	1.5	47.2
Corporate	1.2	71.0	1.2	58.0	1.1	47.2
SME	2.6	71.0	2.6	58.0	1.5	47.2
Retail	3.8	71.0	3.8	58.0	2.6	47.2
Stress test	3.6	40.0				
Corporate	2.0	40.0				
SME	4.2	40.0				
Retail	6.3	40.0				
Primary	6.2	36.8	6.2	34.6	2.5	39.4
Corporate	3.4	36.8	3.4	34.6	1.7	39.4
SME	6.1	36.8	6.1	34.6	2.4	39.4
Retail	7.3	36.8	7.3	34.6	3.8	39.4
Petroleum	2.3	51.5	2.3	43.2	1.6	50.0
Corporate	1.5	51.5	1.5	43.2	1.3	50.0
SMB	5.7	51.5	5.7	43.2	2.2	50.0
Retail	6.9	51.5	6.9	43.2	3.1	50.0
Manufacturing and mining	2.0	81.9	2.0	66.5	1.6	54.8
Corporate	1.4	81.9	1.4	66.5	1.4	54.8
SME	2.5	81.9	2.5	66.5	1.5	54.8
Retail	4.0	81.9	4.0	66.5	2.5	54.8
Construction, electricity abd water supply	1.8	75.2	1.8	62.2	1.8	38.0
Corporate	0.8	75.2	0.8	62.2	0.9	38.0
SME	2.4	75.2	2.4	62.2	1.8	38.0
Retail	4.0	75.2	4.0	62.2	2.7	38.0
Retail trade, hotels and restaurants	4.2	54.5	4.2	43.9	2.9	28.9
Corporate	2.1	54.5	2.1	43.9	1.5	28.9
SME	4.3	54.5	4.3	43.9	2.6	28.9
Retail	5.9	54.5	5.9	43.9	4.6	28.9
Shipping	1.7	57.7	1.7	57.5	1.0	61.4
Corporate	1.0	57.7	1.0	57.5	0.7	61.4
SME	2.2	57.7	2.2	57.5	1.3	61.4
Retail	4.5	57.7	4.5	57.5	3.1	61.4
Property management and commercial services	1.7	76.9	1.7	61.1	1.1	49.4
Corporate	0.9	76.9	0.9	61.1	0.9	49.4
SME	1.7	76.9	1.7	61.1	1.0	49.4
Retail	1.9	76.9	1.9	61.1	1.4	49.4
Transport, communications and other services	3.0	51.9	3.0	43.1	1.8	36.1
Corporate	1.6	51.9	1.6	43.1	1.2	36.1
SME	3.3	51.9	3.3	43.1	1.8	36.1
Retail	4.9	51.9	4.9	43.1	3.3	36.1

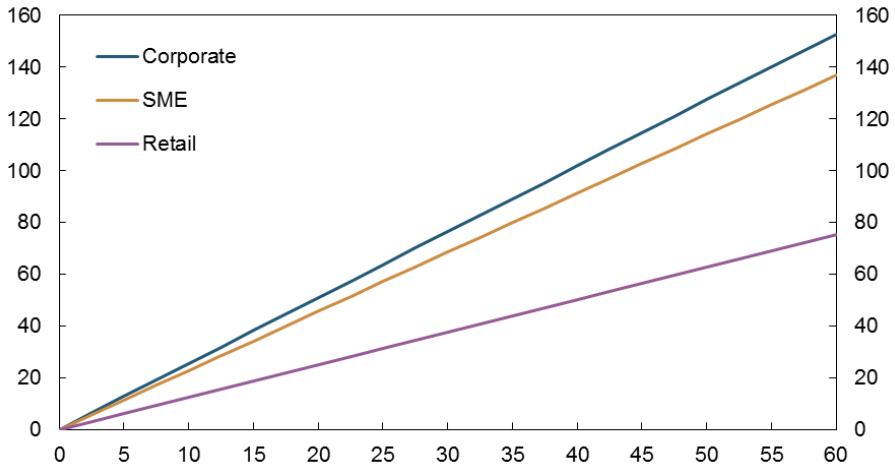
1) Alternative 2 uses the same PD and LGD as alternative 1, but the estimated risk weight is multiplied by 0.75 in alternative 2.
Source: Norges Bank

Chart A1 Relationship between PD (X-axis) and risk weight[1)] (Y-axis) in the Basel formula



1) Calculated with different values for PD (X-axis), LGD at 40 percent and maturities of 2.7 and 2.9 years for *Corporate* and *SME*, respectively.
Source: Norges Bank

Chart A2 Relationship between LGD (X-axis) and risk weight[1)] (Y-axis) in the Basel formula



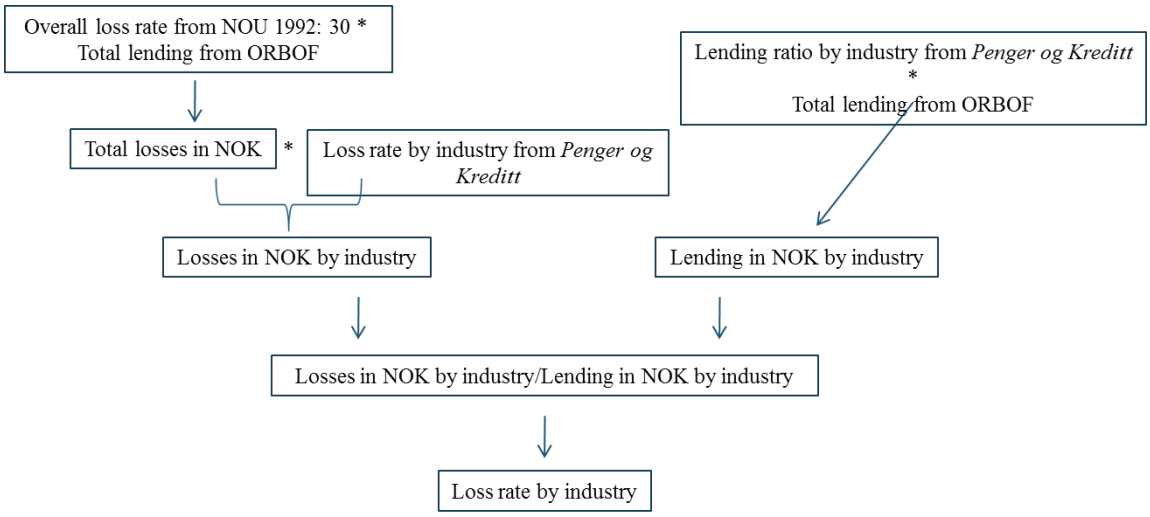
1) Calculated with different values for LGD (X-axis), PD at 1.5 percent and maturities of 2.7 and 2.9 years for *Corporate* and *SME*, respectively.
Source: Norges Bank

Appendix 2 - Method for the calculation of loss rates by industry

We use several data sources to calculate loss rates by industry. Loan losses by industry for the period 1986–1996 were published in several issues of Norges Bank's series *Economic Bulletin* (see Eeg et al (1989), Erlandsen (1990), Erlandsen et al (1991), Eeg et al (1992), Johansen et al (1993), Johansen et al (1994), Nordal et al (1995), Karlsen et al (1996), Karlsen et al (1997) and Nilsen et al (1998)). More recent figures have been published in Norges Bank's *Financial Stability Report*. In addition, total and industry loss rates for the period 1986-1991 were reported in NOU (Official Norwegian Report) 1992:30. In the period 1986-1996, losses for commercial banks and savings banks were published separately, while as from 1997, losses were reported for the banking sector as a whole. Loss figures for some years are available in several of the data sources. We use figures from the most recent publications throughout as the figures have in several instances been revised after the initial publication.

We use banks' loan distributions to weight together loss rates in the periods where the reporting is most detailed. We also use banks' loan distributions to derive banks' loss rates before 1992. Loss rates were not reported for all of the eight industrial classes until 1992.[27] However, banks' losses by industrial class as a percentage of total corporate losses were reported in *Economic Bulletin*. We therefore derive loss rates for the eight industrial classes on the basis of data for industry losses as a percentage of total losses from *Economic Bulletin*, the overall loss rate from NOU 1992:30, banks' lending from the ORBOF banking statistics, and banks' loan distribution from *Economic Bulletin* (see Chart A3).

Chart A3 Procedure for calculating pre-1992 loss rates by industry



We calculate banks' loan distribution for the period 1986-1992 using figures for total corporate lending from the banking and monetary statistics and loan distribution as published in Eeg et al (1989), Erlandsen (1990), Erlandsen et al (1991), Eeg et al (1992) and Johansen et al (1993) (see Chart A3). Banks' absolute loan distribution for the period 1993-1996 was reported in Johansen et al (1994), Nordal et al (1995), Karlsen et al (1996), Karlsen et al (1997) and Nilsen et al (1998). Lending figures for the period 1997-2015 are taken from banks' reporting to Norges Bank on industry losses and defaults.

[27] In NOU 1992:30, losses by industry were reported for six of the eight industrial classes.

Appendix 3 - Accounting rules for the recognition of banks' losses

Before 1987, there was no specific regulation regarding the recognition of banks' losses, and loan losses were probably for the most part recognised losses on individual loans. Banks were, however, required to adhere to generally accepted accounting principles, which meant that loans could not be recognised at a higher value "than an amount deemed achievable".

In January 1987, guidelines for the recognition of impairment losses on non-performing loans were introduced. Banks were also encouraged to use the guidelines for the 1986 accounting year. The guidelines were replaced by a regulation effective from 1987 that was based on the content of the guidelines. The regulation included rules on how losses on non-performing loans should be calculated. As a result, losses were probably recognised earlier than had usually been the case.

Up until 1992, loan loss recognition by banks was heavily influenced by tax rules. The tax rules permitted banks to make annual en bloc provisions to cover recognised, estimated and latent losses. The en bloc provisions could be deducted from banks' taxable income, even though they were not required to be documented. According to the tax rules, the annual en bloc provisions could be up to 1 percent of the stock of loans until the en bloc fund reached 5 percent of the loans. The limit of 5 percent was not effective during periods of rapid lending growth, and banks' annual provisions were most often close to the 1 percent limit.

A new regulation was introduced as from the 1992 accounting year, and the option to make en bloc provisions was discontinued. The new regulation specified a clearer duty to assess losses on a more general basis. The regulation required banks to distinguish between specified and unspecified loan loss provisions and contained guidelines for the calculation of these loan loss provisions. The regulation also allowed banks to make general reserve provisions. These were accounted for as a closing of the books allocation and not as a loss in the income statement. From 1992, en bloc funds were entered on bank balance sheets as unspecified loss provisions.

According to the Smith Commission, neither the 1987 nor the 1992 regulation contributed to substantial real changes to loan loss recognition by banks (see Stortinget, 1998). However, the Smith Commission's assessment of the 1987 regulation was only based on a review of two banks, DnC and Kreditkassen. Loan loss recognition by these two banks was not necessarily representative of the banking sector as a whole. The Commission also assumed that the unspecified provisions replaced the en bloc provisions. This is not necessarily correct because en bloc provisions were primarily made for tax reasons, while there were clearer rules for calculating the unspecified provisions. On the contrary, it is likely that the specified loan loss provisions under the 1992 regulations are comparable with pre-1992 loss figures.

New accounting rules were introduced in 2005 that may have influenced loan losses in the years preceding, during and following the financial crisis. The regulation of 21 December 2004 (no. 1740) is based on the principle of fair value accounting. Banks are required to write down the book value of individual loans (individual impairment loss) and groups of loans (collective impairment loss) when there is objective evidence of impairment. The regulation defines what may be regarded as objective evidence. Total impairment losses must be recognised in the profit and loss statement as a loss. Impairment losses may be reversed.