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

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

Timing of banks' loan loss provisioning during the crisis*

Leo de Haan[a] and Maarten van Oordt[b]

[a] *De Nederlandsche Bank, P.O. Box 98, 1000 AB Amsterdam, The Netherlands*
[b] *Bank of Canada, 234 Laurier Ave West, Ottawa, ON K1A 0G9, Canada*

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Abstract

We estimate a panel error correction model for loan loss provisions, using unique supervisory data on flow of funds into and out of the allowance for loan losses of 25 Dutch banks in the post-2008 crisis period. We find that these banks aim for an allowance of 49% of impaired loans. In the short run, however, the adjustment of the allowance is only 29% of the change in impaired loans. The deviation from the target is made up by (a) larger additions to allowances in subsequent quarters and (b) smaller reversals of allowances when loan losses do not materialize. After one quarter, the adjustment toward the target level is 34%, and after four quarters is 81%. For individual banks, there are substantial differences in timing of provisioning for bad loan losses. We present two model-based metrics that inform supervisors on the extent to which banks' short-term provisioning behaviour is out of sync with their target levels.

Keywords: Loan loss provisioning, Impairments, Financial institutions, Supervision, Crisis.
JEL classification: G01, G21, G32.

* *E-mail addresses:* l.de.haan@dnb.nl (L. de Haan), mvanoordt@bankofcanada.ca (M.R.C. van Oordt).
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1. Introduction

The recent global financial crisis was accompanied by a strong decline in bank profitability (e.g., BIS (2009a)). Although banks provision for bad loan losses at all times, the allowances for bad loan losses were not designed to absorb all loan losses since the crisis began. Banks had to increase the level of their allowances as a consequence of the accumulation of problem loans, which came at the expense of bank profits, thus making provisioning procyclical (e.g., BIS (2009b)).

Obtaining timely information on banks' bad loan losses is essential to bank supervisors. Slowing banks' reporting of loan loss provisioning could delay regulatory interventions by several quarters, as it results in a rosier picture of the banks' solvency than is justified. The potential information asymmetries between banks and their supervisors require bank supervisors to have clear insight into banks' timing of loan loss provisions.

In this paper, we show how panel error correction models may provide insight into the timing of loan loss provisions. Using supervisory micro data on the allowance for loan losses of 25 Dutch banks over the period 2008Q2–2014Q2, we apply this model to answer three questions: (1) Do banks immediately make provisions when impaired loans arise? (2) What are banks' target levels for the allowance for loan losses? (3) And at what speed are allowances adjusted to this target level? In particular, we show how supervisors may process the model output into two metrics that reveal the extent to which banks' short-term provisioning behaviour is out of sync with their target levels.

Specifically, for our sample, we find that banks aim for an allowance of 49% of impaired loans. In the short run, however, the adjustment of the allowance amounts to only 29% of the change of impaired loans. The resulting deviation from the target level is mostly made up by (a) provisioning more in subsequent quarters and (b) reversing lower amounts when loan losses do not materialize. After one quarter, the adjustment toward the target level is 34%, and after four quarters is 81%. For individual banks, the model outcomes are used to compile two metrics that reveal the extent to which banks' short-term provisioning behaviour is out of sync with their target levels. These reveal considerable differences in the timing of provisioning for bad loan losses between banks.

Previous empirical literature on banks' loan loss provisioning mainly focuses on three different issues. One strand of literature addresses the cyclicality of loan loss provisioning. Many studies have shown that loan loss provisioning is mostly backward-looking and procyclical (e.g., Laeven and Majnoni (2003), Bikker and

Metzemakers (2005), Bouvatier and Lepetit (2008), Foos et al. (2010), Bolt et al. (2012), Pool et al. (2015)).[1] The incurred loss model, as implemented under International Accounting Standards (IAS) 39, generally does not allow provisioning for bad loan losses before a "loss event" – such as a 90-day overdue payment – has occurred. This model has been viewed as recognizing impairment losses "too little and too late" and promoting cyclicality. To avoid procyclicality, this literature often recommends the introduction of a forward-looking loan loss provisioning practice rather than a backward-looking one (e.g., Bouvatier and Lepetit (2012)). After the global financial crisis, and following the suggestion of the Financial Stability Board, the G-20 and the Basel Committee on Banking Supervision initiated a project to replace the incurred loss model with the expected loss model. This has resulted in the changeover from the incurred loss model under IAS 39 toward the expected loss model under International Financial Reporting Standards (IFRS) 9, scheduled to become effective in 2018 (e.g., Gaston and Song (2014)). Under IFRS 9, banks will have to provision not only for credit losses that have already occurred but also for losses that are expected in the future. Users of financial statements have noted that significant opportunity remains for banks to improve disclosure before the transition to these new standards; see Financial Stability Board (FSB) 2015.

The second strand of literature deals with the empirical modelling of loan loss provisioning behaviour as such. Beatty and Liao (2014, especially Section 5) summarize and investigate nine such provisioning models.[2] In all these models, the dependent variable is the net change of the allowance for loan losses (called "loan loss provision"), scaled by total loans. However, the explanatory variables differ. Beatty and Liao (2014) find that one of the main factors behind the differences in performance between these nine models is the inclusion or exclusion of lagged loan loss allowances (scaled by total loans) among the explanatory variables. Beatty and Liao (2014) explain: "The rationale of controlling for past allowance is that if banks recognize sufficiently high provision in the past, then the current provision may be lower." (p. 366). This rationale hints at a short-term adjustment of the allowances in view of some target or equilibrium level that is considered to be "sufficiently high". This type of adjustment behaviour may be, but is not in any of these studies, captured by an error correction modelling specification. An error correction model incorporates a long-run relation, e.g., between provisions and impaired loans, and allows for short-term deviations from that relation that are closed or "corrected" over time according to a particular adjustment speed. In this study, we will estimate such a model for the provisioning behaviour of banks.

[1] A few studies document loan loss provisioning in a fashion that reduces financial system procyclicality; see, e.g., Packer and Zhu (2012) for a study on emerging economies in Asia.

[2] These studies are: Wahlen (1994), Collins et al. (1995), Beatty et al. (1995), Beaver and Engel (1996), Kim and Kross (1998), Liu and Ryan (2006), Kanagaretnam et al. (2010), Bushman and Williams (2012), Beck and Narayanmoorth (2013).

The third strand of literature addresses the hypothesis that loan loss provisioning is discretionary, to fulfil managerial objectives such as tax evasion, income smoothing, and/or capital management (e.g., Beaver and Engel (1996), Ahmed et al. (1999), Shrieves and Dahl (2003), Fonseca and González (2008), Huizinga and Laeven (2012), Cohen et. al. (2014), Norden and Stoian (2014)). Our empirical evidence suggests that banks adjust the level of the allowance gradually to their target levels. We will show theoretically that this gradual adjustment behaviour does not result in a structurally lower or higher average level of the allowance. However, the gradual adjustment behaviour will result in a delayed and smaller increase of the allowance for loan losses when there is a strong increase of the amount of impaired loans. This may result in provisioning too little, too late, especially in crisis times. Our empirical evidence also shows that the adjustment speed differs between individual banks.

Our research results are relevant for bank supervisors for two reasons. First, if bank supervisors are sufficiently aware of the gradual adjustment in loan loss provisioning as described by our empirical model, this may help to assess the severity of the situation if the amount of impaired loans starts to rise sharply during a crisis, such as the recent one in 2008. Second, if bank supervisors are sufficiently aware of the differences between banks in the timing of provisioning, this may add to their judgment of which banks face the most acute problems in their loan portfolios. In other words, for supervisors, it is relevant to know which banks are slower when adjusting their allowances for loan losses to their target levels.

Our contribution to the literature is threefold: First, we estimate a panel error correction model using supervisory micro data on the allowance for loan losses of 25 Dutch banks over the period 2008Q2–2014Q2. The estimation results yield insights into the timing of loan loss provisioning of the sample of banks during the recent crisis. Second, we examine which flow of funds into and out of the allowance for loan losses contributes most to the adjustment of the level of the allowance to the target level. For this, we use supervisory data that are unique in the sense that they comprise detailed flow of funds into and out of the allowances for loans losses at a quarterly frequency. Moreover, instead of observing the flow of funds on the total of all impairments, our data provides the impairments specifically for loans and receivables. Third, we use the model outcomes to reveal differences in provisioning behaviour among the individual banks in our sample. For this, we define two metrics that are based on model output and may be useful for supervisors as a tool to assess provisioning behaviour of individual banks.

The remainder of this paper is structured as follows. Section 2 discusses the data. Section 3 presents the model and sets out the estimation strategy. Section 4 presents the results for the whole sample. Section 5 discusses the theoretical implications from a supervisory point of view. Section 6 shows how estimation results may be used to monitor the provisioning behaviour of individual banks. Robustness checks with alternative model specifications are presented in Section 7. Section 8 concludes.

2. Data

We use supervisory data on the levels of, as well as the flow of funds into and out of, loan loss allowances of Dutch banks. Instead of observing the general level of impairments and allowances, we use data specifically on the banks' loans and receivables. The data have a quarterly frequency and are available since 2008, when the reporting framework was redesigned. Banks' loan loss provisioning during this period was based on the incurred loss model.[3] Despite a relatively short time span, the data set is interesting, as it comprises the financial crisis period and the subsequent recession. Moreover, the data are unique because they comprise all flow of funds into and out of the allowance on the quarterly frequency, specifically for bad loan losses.

As the supervisory data are raw, they must undergo several consistency checks. These checks revealed several errors and omissions, which have been corrected manually if the causes were tractable.[4] Observations that could not be corrected have been deleted from the data set. This left us with a data set of 25 banks with sufficiently long and reliable time series.[5] These 25 banks are mostly larger, universal banks, together comprising 89% of total loans of the Dutch banking industry.

All data used for the present study specifically concern "loans and receivables", which we will from now on simply denote as "loans". Hence, impairments not related to loans do not obscure the data. Impaired loans have increased strongly, starting from a level of less than 1% of total loans at the beginning of 2008, to 2.5% in 2009–2011; see Figure 1. This increase has been followed by a further increase by 1 percentage point to 3.5% in 2013. Since 2009, allowances amount to more than 1%; an increase of 0.5 percentage point compared with the beginning of 2008.

[insert Figure 1]

[3] Except for two banks, all banks report under the IFRS standards for the entire period. The two remaining banks report (partly) under NL GAAP. The applicable measurement and impairment methodology for loans and receivables is similar under both accounting standards; see, e.g., PricewaterhouseCoopers (2013, Section 5.2). The results hardly change if the two banks reporting (partly) under NL GAAP are excluded.
[4] Errors were due to, among others things, the incorrect accumulation of quarterly amounts within a year and erroneous beginning- and end-of-year figures.
[5] Appendix A gives data definitions and sources.

The changes of the allowances can have different causes (Figure 2). We have detailed data on flow of funds into and out of the allowance for 22 of the 25 banks in our sample. *Additions* to the allowance occur when banks set aside amounts for estimated probable loans losses. *Write-offs* are done when banks take amounts against allowances to cover actual loan losses; these are negative figures, as the allowance decreases by such write-offs. The allowance also decreases as a result of *reversals*, when the allowance is reversed because the loss for which the allowance was meant does not materialise. Finally, there can be *other adjustments*, such as transfers between allowances, exchange rate movements, mergers and acquisitions, the selling of subsidiaries, or the selling of a portfolio. This level of detail with respect to flow of funds into and out of the allowance is, to the best of our knowledge, quite unique in the literature.[6]

[insert Figure 2]

Figure 3 shows the aggregate flow of funds for the allowances for our sample of banks, scaled by the loan portfolio. Additions to allowances vary mostly between 10 and 20 basis points of total loans, with two peaks in the periods 2008Q4–2009Q2 and 2011Q3–2011Q4, respectively. These peaks coincide with the outburst of the financial crisis and the second recession following the weak recovery (the "double dip"). Write-offs vary mostly between 0 and -10 basis points, and on balance they have increased during the sample period. Table 1 offers some descriptive statistics for the level of allowances, impaired loans and the causes for the changes of the allowances.

[insert Figure 3 and Table 1]

3. Model and estimation

Our research questions are the following: (1) Do banks immediately make provisions when impaired loans arise? (2) What are banks' target levels for the allowance for loan losses? (3) And at what speed are allowances adjusted to this target level? We answer these questions by means of a panel error correction model. According to the model, the change in allowances depends on (a) the change of the level of impaired loans and (b) the deviation from the target level in the ratio of allowances to impaired loans.

[6] Existing studies using BankScope or Compustat data do not seem to have access to data on reversals, for example.

The baseline model is presented in Eq. (1), where banks are denoted by subscript i and where time is denoted by subscript t. The interpretation of the baseline model is as follows. The immediate adjustment of the allowance for a change in the level of impaired loans is captured by the first term on the right-hand side of the equation, β_i $\Delta\text{Impaired}_{i,t}$. If banks immediately provision for impaired loans, this should be apparent from a relatively large magnitude of coefficient β_i. The adjustment of the allowance to the target or equilibrium level is captured by the term within parentheses, λ_i ($\text{Allowance}_{i,t\text{-}1}$ – δ_i $\text{Impaired}_{i,t\text{-}1}$). The term between parentheses is sometimes referred to as the long-run relationship. In this relationship, coefficient δ_i represents the bank's target for the level of the allowance as a fraction of impaired loans. Coefficient λ_i reveals whether this target level plays an important role in the adjustment of the allowance.[7] The higher coefficient λ_i, the quicker banks adjust the level of allowances toward their targets.

$$\Delta\text{Allowance}_{i,t} = \beta_i\,\Delta\text{Impaired}_{i,t} - \lambda_i\,(\text{Allowance}_{i,t\text{-}1} - \delta_i\,\text{Impaired}_{i,t\text{-}1}) + \varepsilon_{i,t}. \qquad (1)$$

Banks may differ in their provisioning behaviour and their targets for the allowance, because of, for example, differences in their risk profiles. In other words, there is no strong reason to assume that the coefficients in model (1) are the same for each and every bank. In dynamic panel specifications, such differences in the coefficients across banks may induce bias and inconsistent estimates of the *average* effects across banks, when estimating model (1) in a pooled regression. To avoid this issue, we estimate the model with the mean group estimator of Pesaran and Smith (1995).[8] We refer to the robustness checks for a comparison with pooled estimation results.

If the levels of allowances and impaired loans are stationary, model (1) can be interpreted as a reparameterisation of an autoregressive distributed lag (ADL) model (Alogoskoufis and Smith (1991)). If, on the other hand, the levels of allowances and impaired loans have unit roots, model (1) is valid only if the levels of allowances and impaired loans cointegrate. Panel unit root tests provide a somewhat mixed view on the time series properties of the allowances and impaired loans, depending on the panel unit root test and

[7] An alternative model incorporating an adjustment to a target level is a partial adjustment model. Dahl (2013) uses such a model to assess whether loan loss provisioning by banks differs by external audit practice. In our context, the partial adjustment model would read $\Delta\text{Allowance}_{i,t} = \lambda_i$ ($\text{Allowance*}_{i,t}$ – $\text{Allowance}_{i,t\text{-}1}$), where $\text{Allowance*}_{i,t} = \delta_i$ $\text{Impaired}_{i,t} + \nu_{i,t}$. This is equivalent to the constraint $\beta_i = \lambda_i\,\delta_i$ in Eq. (1). Hence, this model requires the direct adjustment in response to changes in the level of impaired loans to be the same as the adjustment in response to deviations from the target level. Because of this prior, this model cannot empirically assess whether banks' short-term provisioning behaviour is out of sync with their target levels.
[8] The mean group estimator is often applied to smaller datasets; see, e.g., Pesaran et al. (1999, tables 3 and 4) for an application with T = 17 and N = 10. Pesaran et al. (1996) study the small sample properties of the mean group estimator based on simulations and conclude that it performs relatively well in small samples, such as T = N = 20, if the error correction parameter is small (i.e., the average λ_i sufficiently far below 0.8).

the mechanism for lag selection (Table 2).[9] Nevertheless, the error correction model panel cointegration test of Westerlund (2007) rejects the null hypothesis of no cointegration at the 1% significance level according to the G_α and G_τ statistic, and at the 10% and 5% significance levels (obtained by means of bootstrapping) according to the P_α and P_τ statistic, respectively (Table 2). Hence, the model is valid regardless of the presence of a unit root in both variables.

[insert Table 2]

4. Average results

The baseline estimation results are presented in Table 3, column (1).[10] The interpretation of the results is as follows. Banks aim, on average, for an allowance of 49% of the quantity of impaired loans. The immediate adjustment of the allowance is only 29% of the change of impaired loans. The difference between the immediate adjustment and the target level is made up in time. After one quarter the difference is closed by 34%; after a year the adjustment is 81%.[11]

[insert Table 3]

To shed more light on the potential change in provisioning behaviour during the crisis period, we split the sample in the early crisis period (2008–2009) and the later crisis period (2010–2014Q2). Columns (2) and (3) in Table 3 present the estimation results for the 22 banks for which data availability was sufficient for these sub-periods. The results in the two columns are very similar and close to the estimation results for the entire sample period. Most notable is the difference in the speed of adjustment to the target level in the early and later crisis periods. In the early crisis period, the speed of adjustment per quarter is 50%, while in the later crisis period the speed of adjustment per quarter is estimated at 29%. This difference suggests that, even though the target level remained the same, banks took more time to reach the target level while the crisis persisted. Apparently, the longer the duration of the crisis, the harder it was for the banks to maintain a sufficient level of provisions.

Thus far, the results do not show which components of the flow of funds into and out of the allowances are contributing most to the desired adjustment of the allowance level. As explained in Figure 2, a change of the allowance can occur because of an addition, write-off, reversal, or another adjustment. To investigate

[9] Results for the panel cointegration tests have been obtained using the Stata command (xtwest) provided by Persyn and Westerlund (2008).
[10] Estimation results have been obtained using the Stata command (xtmg) provided by Eberhardt (2012).
[11] Calculated as $1 - (1 - 0.34)^4 \approx 0.81$.

which components are responsible for the immediate and gradual adjustments of the level of allowances, we estimate the following model:

$$\text{Component}_{i,t} = \beta_i\, \Delta\text{Impaired}_{i,t} - \lambda_i\, (\text{Deviation from the target level}_{i,t}) + \xi_{i,t}. \qquad (2)$$

In this model, $\text{Component}_{i,t}$ may refer to any component of the flow of funds into and out of the allowances, as specified in Figure 2. The model has two explanatory variables. The coefficient for the first variable, β_i, captures a particular component's contribution to the immediate adjustment in response to a change in the level of impaired loans. The coefficient for the second variable, λ_i, captures a particular component's contribution to the gradual adjustment of the allowance level to its target. Moreover, the definition of the deviation from the target level is the same as in model (1). It is calculated as: ($\text{Allowance}_{i,t-1} - d_i\, \text{Impaired}_{i,t-1}$), where d_i is the estimated bank-specific coefficient δ_i for the equilibrium relation in model (1).

Since the flow of funds decomposition data is not available for our entire sample but for a subsample of 22 banks, we first verify whether the behaviour of the immediate and gradual adjustments of the allowance is similar for this subsample. Table 4, column (1) shows the estimate of model (2) based on the subsample if the left-hand side variable is replaced by $\Delta\text{Allowance}_{i,t}$. If the immediate and gradual adjustments in the allowance are similar, the estimated coefficients should be the same as those reported in Table 3, column (1).[12] The magnitudes of the estimated coefficients for the subsample are similar to those reported in Table 3. Hence, the behaviour of the immediate and the gradual adjustments of the allowance in response to the accumulation of problem loans is similar for both samples.

[insert Table 4]

The extent to which the different flow of funds components contribute to the adjustment of the allowance follows from the results presented in columns (2)–(5) in Table 4. Coefficient β is significant in the model only for the additions to the allowance, i.e., column (2). This suggests that the additions especially contribute to the immediate adjustment of the allowance in response to changes in the amount of problem loans. By contrast, we do not observe a significant immediate response in any of the other components.

The contributions of the different flow of funds components to the adjustment of the allowance to its target level follow from the estimates for coefficient λ. Coefficient λ is significant in the models for the addition to and the reversal of the allowance. This implies that banks report both higher additions and lower reversals

[12] The coefficients are precisely the same as those in Table 3, column (1) if we estimate model (2) on our full sample with $\Delta\text{Allowance}_{i,t}$ as the left-hand side variable.

if the actual allowance is below the target level, and vice versa. However, the estimated coefficient for the reversals is smaller than the coefficient for the additions, which suggests that the further additions to the allowance play a major role.

The results obtained so far imply that banks, being confronted by an increase of impaired loans in a particular quarter, do not immediately provision the full target amount for this, but only a part thereof. They compensate for this through larger additions to the allowances in subsequent quarters and also, to some extent, by lower reversals. That write-offs are not used to accommodate desired adjustments of the allowances is to be expected; if loan losses materialise for which provisions have been built, they have to be deducted from the allowance. "Other adjustments" are probably too arbitrary (Figure 3), as they do not fulfil a significant role in the adjustment to the target level.

5. Supervisory implications

The previous section provides empirical evidence for the claim that banks do not adjust the level of allowances immediately to their target level when changes in the amount of problem loans occur. To understand the motivation of banks and the implications from a supervisory perspective, it is important to understand the theoretical consequences of the documented provisioning behaviour on the level of the allowance for bad loan losses. In particular, it is important to notice that the gradual adjustment of the allowance to a target level does not result in a *structurally* lower or higher level of reported allowances. Instead, the empirical behaviour of banks results in a decline of the reported peaks in the level of the allowance.

Formally, this can be shown as follows. Let $\{i_{i,t-s}; \ldots ; i_{i,t+s}\}$ denote the series with the historical and current non-negative amount of impaired loans as a fraction of the total loan portfolio. Moreover, let $\{a_{i,t-s}; \ldots ; a_{i,t+s}\}$ denote the series with the allowance that bank *i* reports for expected losses on problem loans. Let the unconditional (structural) mean of both series be finite.[13] If banks were to fully (F) adjust the level of the reported allowance directly to their target levels, then, for any *t*, banks report the level of the allowance in accordance with the following rule:

$$a^{F}_{i,t} = \delta_i \, i_{i,t}. \qquad (3)$$

[13] Formally, $E(i_{i,t-s}) = \mu_i$ and $E(a_{i,t-s}) = \mu_a$ for all *s*.

Instead, based on estimates of the model in Eq. (1), we find that the empirical (E) behaviour of banks is better described by the following gradual adjustment rule:

$$a^E_{i,t} = \beta_i \,(i_{i,t} - i_{i,t-1}) + \lambda_i \, \delta_i \, i_{i,t-1} + (1 - \lambda_i) \, a^E_{i,t-1}. \quad (4)$$

It is not difficult to see that the rule based on gradual adjustment to a target level in Eq. (4) does not result in a structurally lower or structurally higher level of the allowance than the full adjustment rule in Eq. (3). The average level of the allowance under both rules can be obtained by deriving the unconditional expectation of $a^F_{i,t}$ and $a^E_{i,t}$. It follows from Eqs. (3) and (4) that both rules have the same unconditional expectation for the level of the allowances. This unconditional average equals $E(a^F_i) = E(a^E_i) = \delta_i \, E(i_i)$, where E(.) denotes the expectations operator. In other words, regardless of the rule followed by banks, in the long run, the full adjustment and gradual adjustment will both result in approximately the same average level of the allowance.

Nevertheless, the level of the peaks in the allowances will be different for the two behavioural rules. To see this, consider the top of the highest peaks in the allowance according to both behavioural rules. These maximum levels can be obtained by taking the maximum of $a^F_{i,t}$ and $a^E_{i,t}$. The maximum level of the allowance in case of the full adjustment rule is

$$\max\{a^F_{i,t}\} = \delta_i \max\{i_{i,t}\}. \quad (5)$$

To see whether this is lower than the highest peak in the level of the allowances is in case of the gradual adjustment toward a target rule in Eq. (4), it is useful to rewrite the level of the allowance under the gradual adjustment rule as

$$a^E_{i,t} = \beta_i \, \delta_i^{-1} \, \delta_i \, i_{i,t} - \beta_i \, \delta_i^{-1} \, \delta_i \, i_{i,t-1} + \lambda_i \, \delta_i \, i_{i,t-1} + (1 - \lambda_i) \, a^E_{i,t-1}, \quad (6)$$

$$= \beta_i \, \delta_i^{-1} \, a^F_{i,t} - \beta_i \, \delta_i^{-1} \, a^F_{i,t-1} + \lambda_i \, a^F_{i,t-1} + (1 - \lambda_i) \, a^E_{i,t-1},$$

$$= \beta_i \, \delta_i^{-1} \, a^F_{i,t} + (1 - \beta_i \, \delta_i^{-1}) \, [\lambda_i \, \Sigma_{s = \{1; \, \dots \, ; \, \infty\}} \, (1 - \lambda_i)^{s-1} \, a^F_{i,t-s}], \quad (7)$$

where the first equality follows from Eq. (3), and where the second equality follows from iteration. The expression within brackets in (7) is an exponentially weighted average of $\{a^F_{i,t-\infty}; \dots ; a^F_{i,t-1}\}$. Moreover, the expression in (7) can be considered as a weighted average between $a^F_{i,t}$ and the exponentially weighted average. If both $0 \le \beta_i / \delta_i \le 1$ and $0 \le \lambda_i \le 1$, it follows that

$$\max\{a^E_{i,t}\} = \max\{\beta_i\, \delta_i^{-1}\, a^F_{i,t} + (1 - \beta_i\, \delta_i^{-1})\, \lambda_i\, \Sigma_{s = \{1;\, \dots\, ;\, \infty\}}\, (1 - \lambda_i)^{s-1}\, a^F_{i,t-s}\}; \qquad (8)$$
$$\leq \max\{\beta_i\, \delta_i^{-1}\, a^F_{i,t} + (1 - \beta_i\, \delta_i^{-1})\, a^F_{i,t-1}\};$$
$$\leq \max\{\beta_i\, \delta_i^{-1}\, a^F_{i,t}\}.$$

Both inequalities follow from the fact that $\max\{\gamma\, x + (1 - \gamma)\, y\} \leq \gamma \max\{x\} + (1 - \gamma) \max\{y\}$ for $0 \leq \gamma \leq 1$. The condition on γ implies that the first inequality holds for the parameter value $0 \leq \lambda_i \leq 1$, while the second inequality holds for $0 \leq \beta_i / \delta_i \leq 1$.

The two conditions warranting lower peaks in the reported level of allowances under the gradual adjustment behaviour also have economical interpretations. The condition $\beta_i / \delta_i \leq 1$ requires the immediate adjustment in response to the changes in the amount of problem loans to be less than the amount required to directly adjust to the target level. The results in Table 3, column 1, suggests that the immediate adjustment in the allowance is on average 29% of the change in the problem loans, while the target level is on average 49% of the level of the problem loans. The ratio between the two is 0.59, which implies that this condition is satisfied. The condition $\lambda_i \leq 1$ requires that deviations from banks' target levels do not result in subsequent overreactions, such that the level of allowances will overshoot their target. Empirically, this condition is satisfied, following the results in Table 3, column 1, since the empirical adjustment is on average 34% of the deviation from the target level.

Before discussing the supervisory implications, it may be worthwhile to note that the derivation above does not rely on strong assumptions regarding the statistical properties of the fraction of impaired loans. This is important, because the amount of problem loans may exhibit strongly non-normal behaviour and serial dependence. The derivation above shows that, regardless of this statistical behaviour, the gradual adjustment of the level of allowances by banks will result in lower peaks, while it will not affect the structural average level of the allowances.

The consequences of these theoretical implications are illustrated in Figure 4. Given a hypothetical development of impaired loans, the figure shows the allowance level for the two behavioural provisioning rules described above. The parameter choices for allowances simulated with the gradual adjustment rule based on error correction in Eq. (4) are in line with the empirical results reported in Table 3, column 1, i.e., $\beta_i = 0.29$, $\lambda_i = 0.34$ and $\delta_i = 0.49$. The level of the allowance based on the full adjustment rule in Eq. (3) is in line with the empirical average target level reported in Table 3, i.e., $\delta_i = 0.49$. The figure illustrates the following consequences of the error correction behaviour:

1. With error correction, the peaks in the allowance are less high than with full adjustment;
2. Error correction results in a prolongation of the period of increased allowance levels after the peaks; as a consequence, the mean levels for the allowance are equal under both behavioural rules;
3. When problems at a bank result in a strong increase of the level of impaired loans, error correction will result in a delayed and smaller increase of the allowance.

[insert Figure 4]

For bank supervisors, the third observation may be especially worrisome. When there is an increase of impaired loans, gradual adjustment results in a smaller response in the level of the allowance. This is especially worrisome when impaired loans increase sharply, as was the case in the crisis period of 2008 (and illustrated at the end of the period in Figure 4). In such situations, obtaining timely information on banks' bad loan losses is essential to bank supervisors, since slowing banks' reporting of loan loss provisioning by several quarters can delay regulatory interventions.

6. Monitoring individual banks

The "average" gradual adjustment behaviour of our sample of banks masks potential differences in the provisioning behaviour of individual banks. For bank supervisors it is relevant to know which banks are slower when adjusting their allowances for loan losses to their target levels. Even though the reported average level of the allowances of those banks may seem to be appropriate, such banks will report a lower-than-justified level of allowances when severe problems in their loan portfolios emerge. In this section, we show how the estimation results from the panel error correction model may be processed into two metrics that summarize the provisioning behaviour of the individual banks.

Our first metric provides insight into the extent to which the immediate adjustment of the allowance following a change of the level of impaired loans meets the bank's target level. This metric is presented in Figure 5. It shows the estimated immediate adjustment of the allowance for a change in impaired loans on the horizontal axis against the target level of the allowance on the vertical axis, expressed as a percentage of the change and the level of impaired loans, respectively. Each (blue) diamond denotes a single bank. Each bank's position on the horizontal axis is given by the bank-specific estimate of β_i; its position on the vertical axis is given by the bank-specific estimate of δ_i. The red dot ("All") is based on the average across the whole sample; its location is defined by the mean group estimate presented in the previous section.

[insert Figure 5]

The diagonal line in Figure 5 presents the position of banks for which the immediate adjustment in the level of allowance is precisely sufficient to raise the level of the allowance for impaired loans to their target level. Most banks are positioned above the diagonal line. This indicates that banks in our sample, as a rule, do not immediately adjust the level of their allowances toward the target level that would correspond with the new level of impaired loans.

Our second metric gives an impression of the speed of the adjustment of the allowance. Speed is determined by two factors: the immediate adjustment of the allowance to a change in impaired loans, and the speed by which the deviation of the allowance from the target level is diminished. Figure 6 shows both factors, by plotting the difference between the target level of the allowance and the immediate adjustment (as a percentage of the target level; vertical axis) against the half-life of the deviation from the target, measured in quarters (horizontal axis). The half-life in quarters gives the number of quarters until the deviation from the target has been halved. The vertical coordinate is calculate as $(\delta_i - \beta_i)/\delta_i$; the horizontal coordinate is calculated as $\log(½)/\log(1 - \lambda_i)$. The blue diamonds are based on the bank-specific estimates; the red dot is based on the mean group estimates presented in the previous section.

[insert Figure 6]

Figure 6 may be useful to supervisors who have to assess the risk behaviour of banks. Therefore, we have drawn a horizontal and a vertical line through the red dot representing the estimated values for the whole sample. For banks located above (below) the horizontal line, the immediate adjustment of allowances deviates more (less) from their target levels than average. Banks located to the left (right) of the vertical line adjust their allowances more quickly (slowly) than average. Supervisors may especially be concerned with banks located in the top-right quadrant, i.e., to the right of the vertical line and above the horizontal line, as those banks have a relatively large discrepancy between their targeted and immediate provisioning when they are confronted with an increase of the level of impaired loans. This suggests that their short-term provisioning behaviour is relatively out of sync with their target levels. At the same time, the half-life of the discrepancy between the target and the immediate adjustment is also relatively long for these banks. Both metrics may prompt a supervisor to pay special attention to such banks.

7. Robustness checks

An issue with error correction models is whether or not to include additional lags, constants or trends. In the context of our model, the significance of an additional lag would suggest a delayed response of the level of the allowance to changes in the level of impaired loans that is not captured by the documented correction to the target level. We include an additional lag in Table 5, model (1). The results suggest that the delayed response outside the documented correction to the target level is insignificant, both statistically and economically (1.3% of the lagged change in impaired loans). Moreover, including an additional lag hardly affects the magnitude of the estimated coefficients for the average target level, δ_i, and the average speed of adjustment to the target, λ_i.

[insert Table 5]

Our estimation period coincides with a strong increase in provisioning for bad loans. A potential concern is that our estimation results are distorted because of this trend in the data. To test whether this is the case, we include a constant and a trend in Table 5, model (2). Both the constant and the trend are statistically insignificant. In contrast to the positive trend in the data, we observe a small negative sign for the estimated trend in the model. These results support modelling the level of the allowance based on the target level, which depends on the level of impaired loans during our estimation period.

[insert Table 6]

Results based on alternative estimation methodologies are reported in Table 6. Model (1) shows the estimation results based on the common correlated effects estimator of Pesaran (2006). This can be considered as a more robust estimator than the mean group estimator, as it allows for cross-sectional correlation as a consequence of unobserved common factors. The other models in Table 6 do not allow for full heterogeneity in the estimated coefficients across banks. Table 6, model (2) is estimated using the pooled mean group estimator of Pesaran et al. (1999), and assumes the same target level for the allowances across banks, i.e., $\delta_i = \delta$. Table 6, model (3) is estimated using the pooled within estimator, which also assumes the same short-run effect and adjustment to the target across banks. Notably, the latter two models estimate a slower adjustment to the target level (i.e., a lower λ_i), which is in line with the theoretical prediction that pooled regressions will induce this coefficient to be downward biased in the presence of heterogeneity across banks; see Pesaran and Smith (1995, pp. 85-86). Hence, in our context, allowing for heterogeneity across banks avoids underestimation of the average speed at which banks bring the allowances toward their target levels.

8. Summary and conclusion

In this paper we study the timing of banks' loan loss provisioning during the crisis. First, we have estimated a panel error correction model using supervisory micro data on the allowance for loan losses of 25 Dutch banks over the period 2008Q2–2014Q2. Our results show that our sample of Dutch banks aim for an allowance of, on average, 49% of impaired loans. In the short run, however, the adjustment of the allowance is only 29% of the change of impaired loans. The resulting deviation of the level of the allowance from the target level is closed in subsequent quarters. After one quarter, the adjustment to the target level is 34%; after four quarters it is around 81%. Theoretically, this behaviour results in a delayed and smaller increase of the level of the allowances when banks face a strong increase of the level of impaired loans.

Second, we have examined which flow of funds into and out of the allowance for loan losses contribute most to the gradual adjustment of the level of the allowance to the target level. For this, we used data that are unique in that they comprise detailed flow of funds into and out of the allowances for loans losses. The results of this analysis suggest that the gradual adjustment of the allowance to the target level is achieved mostly by (a) larger additions to the allowance and (b) lower reversals of the allowance when losses do not materialise.

Third, we used the model outcomes to reveal differences in provisioning behaviour among the individual banks in our sample. We presented two metrics that reveal the extent to which banks' short-term provisioning behaviour is out of sync with their target levels. As slowing increases in the allowance for loan losses may result in serious delays in regulatory interventions at banks, these model-based metrics may be useful for supervisors as a tool to assess the provisioning behaviour of individual banks.

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APPENDIX A

Table A. Data definitions

Variable	*Definition*
Allowance	Allowance for loan losses, % of total loans
Change in allowance	ΔAllowance $_t$ = Allowance $_t$ – Allowance $_{t-1}$
Impaired	Impaired loans, % of total loans
Additions	Amounts set aside for estimated probable loan losses on loans during the period, % of total loans
Write-offs	Amounts taken against allowances, % of total loans
Reversals	Amounts reversed for estimated probable loan losses on loans during the period, % of total loans
Other adjustments	Other adjustments and transfers, % of total loans

TABLES

Table 1. Descriptive statistics

Variable	Mean	Standard deviation	10^{th} percentile	90^{th} percentile	Number of observations	Number of banks
Allowance	2.09	2.58	0.13	5.00	539	25
Impaired	3.65	3.55	0.26	8.06	539	25
ΔAllowance	0.06	0.59	-0.21	0.37	539	25
Additions	0.21	0.31	0.00	0.57	349	22
Write-offs	-0.08	0.27	-0.15	0.00	349	22
Reversals	-0.10	0.23	-0.25	0.00	349	22
Other adjustments	-0.01	0.18	-0.04	0.04	349	22

Note. See Appendix A for variable definitions.

Table 2. Unit root and cointegration tests

	Statistic	Value	*p*-value
<u>Panel unit root tests:</u>			
$Impaired_{i,t}$			
IPS (AIC)	$W_{t\text{-bar}}$	-0.547	0.292
IPS (2 lags)	$W_{t\text{-bar}}$	-0.985	0.162
Choi (ADF; 1 lag)	P	55.08	0.288
Choi (PP; 1 lag)	P	82.79	0.002
$Allowance_{i,t}$			
IPS (AIC)	$W_{t\text{-bar}}$	0.441	0.671
IPS (2 lags)	$W_{t\text{-bar}}$	-5.417	0.000
Choi (ADF; 1 lag)	P	46.95	0.596
Choi (PP; 1 lag)	P	43.20	0.741
<u>Panel cointegration test:</u>			
Westerlund	G_τ	-1.988	0.003
Westerlund	G_α	-4.858	0.005
Westerlund	P_τ	-8.294	0.011
Westerlund	P_α	-2.888	0.068

Note: The IPS panel unit root test refers to Im, Pesaran and Shin (2003); AIC refers to lag selection based on the Akaike Information Criterion. The Choi panel unit root test refers to Choi (2001) using either augmented Dickey Fuller (ADF) tests or Phillips-Perron tests (PP). All reported panel unit root tests test against the stationarity of some panels against the null hypothesis of a unit root in all panels.

The Westerlund (2007) statistics test for cointegration in the model $\Delta\text{Allowance}_{i,t} = \beta_i \Delta\text{Impaired}_{i,t} - \lambda_i (\text{Allowance}_{i,t\text{-}1} - \delta_i \text{ Impaired}_{i,t\text{-}1}) + \varepsilon_{i,t}$. The null hypothesis for the cointegration test is no cointegration, i.e., $\lambda_i = 0$ for all *i*. The alternative hypothesis for the G_τ and G_α statistics is $\lambda_i < 0$ for at least one *i*. For the P_τ and P_α statistics, the alternative hypothesis is $\lambda = \lambda_i < 0$. The corresponding *p*-values are based on 1,000 bootstraps to handle potential cross-sectional dependence in the cointegration tests.

Table 3. Estimation results for Equation (1).

Dependent variable is ΔAllowance$_{i,t}$	Whole sample (1)	2008Q2–2009Q4 (2)	2010Q1–2014Q2 (3)
Immediate adjustment:			
ΔImpaired$_{i,t}$ (β_i)	0.285***	0.267***	0.288***
	(0.045)	(0.063)	(0.063)
Gradual adjustment to the long-run relationship:			
Adjustment parameter (λ_i)	0.323***	0.440***	0.290***
	(0.053)	(0.099)	(0.062)
Target level:			
Impaired$_{i,t-1}$ (δ_i)	0.494***	0.595***	0.616**
	(0.067)	(0.087)	(0.241)
Number of observations	539	154	380
Number of banks	25	22	22

Note: Estimated with the mean group estimator of Pesaran and Smith (1995). Standard errors within parentheses. The estimated model is $\Delta \text{Allowance}_{i,t} = \beta_i \, \Delta \text{Impaired}_{i,t} - \lambda_i \, (\text{Allowance}_{i,t-1} - \delta_i \, \text{Impaired}_{i,t-1}) + \varepsilon_{i,t}$. Significance levels at 10%, 5%, 1% levels are denoted by *, **, ***, respectively.

Table 4. Estimation results for Equation (2)

Dependent variable:	Change in allowance (1)	Additions (2)	Write-offs (3)	Reversals (4)	Other adjustments (5)
ΔImpaired$_{i,t}$ (β_i)	0.340***	0.199***	-0.0536	-0.00454	0.0678
	(0.0564)	(0.0509)	(0.0424)	(0.0260)	(0.0420)
Deviation from the target level$_{i,t}$ (λ_i)	0.395***	0.139**	-0.0760	0.0497**	0.110
	(0.0737)	(0.0681)	(0.112)	(0.0230)	(0.0679)
Number of observations	349	349	349	349	349
Number of banks	22	22	22	22	22

Note: Estimated with the mean group estimator of Pesaran and Smith (1995). Standard errors within parentheses. The estimated model is Component$_{i,t}$ = β_i ΔImpaired$_{i,t}$ – λ_i (Deviation from the target level$_{i,t}$) + $\xi_{i,t}$. The "deviation from the target level$_{i,t}$" is calculated as: (Allowance$_{i,t\text{-}1}$ – d_i Impaired$_{i,t\text{-}1}$), where d_i is the bank-specific coefficient for the long-run relationship according to the estimated Eq. (1). Significance levels at 10%, 5%, 1% levels are denoted by *, **, ***, respectively.

Table 5. Alternative specifications

Dependent variable is $\Delta Allowance_{i,t}$	Additional lag (1)	Constant and trend (2)
Immediate adjustment:		
$\Delta Impaired_{i,t}$ (β_i)	0.357***	0.300***
	(0.056)	(0.062)
$\Delta Impaired_{i,t-1}$ (γ_i)	0.016	
	(0.028)	
$\Delta Allowance_{i,t-1}$ (θ_i)	0.015	
	(0.078)	
Gradual adjustment to long-run relationship:		
Adjustment parameter (λ_i)	0.355***	0.564***
	(0.089)	(0.059)
Target level:		
Constant (α_i)		0.038
		(0.080)
$Impaired_{i,t-1}$ (δ_i)	0.493***	0.390***
	(0.073)	(0.084)
Deterministic trend (φ_i)		-0.0002
		(0.0004)
Number of observations	514	539
Number of banks	25	25

Note: Estimated with the mean group estimator of Pesaran and Smith (1995). Standard errors within parentheses. Model (1) is $\Delta Allowance_{i,t} = \beta_i \Delta Impaired_{i,t} + \gamma_i \Delta Impaired_{i,t-1} + \theta_i \Delta Allowance_{i,t-1} - \lambda_i (Allowance_{i,t-1} - \delta_i Impaired_{i,t-1}) + \varepsilon_{i,t}$. Model (2) is $\Delta Allowance_{i,t} = \beta_i \Delta Impaired_{i,t} - \lambda_i (Allowance_{i,t-1} - \alpha_i - \delta_i Impaired_{i,t-1} - \varphi_i t) + \varepsilon_{i,t}$. Significance levels at 10%, 5%, 1% levels are denoted by *, **, ***, respectively

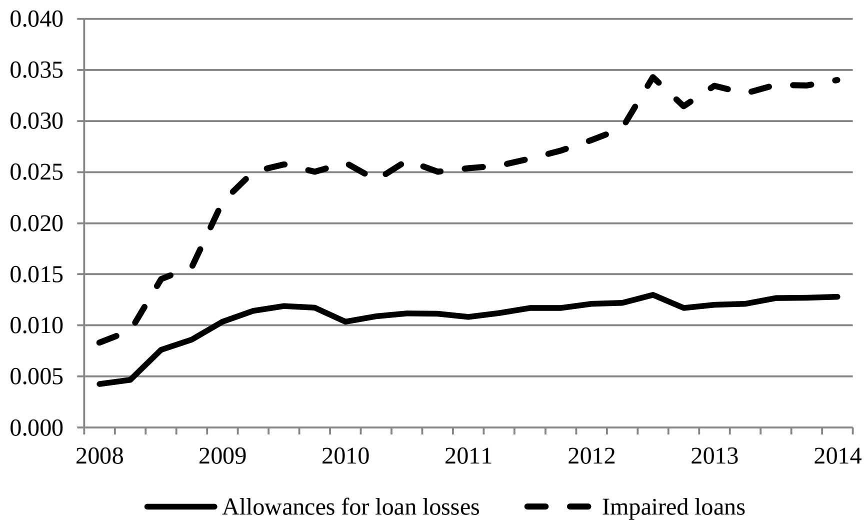
Table 6. Alternative estimation methodologies

Dependent variable is $\Delta \text{Allowance}_{i,t}$	Common Correlated Effects Mean Group (1)	Pooled Mean Group (2)	Pooled Fixed Effects (3)
Immediate adjustment:			
$\Delta \text{Impaired}_{i,t}$ (β_i)	0.245***	0.271***	0.239***
	(0.044)	(0.051)	(0.039)
Adjustment to long-run relationship:			
Adjustment parameter (λ_i)	0.523***	0.210***	0.236***
	(0.078)	(0.050)	(0.040)
Target level:			
$\text{Impaired}_{i,t-1}$ (δ_i)	0.400***	0.458***	0.443***
	(0.097)	(0.035)	(0.099)
Constant (α_i)	-0.001	-0.001**	0.002***
	(0.001)	(0.001)	(0.001)
Number of observations	539	539	539
Number of banks	25	25	25

Note: The estimated model is $\Delta \text{Allowance}_{i,t} = \beta_i \, \Delta \text{Impaired}_{i,t} - \lambda_i \, (\text{Allowance}_{i,t-1} - \delta_i \, \text{Impaired}_{i,t-1}) + \alpha_i + \varepsilon_{i,t}$. Model (1) is the Common Correlated Effects Mean Group estimator of Pesaran (2006) with outlier-robust standard errors. Model (2) is the pooled mean group estimator of Pesaran et al. (1999). This model assumes a common target level across banks, i.e., $\delta_i = \delta$ for all i. Model (3) provides estimates for a pooled regression with fixed effects, with standard errors clustered at both the bank and time level to account for both cross-sectional and serial correlation. This model assumes $\beta_i = \beta$, $\lambda_i = \lambda$, and $\delta_i = \delta$ for all i. Standard errors within parentheses. Significance levels at 10%, 5%, 1% levels are denoted by *, **, ***, respectively.

FIGURES

Figure 1. Allowances for loan losses and impaired loans
(scaled by total loans)



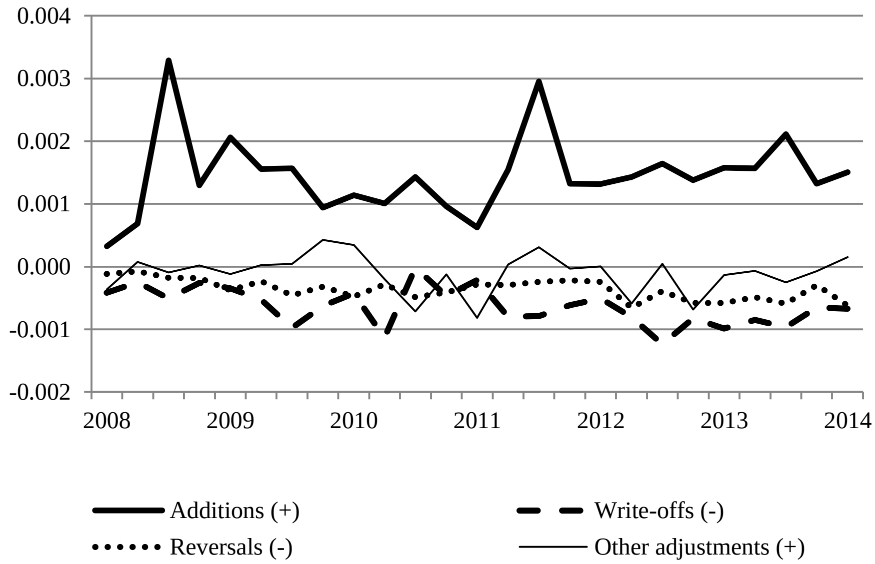
Note: Aggregate percentages for the 25 banks in the sample.

Figure 2. Flow of funds into and out of the allowance for loan losses

	Variable	*Stock/Flow*
a.	Allowance $_{t-1}$	Stock
b.	Additions $_t$	Flow (+)
c.	Write-offs $_t$	Flow (–)
d.	Reversals $_t$	Flow (–)
e.	Other adjustments $_t$	Flow (+)
f.	Allowance $_t$	Stock

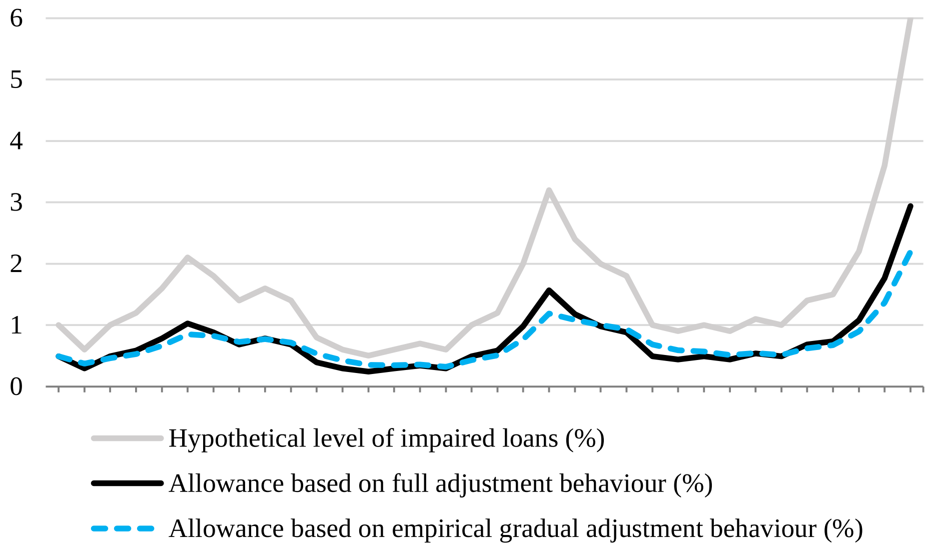
Note: f = a + b + c + d + e. Subscript *t* and *t* – 1 are time operands. (+) and (–) denote whether the data are positive and negative, respectively.

Figure 3. Flow of funds into and out of the allowance for loan losses
(scaled by total loans)



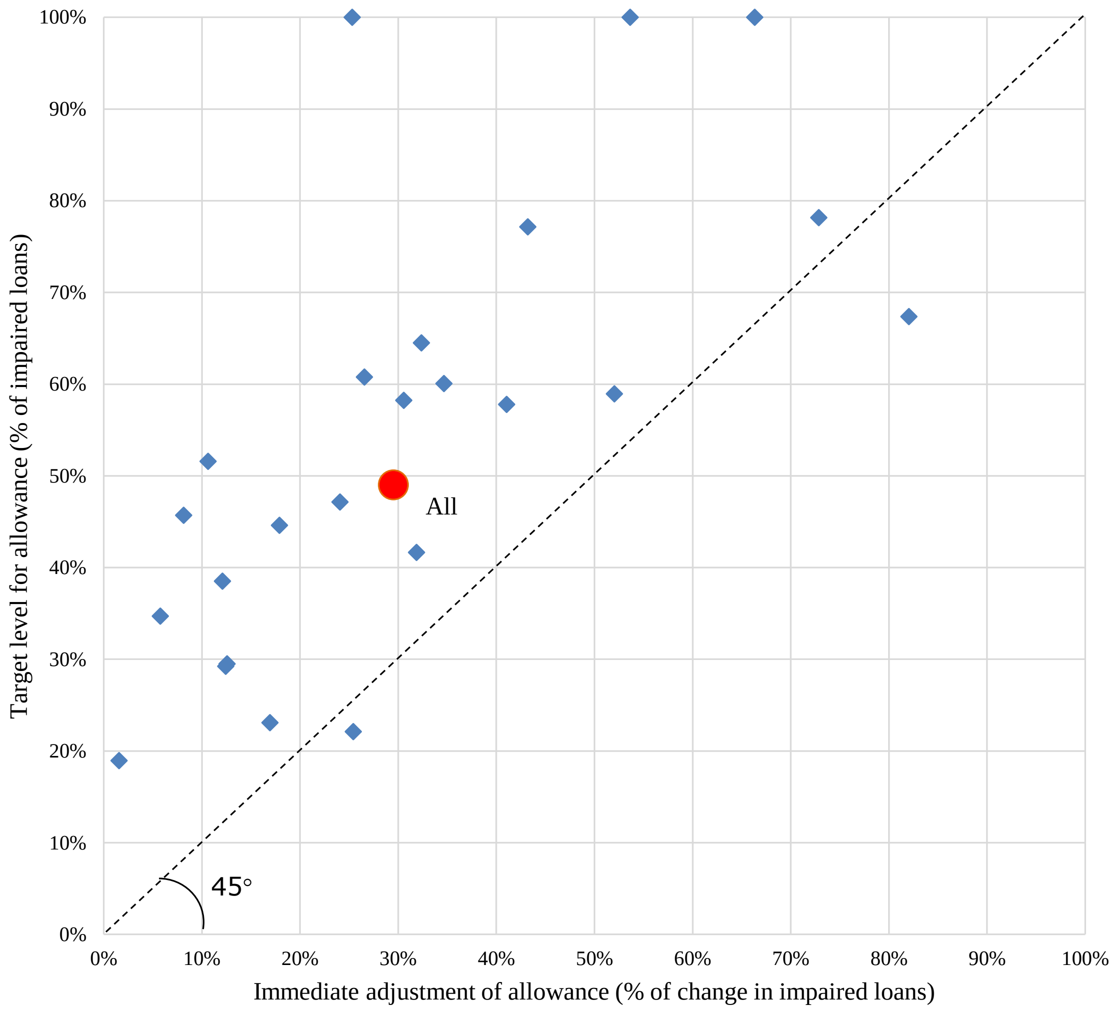
Note: Aggregate percentages for the 22 banks in the sample.

Figure 4. Illustration of the level of the allowance based on the two different behavioural rules
(percent of total loans)



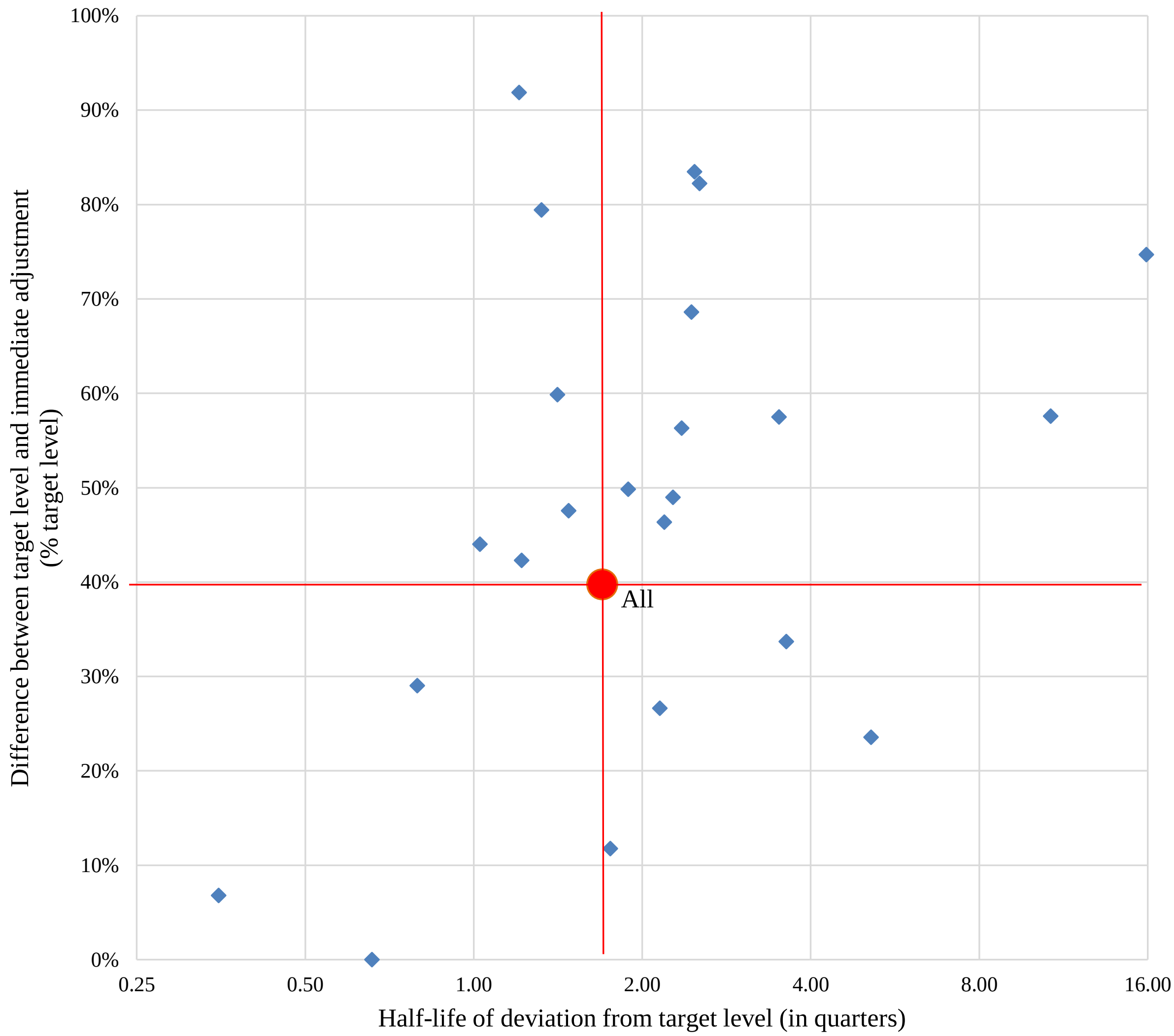
Note: The figure shows a hypothetical path for the level of impaired loans and simulations of the level of the allowance based on two behavioural rules. The allowance based on full adjustment behaviour is simulated as $\text{Allowance}_{i,t} = \delta_i \text{ Impaired}_{i,t}$, where $\delta_i = 0.49$. The allowance based on empirical gradual adjustment behaviour is simulated as $\text{Allowance}_{i,t} = \beta_i \, \Delta\text{Impaired}_{i,t} + \lambda_i \, \delta_i \text{ Impaired}_{i,t\text{-}1} + (1 - \lambda_i) \text{ Allowance}_{i,t\text{-}1}$, where $\beta_i = 0.29$, $\lambda_i = 0.34$ and $\delta_i = 0.49$.

Figure 5. Immediate adjustment of and target level for the allowance for loan losses



Note: The figure is based on the estimated coefficients of the model: $\Delta\text{Allowance}_{i,t} = \beta_i\, \Delta\text{Impaired}_{i,t} - \lambda_i\, (\text{Allowance}_{i,t-1} - \delta_i\, \text{Impaired}_{i,t-1}) + \varepsilon_{i,t}$. The horizontal coordinate is determined by β_i; the vertical coordinate by δ_i. For individual banks (blue diamonds), bank-specific estimates of the coefficients are used. Three banks with an estimated coefficient $\delta_i \geq 1$ are shown in the figure with a target level of 100%. The location of the whole sample (red dot) is based on the mean group estimator of Pesaran and Smith (1995).

Figure 6. Half-life of deviation from target, and difference between target level and immediate adjustment of the allowance for loan losses



Note: The figure is based on the estimated coefficients of the model: $\Delta \text{Allowance}_{i,t} = \beta_i\, \Delta \text{Impaired}_{i,t} - \lambda_i\, (\text{Allowance}_{i,t-1} - \delta_i\, \text{Impaired}_{i,t-1}) + \varepsilon_{i,t}$. The horizontal coordinate is calculated as log(½)/log(1 - λ_i); the vertical coordinate as (δ_i - β_i)/δ_i. For individual banks (blue diamonds), bank-specific estimates of the coefficients are used. The location of the whole sample (red dot) is based on the mean group estimator of Pesaran and Smith (1995).

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De Nederlandsche Bank N.V.
Postbus 98, 1000 AB Amsterdam
020 524 91 11
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