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Current Expected Credit Loss: Lessons from 2007-2009

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Abstract

We use a top-down approach to estimate the amount of credit loss allowances under the current expected credit loss (CECL) methodology during the 2007-2009 financial crisis. The new standard will replace the incurred loss methodology that is used nowadays by banks. We find that CECL would have been highly procyclical had it been in place during the past crisis, amplifying the contraction in bank lending and the severity of the crisis. This procyclicality would have occurred because macroeconomic models (and macroeconomic forecasters) are generally unable to predict turning points in the business cycle. As a result, CECL allowances generated using real-time forecasts of the economy would not have increased significantly until the beginning of 2007. As the problems in the housing sector gained steam in early 2007, credit loss allowances under CECL would have started to rise rapidly and would have caused a sharp decline in banks' regulatory capital ratios. In addition, the trough in banks' regulatory capital ratios would have occurred around the time of the failure of Lehman Brothers. Lastly, we estimate bank lending would have fallen by an additional 9 percentage points during 2009 as it would have been very difficult for banks to raise capital.

Key words: Current expected credit loss approach, loan loss provisions, capital requirements, bank lending, procyclicality.

JEL classifications: G18, G21, G28.

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1. Introduction

In the immediate aftermath of the financial crisis, in April 2009, the Financial Stability Forum (later renamed the Financial Stability Board, henceforth "FSB") recommended that the international accounting standard setters, FASB (Financial Accounting Standards Board) and IASB (International Accounting Standards Board) reconsider how banks account for losses as a way to reduce procyclicality in the financial system. Under the standard in effect at the time—the "incurred loss model"—banks provisioned for losses only when the bank concluded that it was probable that a loss had occurred and the amount of that loss was estimable. The FSB stated that "Identification of the loss event is a difficult and subjective process that results in a range of practices and, potentially, a failure to fully recognize existing credit losses earlier in the credit cycle."[2] The FSB recommended that the FASB and IASB consider alternatives including "…a fair value model, an expected loss model and dynamic provisioning…", the last being the technique used in Spain during the crisis that is similar to the expected loss model.[3]

The FSB's recommendation reflected bank supervisors' sense that it was difficult to get banks to recognize losses quickly during the crisis. Earlier loss recognition was felt to have the potential dual benefits of both reducing income when lending standards eased, and thereby restraining originations of riskier loans as the credit cycle heated up, as well as speeding the recovery of banks following an economic downturn when loans default, because the expense had largely already been taken. Moreover, the natural tendency for banks to tighten standards during a recession would translate into a boost to capital as loan loss reserves were released.

In June 2016, the FASB adopted the "current expected credit loss" (CECL) methodology for accounting for losses. In describing the benefits and costs of the new standard, the FASB cited the benefits as being "[m]ore timely reporting of credit losses, [and] [m]easurement using forward-looking information."[4] The only costs the FASB recognized were one-time implementation costs. In March 2017, the Bank for International Settlements (BIS) published an

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[2] Financial Stability Forum (2009), Report of the Financial Stability Forum on Addressing Procyclicality in the Financial System, 2 April 2009, p.21. Available at http://www.fsb.org/wp-content/uploads/r_0904a.pdf

[3] Dynamic provisioning uses a much simpler approach than CECL (see Jimenez et al 2017 for details) and does not suffer from the procyclicality problem we describe in our paper.

[4] FASB (2016), Understanding Costs and Benefits, ASU: Credit Losses (Topic 326), June 16, 2016. https://www.fasb.org/cs/ContentServer?d=Touch&c=Document_C&pagename=FASB%2FDocument_C%2FDocumentPage&cid=1176168233403

analysis of the new CECL standard in its Quarterly Review. The review was authored by Gerald Edwards, a former advisor to the FSB and Basel Committee on Bank Supervision, chief accountant at the Federal Reserve Board and the Head of the FSB and BCBS accounting task force, and by Benjamin Cohen, the Head of the Financial Markets section at the BIS. Cohen and Edwards conclude that "If [CECL] is performed appropriately and with the full range of future risks in mind, [it] should reduce the procyclicality of the financial system."[5]

Importantly, however, Cohen and Edwards did not reach this conclusion by estimating real-time expected credit losses and the associated level of provisioning under CECL. Instead, they conducted two "exercises." In the first, they adjusted provisions up when they were low and down when they were high, preserving the average level of provisions. In the second, they "simply assume[d]" that banks took provisions two years earlier than they actually did.[6] Similarly, a more recent analysis authored by Chae, Sarama, Vojtech, and Wang (2017) showed that CECL allowances for first-lien residential real estate loans would have been countercyclical during the 2007-2009 financial crisis *if* the future path of macroeconomic variables was assumed to be known (also known as perfect foresight).

In this paper we replace the assumption of perfect foresight with a more realistic approach of using macroeconomic forecasts available at the time and reach a strikingly different conclusion. We find that CECL would have been highly procyclical had it been in place during the 2007-2009 financial crisis. That is, CECL would have raised capital requirements exactly at a time when banks' capital base was already under some pressure because of an increase in losses during the crisis. Intuitively, the rise of CECL-based allowances during a recession works similarly to a multiplier effect: under the incurred loss standard, allowances only rise when losses tip to probable; under CECL, in contrast, allowances increase for every loan, taking into account its entire expected life. Therefore, the impact on loan allowances due to a change in the macroeconomic forecasts is much higher under CECL.

To analyze the performance of CECL during the 2007-2009 financial crisis, we estimate expected credit losses on banks' loan portfolios using a macroeconomic model of the economy, the historical relationship between loan losses and economic conditions by loan type, and bank-

[5] Cohen, Benjamin and Gerald Edwards (2017), The new era of expected credit loss provisioning, BIS Quarterly Review, March 2017, p. 53
[6] Cohen and Edwards (2017), pp. 50-52.

level information on the composition of loan portfolios and remaining loan tenor. To relax the assumption of perfect foresight we develop a macroeconomic model to generate the projections of all macroeconomic series required to forecast CECL allowances. However, macroeconomic models (and macroeconomic forecasters) are generally unable to accurately predict turning points in the business cycle. Most of the time, models predict that economic conditions in the future will be similar to the present while gradually reverting to the mean. Thus, when times are good, these models generally project economic conditions to remain buoyant. Similarly, when times are bad, models generally expect economic conditions to remain depressed, at least for a while.

According to the average survey responses from the Survey of Professional Forecasters (SPF), the Wall Street Journal (WSJ) economic projections, and the projections of our own model, the inaccuracy of the forecasts for the unemployment rate and the house price index were highly significant at the start of the recession and in the early part of the subsequent recovery. For instance, our own projections and those available at the time significantly underestimated the rise of the unemployment rate at the start of the recession. In particular, the two-year-ahead forecast error reached approximately 4 percentage points for the forecast ending in 2009:Q4 based on the average survey responses from the SPF and our own models. Moreover, during the early part of the subsequent recovery, forecasts were slow to project the decline in the unemployment rate. Meanwhile, macroeconomic projections also overstated the path of the house price index at the start of the recession. For example, the two-year ahead house price index projection ending in 2008:Q4, was overstated by more than 30 percent according to our macroeconomic model. Of note, because forecasts published by the SPF and WSJ are not available for all the macroeconomic variables and periods required to forecast CECL-based allowances, we developed our own macroeconomic models to generate such forecasts.

The key contribution of this paper is to measure the impact of the inability of forecasters to predict turning points in the business cycle on the likely level of CECL allowances. In particular, CECL allowances conditional on the macroeconomic variables projected by our own models would not have increased significantly relative to allowances determined using the incurred loss methodology until the beginning of 2007. Thereafter, over the period between the first quarter of 2007 and third quarter of 2008, CECL allowances would have risen from 1½ percent of loans to approximately 4¾ percent. The rapid increase in allowances under the new accounting standard will be especially impactful for portfolios with longer loan lives, such as first-lien residential mortgage loans. For example, for a $500 thousand mortgage loan our results indicate a bank would be booking a loss of $3 thousand in good times for originating that loan and nearly a $30 thousand loss in bad times for the same loan, almost a tenfold increase.

As a result of the rapid increase in CECL allowances during the crisis, we estimate that banks' regulatory capital ratios would have declined an additional 1.6 percentage points in the third quarter of 2008 relative to the reported regulatory capital ratios under the incurred loss methodology. Our estimate likely understates the impact on regulatory capital ratios because although we take into account the impact of losses on tax payments, we do not apply the Tier 1 common capital limits on deferred tax assets. Based on estimates provided in the academic literature, a 1.6 percentage point increase in capital requirements during the recession would have led to a contraction in lending by an additional 9 percentage points and would have doubled the decline in loans on banks' books over the course of 2009. This decline would have translated to an additional $600 billion decrease in aggregate holdings of loans on banks' books during that year.

Importantly, we only consider the cyclical implications of CECL on bank lending through its impact on regulatory capital. However, as noted, CECL will also have a material effect on a bank's net income. Under the incurred loss methodology, theoretically, when a bank originates a loan, it should have no immediate effect on net income.[7] Over time, net income is reduced through higher provisions as some loans in the portfolio default, but net income is also being boosted by interest earned on such loans. In general, those two effects will cancel out because interest rates are higher for riskier loans. Under CECL, however, banks are required to establish a credit loss allowance based on the expected lifetime losses on the loan *when they originate the loan*. Banks do not book a corresponding gain that would reflect their expected higher future interest earnings. As a result, banks will book an immediate loss, with no

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[7] In practice, a provision may be recorded under the incurred loss method at origination, depending on a bank's loss emergence period. The loss emergence period is the period that it takes, on average, for a bank to identify the specific borrower and amount of loss incurred by the bank in a pool of loans for a particular loan that has suffered from a loss-causing event. However, because this provision relates to those losses that are incurred but not reported, it will be, by definition, lower than the provision under CECL, which relates to losses that are expected to be incurred over the full lifetime of the loan.

compensating gain, for each loan they make, and that loss will be highest for bank dependent borrowers that are most vulnerable in an economic downturn. Banks struggling to maintain profitability in a downturn will have a strong incentive to stop lending to such borrowers. The procyclicality of CECL caused by its impact on net income is a critical item for future research.

In summary, provisioning for losses under the current expected credit loss standard is highly procyclical, not countercyclical as was intended. The procyclicality is similar to that arising when capital risk-weights are calculated using contemporaneous rather than through-the-cycle estimates of risk as in Behn, Haselmann, and Watchel (2016). Thus, as discussed below, banks will reduce lending to riskier, generally bank-dependent borrowers, in downturns. That reduced credit supply will lead to further declines in economic activity, amplifying the downturn.

The rest of the paper is organized as follows. Section 2 reviews some of the main assumptions around the incurred loss and CECL standards. Section 3 outlines our econometric framework used to generate the macroeconomic scenarios. Section 4 describes the data and methodology. In Section 5, we estimate the level of CECL allowances in real time during the 2007-2009 financial crisis. Section 6 discusses the implications to capital requirements and lending. Section 7 concludes.

2. Overview of CECL

The accounting for losses on loans works as follows. When a bank estimates a loss, it "provisions" for the loss. The provision is an expense that is deducted from income and added to the bank's "allowance for loan and lease loss" ("ALLL"). The ALLL is presented on the balance sheet as a contra asset and so reduces a bank's capital. When the bank recognizes the loss on the individual loan, it charges off all or part of the loan, reducing both the loan amount and the ALLL by the same amount. Therefore, the charge-off has no effect on bank capital. If the bank later makes a recovery on the loan, the recovery is then credited to the loan amount. "Net charge offs" are charge offs minus recoveries.

The most complicated element to loan loss accounting is determining when, exactly, a bank should estimate a loss. Under the "incurred loss" standard, banks provision for a loss when they determine that it is probable that a loss has been incurred. While outside of the U.S., where objective evidence of impairment on individual loans was required prior to recording a credit loss, practice within the U.S. also includes pool-based estimates that were based on historical annual charge-off rates, adjusted for other credit risk factors present at the balance sheet date. Concerns related to earnings management and increasingly stringent auditing standards, however, largely limited such estimates to those supported by historical annual charge-off rates. Consideration of most forward-looking information has been specifically disallowed from such allowances.

In June 2016, the FASB published "Accounting Standards Update No. 2016-13," which revised how accountants were required to account for credit losses on financial instruments.[8] The standard changes the accounting from a "probable incurred loss" approach for determining that a loss should be anticipated to a "current expected credit loss" or "CECL" approach. Under this new standard, the use of forecasted information is critical as banks take a credit loss provision when making a new loan equal to the expected losses over the entire life of the loan. For example, if the net charge off rate on a portfolio of construction and land development loans averaged about 10 percent over the full life of the loans, the bank would take a provision when issuing the loan of about 10 percent of the amount of a new construction loan, adjusted for individual loan characteristics and the forecasted state of the economy.[9] Each period, the bank takes new provisions, positive or negative, to update its projection of lifetime loan losses.

In practice, forecasts of lifetime expected credit losses will span three time periods. Over the period under which the bank can make a "reasonable and supportable" forecast, the bank projects the lifetime probability of default of a loan using its own models conditional on a forecast of the economy and loan characteristics. The "reasonable and supportable" period will likely be between one to three years, though it could extend beyond that. Beyond the "reasonable and supportable" period, the lifetime probabilities of default are assumed to revert to their historical performance (unadjusted for current conditions and forecasts of the future) for that loan category for the remaining life of the loan. The length of the period over which the reasonable and supportable forecast reverts to historical performance may also vary by bank and

[8] Financial Accounting Standards Board, Accounting Standards Update No. 2016-13, Financial Instruments—Credit Losses (Topic 326), Measurement of Credit Losses on Financial Instruments, June 2016. https://www.fasb.org/jsp/FASB/Document_C/DocumentPage?cid=1176168232528&acceptedDisclaimer=true

[9] In practice, net charge-off rates are typically computed on an annualized or quarterly basis; this is a simplified example that assumes the net charge-off rate is then converted into a lifetime loss rate.

product. The lifetime expected credit loss of a loan is simply equal to its lifetime probability of default times its loss given default. In the analysis below, we use banks' reported net charge-offs to estimate the lifetime expected credit loss on a portfolio of loans.

While current practice of incurred loss accounting and specific forecasts of economic factors under CECL are significant factors in assessing the expected impact of CECL, the loan and lease loss allowance is expected to normally be higher under CECL than under the incurred loss methodology, however some types of loans with shorter tenors may show lower allowances under CECL during economic expansions. Other things equal, because the allowance is a negative asset, the higher allowance implies lower levels of capital.

Moreover, as we show in this paper, the CECL methodology is more procyclical than the incurred loss methodology. Provisions rise by more in bad times than under the incurred loss methodology, and the increase is especially acute for loans with longer maturities, such as residential mortgage loans, and riskier loans including small business loans.

3. Macroeconomic Scenarios

In this section we develop a macroeconometric model to generate the forecasts of the macroeconomic variables needed to project net charge-offs and CECL allowances. In order to minimize perception of unreasonable bias within credit loss forecasts, banks will normally refer to economic forecasts performed by professionals or professional organizations. Consensus forecasts, such as the ones published by the Survey of Professional Forecasters (SPF), are not available for all the macroeconomic variables required to forecast net charge-offs and CECL allowances back in time. Therefore, this section uses a vector autoregression model to generate the projections of all macroeconomic series required to forecast CECL allowances during the 2007-2009 financial crisis. We then look at the size of the forecast errors at various horizons and compare those with the forecast errors obtained using consensus forecasts to the extent those are available.

3.1 Vector Autoregression Model

We use a vector autoregression (VAR) model to generate predictions for the macroeconomic series. These projections are key inputs needed to forecast net charge-offs and CECL allowances for each major loan portfolio. The main advantage of VAR models is that they are very flexible and are widely used to forecast macroeconomic series by central banks and practitioners. In particular, because of VAR models' reduced form nature, they often produce superior forecasts than more elaborate theory-based simultaneous equations models.

Let

$$y_t = \left(y_{1,t},\ y_{2,t}, \dots,\ y_{n,t}\right)'$$

denote a vector $(n\times 1)$ of macroeconomic series and $t = 1, \dots, T$ index the time-series dimension of the VAR model. Also, let p denote the number of lags of the VAR model. We consider the following VAR (p) model to generate the projections of the macroeconomic variables:

$$y_t = c + A_1 y_{t-1} + \cdots + A_p y_{t-p} + \epsilon_t \tag{1}$$

where c is an $(n\times 1)$ vector of intercept terms, A_i are $(n\times n)$ coefficient matrices and ϵ_t is an $(n\times 1)$ unobservable zero mean white noise vector process with time invariant covariance matrix Ω. Since there are n equations in the VAR, each one is estimated individually using ordinary least squares. We include four macroeconomic variables in the VAR model: (1) civilian unemployment rate (UR); (2) real gross domestic product (GDP); (3) the house price index (HPI); and (4) the commercial real estate price index (CRE). The data are quarterly and over the sample period between 1977:Q2 and 2017:Q4.[10] The sample period is the same as for the macroeconomic variables available in the scenarios provided by the Federal Reserve to the bank holding companies that participate in the U.S. stress tests conducted under the Dodd-Frank Wall Street Reform and Consumer Protection Act.[11]

[10] Note that we always use the entire sample period available to estimate our models. We did this to show that the procyclicality of CECL is driven by the inaccuracy of forecasts around turning points of the business cycle and not driven by parameter uncertainty or by not including enough recessions in the estimation of loan loss models. Extending our analysis to also use real-time model estimation would have likely exacerbated the issues around using CECL projections in real time.
[11] The historical data provided to banks is available in the following link: https://www.federalreserve.gov/supervisionreg/ccar-2018.htm.

The VAR model includes all macroeconomic series in first differences. The number of lags of the macroeconomic variables is set equal to two, which was selected according to the Bayesian information criterion. We use the entire sample to estimate all the parameters of the VAR. This is a conservative assumption, as using only the information available at the time of the forecasts would have reduced even further the accuracy of the projections.

3.2 Baseline Forecast and Forecast Errors

This section describes how the forecasts of each macroeconomic variable are generated and computes the size of the forecast errors for each variable over time. We calculate dynamic forecasts by using the values of the previous forecasted values of the macroeconomic variables in place of the actual values to evaluate the next forecast. For example, the one-quarter -ahead forecast uses only historical data to project the value of the macroeconomic variables, while the two-quarter-ahead forecast uses the values of the one-quarter-ahead forecast as an input in place of the actual values of the lagged macroeconomic variables. Similarly, the three-quarter-ahead forecast uses the one- and the two-quarter-ahead forecasts as the value of the lagged macroeconomic variables. We repeat this procedure to construct any number of quarter-ahead forecasts. In this section we go up to three years (12 quarters), but the length of forecast period depends on the assumption governing the "reasonable and supportable horizon" utilized under CECL.

Figure 1 displays the baseline dynamic forecasts for the unemployment rate and the natural logarithm of the house price index over the following 8 quarters. In particular, the figure shows five different sets of forecasts, starting in the first quarters of 2006 through 2010, to illustrate the variation in the baseline projections as the start of the forecast period changes. In general terms, there are some periods where the forecasts appear to be fairly accurate, while there are other periods that are very difficult to predict. In particular, the charts show periods in which the projections understate the rise in the unemployment rate (e.g., 2008:Q1 vintage) or overstate the increase in house prices (e.g., 2007:Q1 vintage), particularly at the onset of the 2007-2009 financial crisis, while there are other periods in which the projections overshoot the rise in the unemployment rate (e.g., 2010:Q1 vintage) and the decline in house prices right around the trough of the recession in mid-2009.

Next, we evaluate the accuracy of the forecasts starting in each period before, during and after the 2007-2009 financial crisis. Figure 2 shows the errors of the four-quarter-ahead, eight-quarter-ahead, and twelve-quarter-ahead forecasts for the unemployment rate between 2004:Q4 and 2012:Q4. Positive values in the y-axis correspond to the VAR model underestimating the rise in the unemployment values and, conversely, negative values indicate the model is overestimating the increase in the unemployment rate. Before the start of the recession in 2007:Q4, the forecast errors are generally small. For example, the forecast error was -0.1 percentage points using the 8-quarter-ahead forecast ending in 2007:Q4. In contrast, when the recession starts, the model significantly underestimates the rise of the unemployment rate, with the four-quarter-ahead forecast error reaching 2½ percentage points for the forecast ending in 2009:Q2, and the eight-quarter-ahead and the twelve-quarter-ahead forecast errors exceeding 3¾ percentage points and 5¾ percentage points for the forecast ending in 2009:Q4, respectively. During the subsequent recovery, the model tends to understate the decline in the unemployment rate. For example, the eight-quarter ahead forecast error was -2½ percentage points for the forecast ending in the 2012:Q3 period. In summary, these results indicate that the size and the direction of the forecast errors for the unemployment rate series are closely tied to the business cycle turning points.

Figure 3 displays the corresponding information for the house price index. The negative values in the y-axis indicate instances where the forecasts produced by the VAR model underestimate the decline in the house price index. The largest forecast errors occur in the forecast period ending in the fourth quarter of 2008, approximately one year before the peak in the forecast errors for the unemployment rate. For example, the eight-quarter-ahead forecast error for the period ending in 2008:Q4 was about -32¼ percent.

To demonstrate that the size of forecast errors reflects the difficulty of predicting turning points in the business cycle and is not driven by the lack of sophistication of our model, Figure 4 compares the 8-quarter-ahead forecast errors for the unemployment rate obtained using our model with those obtained using the average responses from the SPF. As shown in the chart, the eight-quarter-ahead forecast errors are generally higher using the average responses from the SPF for the forecast period ending during the 2007-2009 recession. In addition, the root mean-squared error of the forecast of the unemployment rate using the average responses from the SPF is 19 percent higher than those obtained via the VAR model. The VAR model may have a better forecast performance because it uses the entire sample period to estimate the parameters of the model and therefore understates the forecast errors that would be made in real time. Note that we are only able to evaluate the forecast performance of the unemployment rate since the SPF did not have projections for the house price index during that period of time.

Relatedly, the analysis presented here uses the final estimates of the macroeconomic variables to generate the projections for key macroeconomic variables during the crisis period. In reality, banks would have to generate projections in real-time using the first preliminary estimates of the macroeconomic series before any revisions. It is probably worth exploring this issue in more detail, but because most of the series we use are measured precisely and thus are not subject to large revisions in real time, this might be a secondary consideration.

3.3 Density Forecasts

In practice, banks will use more than one macroeconomic scenario to estimate their loan allowances under CECL. In particular, banks will likely generate projections for CECL allowances under a baseline scenario as well as an optimistic and a pessimistic scenario. In reality models used by banks are nonlinear, with CECL-based allowances rising significantly more under a pessimistic scenario, than being reduced under an optimistic scenario. Thus, averaging the two results may be more prudent from a risk management perspective than simply relying on the baseline projection.

We construct an optimistic scenario and a pessimistic scenario by generating density forecasts for each of our macroeconomic series. We then can label the optimistic scenario as the one corresponding to the path of the macroeconomic series in the more favorable tail of the density forecast, and in contrast choose the pessimistic forecast in the opposite percentile of the density forecast.

To generate the density forecasts for each of our macroeconomic series, we use a simulation-based approach designed to preserve the time-series dependence across the various macroeconomic series in our sample. Let

$$\left\{\hat{\epsilon}_{1,t}, \hat{\epsilon}_{2,t}, \dots, \hat{\epsilon}_{n,t}\right\}_{t=1}^{T}$$

denote the full set of residuals from the estimated VAR model. Using this set of residuals, we construct 200 bootstrap samples by resampling from the vector of residuals. The size of each bootstrap sample is determined by the length of the forecast horizon. Next, having bootstrap sample j the one-quarter-ahead forecast is given by:

$$\hat{y}^{j}_{T+1|T} = \hat{c} + \hat{A}_1 y_T + \cdots + \hat{A}_p y_{T-p} + \hat{\epsilon}^{j}_{T+1} \tag{2}$$

where $\hat{c}$ and $(\hat{A}_1, \ldots, \hat{A}_p)$are the OLS estimates of the model coefficients, and the residual $\hat{\epsilon}^{j}_{T+1}$ is the jth draw from the first bootstrap sample. We then apply equation (2) recursively to generate the two-quarter-ahead forecast:

$$\hat{y}^{j}_{T+2|T} = \hat{c} + \hat{A}_1 \hat{y}^{j}_{T+1|T} + \cdots + \hat{A}_p y_{T-p+1} + \hat{\epsilon}^{j}_{T+2} \tag{3}$$

We can apply this procedure recursively to generate the H-quarter ahead forecasts for the j^{th} bootstrap sample

$$\left\{\hat{y}^{j}_{T+1|T}, \hat{y}^{j}_{T+2|T}, \ldots, \hat{y}^{j}_{T+H|T}\right\}.$$

As noted earlier, we construct 200 different forecasts for each series, namely let $j = 1, \ldots, 200.$

Figure 5 shows the density forecasts for UR and HPI. The shaded areas in the charts represent the 5th and 95th percentiles of the paths of the macroeconomic variables and the dashed line represents the median. Going back to the original goal of generating density forecasts, a bank could select the optimistic path for the unemployment rate as the one corresponding to the 5th percentile of the density forecast, and the pessimistic path as the one corresponding to the 95th percentile.

4. Estimation of CECL allowances

This section describes the methodology used to estimate CECL allowances for the loan portfolios available on the regulatory reports. We estimate CECL allowances using predictions for net charge-off rates of loan portfolios over a particular horizon. These projections are generated using top-down models proposed by Hirtle et al (2015), which rely on the path of macroeconomic variables and past values of net charge-offs to generate projections for industry-wide loan losses.

4.1 Methodology

The definition of CECL allowances follows closely the approach developed in Fadil (2018). The main difference is that we use top-down models to project net charge-off rates instead of using the realized values of net charge-off rates. In addition, to project net charge-off rates we also use forecasts for the path of macroeconomic variables instead of actual realizations for these series. Lastly, we also expand our analysis to include all the 15 loan categories available on the bank regulatory reports.[12]

The size of loan reserves under CECL for each loan portfolio in a given quarter depends on the loan balance at that time, the expected life of the loan portfolio, the projections for net charge-off rates over the reasonable and supportable period, and a set of assumptions governing the evolution of loan balances over time until those balances are reduced to zero and how quickly loss rates revert to long-run values. Figure 6 displays the forecasting horizon of a particular loan portfolio assumed to have an expected life of 28 quarters (7 years). The charts displays three important sub-periods. We define the reasonable and supportable period in red, which represents the forecast horizon of net charge-off rates. In the baseline case, we assume the reasonable and supportable period is equal to 12 quarters (3 years). We have also generated results using shorter forecast horizons. The second sub-period is the reversion period, under which the net charge-off rate is assumed to revert to its long-run value. In our analysis, the reversion period is portfolio specific and corresponds to the number of quarters it took for net charge-offs rates to reach their long-run average value after the 2007-2009 financial crisis. Finally, the third sub-period denoted in blue sets the net charge-off rates at their long-run values. This last period is only relevant for loan portfolios with longer expected lives, such as various types of residential real estate loans.

For each loan portfolio in the analysis, we assume a straight-line balance reduction to zero over the expected life of the loan portfolio. This is a simple way of capturing the amortization and pre-payment of loans included in each loan portfolio. We acknowledge that not all loan portfolios behave in this manner. In particular, some loan portfolios with relatively short

[12] Net charge-offs are reported in schedule HI-B in the FR Y-9C regulatory report. See, https://www.federalreserve.gov/apps/reportforms/reportdetail.aspx?sOoYJ+5BzDal8cbqnRxZRg==.

expected loan lives (e.g., construction and land development loans) are more likely to have a more constant balance over their life as customer draws for construction may be roughly offset with maturities and paydowns. Although we assume in this paper a straight-line balance reduction for all loan portfolios, we believe this is an important issue that deserves further consideration as it may lead to an underestimation of CECL allowances for some portfolios.

Having described the forecast horizon and the evolution of loan balances over the expected life of the loan, the estimate of CECL allowances in quarter t, for loan portfolio j is defined as:

$$CECL_t^j = \sum_{i=0}^{T+N_j+R_j-1} \left(\widehat{NCO}_{t+i}^j \times Loan\ balance_{t+i}^j\right) \tag{4}$$

where $\widehat{NCO}_{t+i}^j$ represents the forecast of the net charge-off rate for loan portfolio j in quarter $t+i$. As noted earlier, we use top-down models to generate the predictions of the net charge-off rate for the first T periods. After that, the net charge-off rate is assumed to revert linearly to its long-run value over the next N_j quarters and stays at that level for the remaining R_j quarters until portfolio j's loan balance reaches zero.

4.2 Forecasting Net Charge-Off Rates

A key element of our analysis is the forecasting of net charge-off rates conditional on the path of the macroeconomic variables. Since we are interested in studying the impact of variations in the accuracy of macroeconomic forecasts over time, we use exactly the same top-down models as proposed by Hirtle et al (2015). The advantage of using that suite of models is that those have already been shown to having some power in explaining changes in banks' regulatory capital ratios under a stressful macroeconomic environment. Hirtle et al (2015) estimated model specifications for fifteen different loan portfolios as a function of an autoregressive term and a set of macroeconomic variables. Specifically, each of the top-down model specifications is of the form:

$$\widehat{NCO}_t^j = \alpha + \rho \widehat{NCO}_{t-1}^j + \beta \widehat{Macro}_t + \varepsilon_t \tag{5}$$

where α is the constant term, $\rho$is the first-order autoregressive coefficient and $\beta$is a vector of coefficients associated with the macro variables (some models have more than one macroeconomic variable as the driver of net charge-offs). Table 1 contains a list of all loan portfolios included in the analysis and the corresponding macroeconomic variables used to generate the projections of net charge-offs for each portfolio.

In terms of the path of the macroeconomic variables, we consider two cases. First, the baseline case which generates projections for net charge-off rates using the baseline forecast obtained using the VAR model described in the previous section. Specifically, the VAR model generates projections for each of the macroeconomic series needed to project net charge off rates, namely the unemployment rate, the house price index and the commercial price index. The second case uses a Monte Carlo approach that generates many possible paths for the macroeconomic variables and reports the range for CECL allowances across all possible realizations of such scenarios. In particular, we focus on the results for the median scenario as well as the results under the 5^{th} percentile (optimistic) and the 95^{th} percentile (pessimistic) cases.

4.3 Data

To implement the methodology described above, we use the Consolidated Financial Statements for Bank Holding Companies (the FR Y-9C) and the Consolidated Reports of Condition and Income (the FFIEC 031/041) for commercial banks published by the Federal Reserve to construct a dataset that includes all bank holding companies and all commercial banks that do not have a parent that file a FR Y-9C. As noted earlier, all models are estimated with aggregated time-series for the entire U.S. banking system.

In terms of target variables for bank losses, we model quarterly net charge-off rates for fifteen loan categories. For each category, the net charge-off rate is defined as charge-offs net of recoveries, scaled by average loans during the corresponding quarter and is annualized. The fifteen loan categories are as follows: (1) C&I = commercial and industrial; (2) CLD = construction commercial real estate; (3) MF = multifamily real estate; (4) NFNR = non-farm non-residential commercial real estate; (5) FL = first lien residential real estate; (6) JL = junior lien residential real estate; (7) HLC = home equity lines of credit; (8) CC = credit card; (9) CON = other consumer; (10) LEA = leases; (11) OTHRE = other real estate; (12) FG = loans to foreign governments; (13) AG = agriculture loans; (14) DI = loans to depository institutions; (15) OTHL = other loans.

Table 2 contains the selected summary statistics for the net charge off rates used in the empirical analysis. Although loan net charge-offs are, on average, higher for credit card and a bit higher for other consumer loans, junior-lien mortgages and construction commercial real estate loans, net charge-off rates for all major loan categories exhibit significant variability, as shown by the difference between the maximum and minimum values of the series. This mainly reflects the cyclical nature of bank losses. For instance, net charge-offs for first-lien residential real estate loans ranged between 0.05 percent and 0.36 percent during 1991:Q1 and 2007:Q4. During the crisis period, net charge-offs for first-lien residential real estate loans reached 2.8 percent in the fourth quarter of 2009.

The expected life of each loan portfolio has a first-order impact on the level of CECL allowances, and so is an important input in our model.[13] We were able to receive confidential data on the expected life of loans from nine large banks for most of the fifteen loan portfolios. Banks provided data on the life of loans as of the fourth quarter of 2008; in a few instances, however, the data was only available for the current portfolio and we used those estimates to supplement the calibration of CECL allowances. Since we use aggregate industry models, we calculate an aggregate value for the expected life of loan using the corresponding loan balances of each bank for that particular portfolio as the weight. The left column in Table 3 shows the weighted-average expected life for each of the 15 loan portfolios included in our analysis. As shown in the table, residential real estate loans have an expected life of loans that varies between 34 quarters (FL) and 30 quarters (HLC). On the commercial side, commercial and industrial loans have an expected life of 15 quarters, while commercial and real estate loans have expected lives between 11 quarters (CLD) and 30 quarters (MF). On the consumer side, credit card loans have an expected life of 7 quarters and other consumer have loan lives of 16 quarters.[14]

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[13] The use of expected portfolio lives within the top-down models is different from the bottom-up approaches used by banks to estimate current CECL allowances. This study, uses lagged net charge-offs and projections for the future path of macroeconomic variables to estimate CECL allowances for each major loan portfolio. In their own modelling, banks will also be taking into account portfolio specific variables, such as loan to value ratios, among other loan specific variables to estimate CECL allowances using their own bottom-up models.

[14] A recent study by S&P industry analysts used the following expected life of loans: 7 years for mortgages, 6 years for multifamily loans, 1.6 years for commercial and industrial loans, 3.8 years for commercial real estate loans, and

Lastly, another parameter of the model that is needed to estimate the level of CECL allowances is the length of the reversion period. We used historical data on net charge-off rates to calibrate the duration of the reversion period. Namely, for each of the fifteen loan portfolios we calculated the number of quarters it took for loss rates to revert back to their long-run values after the 2007-2009 crisis. In particular, the last column of Table 3 reports the number of quarters it took net charge-off rates to recover from their peak level to their long-run average during the past crisis. Since the depth of the past recession was much more severe for residential mortgage loans, we find that the reversion period is higher for such loans. Namely, the first-lien mortgage portfolio has a reversion period of 15 quarters while the junior-lien mortgage portfolio and the HLC portfolio have a reversion period of 18 quarters.

5. Results

This section estimates CECL allowances in real-time. It starts by presenting the results of the net charge-off rate regressions and discusses the estimation of CECL allowances using those projections and several other auxiliary assumptions described in the previous section. We finish the section by providing a confidence interval around our estimation of CECL allowances using Monte Carlo methods.

5.1 Net Charge-Off Rates

Before delving into our main results, we present the estimated coefficients of the models for net charge-offs. As noted earlier, we used the same model specifications as those presented by Hirtle et al (2015). All specifications use the net charge-off rate, defined as net charge-offs scaled by the corresponding loan balance during that quarter, as the dependent variable. The only difference is that we updated the sample and re-estimated the coefficients of each model by using data through the fourth quarter of 2017.[15]

According to the entries in Table 4, the coefficients on the macroeconomic variables have economically intuitive signs and almost all are statistically significant at conventional levels. In particular, net charge-off rates change positively with the year-over-year change in the unemployment rate and the charge off rates for real estate loan categories vary inversely with the

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two years for consumer loans. Thus, our calibration of loan lives is well within the estimates of other industry studies.

[15] See footnote 10 on page 10.

change in the house price index and the CRE price index. Following Hirtle et al (2015), the model specifications for the real estate loan categories (CLD, MF, NFNR, FL, JL and HLC) depend nonlinearly on the changes in the price indexes for commercial real estate properties (CRE loans) and house prices (RRE loans). This is implemented by assuming that it is only when real estate prices decline that such variables have an impact on loss rates, as measured by net charge-offs. As shown by the coefficient on the lagged net charge-off rate, the degree of persistence is noticeably higher for the major loan portfolios, such as first-lien closed-end mortgage loans (0.89), home equity lines of credit (0.91), and credit card loans (0.86). In practice, this implies that periods of acute macroeconomic stress generate loan loss rates that are highly persistent and will account for most of the change in CECL allowances. In contrast, the degree of persistence is significantly lower for loss rates to depository institutions (0.36) and other loans (0.57) which implies a quick reversion to long-run loss rates after experiencing a period of macroeconomic stress. As evidenced by the relatively high R^2, all specifications fit the data quite well, however the high degree of statistical fit of the models relies importantly on the presence of lagged dependent variables.

5.2 CECL Allowances under the Baseline Scenario

This section estimates CECL allowances during the 2007-2009 financial crisis. As discussed below, the estimation of CECL allowances is done using equation (4)[16] and relies heavily on the projections of net charge-off rates over the following 12 quarters (under the baseline scenario). We start the estimation of CECL allowances in the first quarter of 2005, two years before economic conditions started to show a noticeable deterioration. We end our analysis in the fourth quarter of 2012, well after the end of the recession, to also study the dynamics of CECL allowances post-recession in which forecast errors tend to be significantly smaller.

Figure 7 plots the results for CECL allowances under the baseline macroeconomic scenario. The level of CECL allowances is scaled by the sum of loans across all 15 loan categories used in our net charge-off rate projections. For comparison purposes, the chart also depicts reserves that were actually taken under the incurred loss methodology scaled by total loans (allowance for loan and lease losses, or ALLL). The chart shows two main results: (1)

[16] Reported on page 15 above.

CECL allowances are not significantly different from ALLL when the economy is not in a recession (in fact, CECL allowances may sometimes be lower than the ALLL); (2) when the macroeconomic forecasts start to pick-up the deterioration in economic conditions CECL becomes very procyclical, with allowances rising sharply and overshooting levels that would have been applied had perfect foresight been possible. This increase would have most likely exacerbated the impact on credit availability of the 2007-2009 financial crisis.

As shown in Figure 7, between the first quarter of 2005 (the first quarter in which we estimate CECL allowances) and the first quarter of 2007, the ratio of CECL allowances to loans trends slightly upwards, reflecting the increasing share of loans in banks' loan books with very long lives, such as mortgage loans. In particular, in the first quarter of 2007 reserves under CECL were just 50 basis points above reserves under the incurred-loss methodology. This modest rise casts doubt on the premise that CECL allowances would have been countercyclical by forcing an early recognition of loan losses, incentivizing banks to tighten lending standards, and leading to a more moderate growth of loans. As we show next, the main reason why the path of CECL allowances is not so different from the incurred loss methodology is because until the end of 2006 almost all forecasts were projecting the house price index to continue to rise over the next 2 to 3 years.

In early 2007, however, the HPI forecasts are reversed and between the first quarter of 2007 and the third quarter of 2008, CECL allowances ramp up rapidly from 1½ percent to 4¾ percent. The rapid change in reserves under CECL in this period is also supported by revisions to the unemployment rate projections, especially at the end of 2007 and early 2008. In contrast, actual reserves that were taken under the incurred loss methodology rise approximately 1 percentage point between the first quarter of 2007 and the third quarter of 2008.

Thus, the new accounting framework could force banks to hold significantly more reserves over the life of the loan in a relatively short amount of time at the same time as a bank's capital starts to be eroded by loan losses. The requirement to increase reserves is akin to an increase in capital requirements in a downturn. As a result, had CECL been in place during the 2007-2009 financial crisis, some banks would have had to cut lending very aggressively in an attempt to partly offset the increase in capital requirements as it likely would have been extremely difficult and costly for banks to raise new equity during that period. The converse is also true: when economic conditions recover, reserves under CECL decline at a much more rapid pace relative to the incurred loss methodology. As a result, by the third quarter of 2011, reserves under CECL would be projected to be lower than those under the incurred loss methodology.

Next, we explain why CECL is more procyclical than the incurred loss methodology. The first main reason is the inaccuracy of the forecasts for the house price index in the years prior to the crisis. In particular, up until the end of 2006, HPI forecasts over the next 12 quarters (the reasonable and supportable period under the baseline specification) were projecting continued appreciation in housing prices, while in reality the HPI declined. In particular, the HPI declined approximately 25 percent between 2007:Q1 and 2009:Q2. The results of our model are similar to consensus forecasts available at the time. According to the average forecasts from the WSJ Economic Forecasting Survey, at the end of 2006 the average projection for the HPI was to be about unchanged over 2007, similar to our baseline projection. In reality, the HPI declined 10 percent over that year.[17]

Figure 8 presents the projections for CECL allowances assuming perfect foresight for the house price index. That is, the projections for net charge-off rates are generated assuming the actual future path of the HPI is known to the forecasters, while forecasters still need to project the remaining macroeconomic series, namely the UR and the CRE. Under this set of assumptions, the ratio of CECL allowances-to-loans would have been projected to be 0.3 percentage points higher in 2005:Q1 and 1.9 percentage points higher at the start of 2007 relative to the incurred loss methodology. That is, an assumption of perfect foresight for the HPI under CECL would have generated a much higher level of reserves at the onset of the crisis. Therefore, a more aggressive rise in reserves before the start of the recession may have incentivized banks to start tightening lending standards for residential real estate loans earlier and made the recession considerably less severe. However, as shown by the inaccuracy of HPI forecasts, perfect foresight is an unreasonable scenario from a practical perspective.

There is a second instance, namely between the end of 2007 and the third quarter of 2008, where models used to project CECL allowances call for a rapid increase in loan reserves under the baseline scenario. This second occurrence of the rapid build-up of reserves is driven by

[17] The WSJ economic projections for house prices are available at: http://projects.wsj.com/econforecast/?standalone=1#ind=homeprices&r=10.

revisions to the projections of the unemployment rate. At the end of 2007, many such projections were still predicting a mild recession and only a modest increase in the unemployment rate; but those projections were increased beginning with the exacerbation of the financial crisis in the first half of 2008 through the default of Lehman Brothers in the fall of 2008. As economic conditions deteriorated and the UR continued to rise sharply, revisions to future projections of the UR drove the acceleration in loan reserves under CECL observed in the first-half of 2008.

Figure 9 depicts CECL allowances for two loan portfolios with longer loan lives: – first-lien residential real estate and home equity lines of credit. Each plot shows CECL allowances assuming perfect foresight for the macroeconomic variables (dashed line) and using real time forecasts (solid line). Data on allowances under the incurred-loss methodology is not available for these two portfolios on the regulatory reports so we cannot show ALLL in the chart. For these two portfolios, the difference between CECL under perfect foresight and real time is clear. Between 2005 and 2007, CECL allowances under perfect foresight would have started to increase at a steady pace, while real-time CECL allowances would have remained about unchanged. During 2007 and 2008, CECL allowances in real-time would have risen very rapidly to catch-up CECL allowances under perfect foresight. For instance, CECL based allowances in real time would have been 0.6 percent in 2005:Q4 and 5.7 percent in 2008:Q4. For a \$500 thousand first-lien mortgage loan, a bank would be booking a loss of \$3 thousand in good times and \$28.5 thousand in bad times. Lastly, the charts in Figure 9 show that the procyclicality of the CECL methodology is in large part driven by loan portfolios with longer loan lives.

Ultimately, we are most interested in the implications of CECL on the level of capital and lending. Figure 10 plots provisions under the CECL standard and as reported by banks under the incurred loss methodology. Because provisions under CECL were so volatile and lumpy, the chart depicts provisions using a four-quarter moving average just to be able to compare the behavior of provisions under the two accounting regimes. As shown in the chart, provisions under CECL start to ramp up about two quarters before the increase in provisions under the incurred loss methodology. Although, provisions under the two standards look remarkably close, CECL-based provisions are higher than those under the incurred loss methodology between the first quarter of 2006 and the fourth quarter of 2008. The level of allowances shown in Figure 7, depicts the cumulative difference in the level of provisions over time. That chart also shows that CECL allowances are not smooth and exhibit some excess volatility as a result of updates to the macroeconomic projections. Without the four-quarter moving average, CECL-based provisions would have been much more volatile.

In summary, our results show that CECL would have been very procyclical had it been in place during the 2007-2009 financial crisis. In particular, the new standard will reduce bank capital when it is difficult or more costly for banks to raise outside equity, therefore banks could be forced to cut back on lending, which in turn could amplify the decline in economic activity. The main reason underlying the procyclicality of CECL is that it is very difficult to predict turning points in the business cycle, and those forecast errors will be especially impactful on the determination of CECL allowances for portfolios with longer loan lives.

5.3 CECL Allowances using Monte Carlo

This section shows the sensitivity of CECL allowances to different macroeconomic scenarios. The estimation of CECL allowances is very sensitive to the macroeconomic scenario considered. In reality, banks will project their CECL allowances under more than one scenario. Figure 11 plots the results for CECL allowances under the baseline macroeconomic scenario, an optimistic scenario (equivalent to the 5th percentile of the path of the macroeconomic projections) and a pessimistic scenario (equivalent to the 95th percentile). Using a more pessimistic scenario during 2005 through 2007 would have raised CECL allowances from 1.6 percent to 2.6 percent. However, that would not have prevented the procyclicality of CECL because models would have required banks to still raise reserves aggressively during the 2007-2009 financial crisis. Moreover, under the current specifications of our top-down models we didn't find a significant difference between CECL-based allowances obtained under the baseline macroeconomic scenario and those obtained by averaging the results across all possible scenarios. Although our top-down models are nonlinear, it only impacts some portfolios. This in area we intend to explore further, perhaps using quantile regressions as in Covas, Rump and Zakrajsek (2014).

6. Procyclicality of CECL

This section assesses the impact of CECL on banks' regulatory capital ratios. It also presents an estimate of the increase in capital requirements on the lending capacity of the banking sector and GDP during the 2007-2009 financial crisis.

6.1 Impact on Regulatory Capital Ratios

We first study the impact of CECL on the behavior of the Tier 1 common capital ratio during the 2007-2009 financial crisis for the entire U.S. banking industry. We chose the Tier 1 common capital ratio (Tier 1 common capital as a percent of risk-weighted assets) because it was the same regulatory capital ratio used in the Supervisory Capital Assessment Program (2009) to assess the capital adequacy of banks, and provides the greatest loss absorption capacity. The changes in equity and capital are determined by the evolution of provisions under CECL. Specifically, provisions under CECL in quarter t are determined by

$$Prov_t^{CECL} = CECL_t - CECL_{t-1} + NCO_t \tag{6}$$

where NCO_t are the dollar amount of net charge-offs in quarter t. Next, the estimated impact of CECL on the Tier 1 common capital ratio for the U.S. banking industry is defined as:

$$T1CR_t^{CECL} = T1CR_t^{ALLL} - (1-\tau)\frac{\sum_{i=0}^{t}\left(Prov_i^{CECL} - Prov_i^{ALLL}\right)}{RWA_t} \tag{7}$$

where τ is the tax rate, which is assumed to be equal to 21 percent and RWA_t is risk-weighted assets. Our estimate likely understates the impact of the CECL-based allowance on regulatory capital ratios because although the calculation includes the impact of taxes, it does not take into consideration the Tier 1 common capital limits on deferred tax assets.

The adjusted Tier 1 common ratio is first calculated in the second quarter of 2005 (i.e., the quarter in which $i = 0$) since the first estimate of CECL allowances is only available in the first quarter of 2005 and to calculate the provision expense the previous quarter of CECL-based allowances is required. Also, for simplicity, the analysis on the impact of capital assumes that there is no "day one" impact of the adoption of CECL on banks' regulatory capital ratios. That is, we are implicitly assuming the level of reserves under CECL is approximately the same as the level of reserves under the incurred loss methodology when CECL is implemented. As shown in Figure 7, this is not a very strong assumption since we estimate CECL allowances to be only slightly lower relative to ALLL in the first quarter of 2005.

Figure 12 plots the observed Tier 1 common ratio for the entire U.S. banking industry and the Tier 1 common ratio under CECL baseline forecasts. The shaded area represents the range for the Tier 1 common ratio under more pessimistic and optimistic scenarios, respectively. The difference in the Tier 1 common ratios under the incurred loss methodology and CECL is approximately 25 basis points in the first quarter of 2007. Therefore, the implementation of CECL in 2005 would not have induced banks to significantly increase loan loss allowances up to the period in which the economic outlook starts to deteriorate.

The gap between the Tier 1 common ratio under the incurred loss methodology and CECL starts to widen in early 2007. In particular, the Tier 1 common ratio under CECL falls from 7.9 percent to 5.3 percent between the first quarter of 2007 and the third quarter of 2008. Moreover, the difference between the Tier 1 common ratio under the incurred loss methodology and CECL is 1.6 percentage points in the third quarter of 2008. Note that the Federal Reserve considered a 5 percent Tier 1 common ratio as the level of capital necessary for a bank to remain "a going concern throughout stressful conditions and on a post-stress basis" in the 2011 Comprehensive Capital Assessment Program. Because the aggregate regulatory capital ratio reached 5.3 percent in the third quarter of 2008, many banks would have crossed the 5 percent threshold under the CECL regime. It is also possible that more banks would have failed during the financial crisis as a result of an inability to satisfy minimum capital requirements.

Had CECL been in place in the 2007-2009 financial crisis, the decline in Tier 1 common ratios would probably not have been so dramatic because banks would have done all they could to prevent such declines and continued to be viewed as viable and solvent by investors and creditors, including the providers of short-term funding. To avoid such large declines in their regulatory capital ratios during the crisis, banks would have had no other viable alternative than slashing their equity payouts and reducing lending very aggressively, thereby amplifying the recession. In the next section we try to provide an estimate of the impact of CECL on lending during the last crisis.

6.2. Macroeconomic Implications of CECL

The previous results showed that CECL will reduce banks capital during a recession, likely encouraging banks to reduce lending, which could exacerbate a downturn. The consequences for bank lending would be similar to those from increasing capital requirements. In this section we try to quantify the impact of CECL on the availability of credit during a downturn and on GDP using the estimated impact on banks' regulatory capital ratios obtained in the previous section. In the case of CECL, it is crucial to evaluate the effective increase in capital requirements at the onset of a recession because that is when capital is the most valuable to absorb losses and at a time when banks are likely unable to raise new equity.

Generally, it is difficult to estimate the impact of an increase in capital requirements on credit supply during an economic downturn because a recession affects both banks' capital ratios via write-downs and depresses loan demand. Thus, we need to be able to separate changes in loan supply from changes in loan demand in driving the overall change in bank lending during a recession. A recent paper by Behn, Haselmann and Wachtel (2016) looked at changes in credit supply by comparing changes in lending to the same borrowers by banks using model-based capital requirements versus banks using capital requirements that are invariant to changes in economic conditions, namely the standardized approach. In particular, the risk-weighted assets of banks using model-based capital requirements increase as a result of a worsening in economic conditions driven by a rise in the likelihood of a borrower defaulting on its loan. This methodology works as an identification strategy because the paper controls for the impact of changes in loan demand on lending by focusing on loans to the same borrower provided by different banks subject to different types of capital requirements. Thus, this mechanism is very similar to CECL because banks using a model-based approach to determine their risk-weights experienced a decline in their capital ratios during the 2007-2009 financial crisis as credit risk rose. In particular, the paper finds that a 0.5 percentage point increase in capital requirements causes a reduction in the supply of such loans by an additional 3 percentage points relative to loans subject to invariant capital requirements. Since we have estimated a 1.6 percentage point increase in capital requirements, or 3x higher than the findings in Behn et al (2016), the adoption of CECL in the past financial crisis would have led to a decline in lending by an additional 9 percentage points relative to what occurred during the crisis. This decline would have translated to an additional $600 billion decrease in aggregate holdings of loans on banks' books during that year. According to the Fed's H.8 release, total loans declined 10.2 percent in 2009.

Lastly, we tried to translate the 9 additional percentage point decline in loan growth to GDP. According to the Federal Reserve's October 2008 Greenbook Forecast, tighter bank lending standards observed over 2008 were projected to reduce the level of real GDP between 3 and 4 percent by the end of 2009. Our results indicate that the impact of CECL would lead to an additional 9 percentage point decline in lending, approximately twice the reduction in bank lending registered over 2009. Thus, the additional reduction in bank lending would have translated into a very sizable decline in real GDP during the crisis period according to the Fed's own forecasts at the time.

7. Conclusions

In this paper, we used a top-down model to assess the impact of CECL on banks' regulatory capital ratios during the 2007-2009 financial crisis. Specifically, we were able to generate forecasts for net charge-offs for various loan portfolios, using real-time projections for the macroeconomic variables that drive the behavior of net charge-offs. Other existing literature on this topic refers to "perfect foresight" in assessing the earlier recognition capabilities of CECL. This is not realistic, however, as professional forecasters were unable to effectively foresee the timing and the extent of turning points in the business cycle. We, therefore, apply macroeconomic forecasts available at the time in order to generate the loss rate forecasts for all major loan portfolios. We show that this more realistic scenario causes the level of CECL allowances to be just slightly higher than the level of allowances actually recorded under the incurred loss methodology until the start of the crisis in 2007. After that, CECL allowances would have experienced a rapid rise over the following six quarters causing banks' regulatory capital ratios to fall abruptly at the worst possible time during the past crisis. Moreover, our results also indicate that CECL-based allowances would have overshot and prolonged the recession as forecasts were slow to recognize the start of the recovery. Lastly, our results also suggest that in real time loan loss provisions under CECL would be highly volatile. Thus, our results indicate that CECL will increase procyclicality and will amplify the decline in credit availability during the recession due to inherent difficulties of macroeconomic models (and forecasters) being able to accurately predict turning points in the business cycle.

In addition, as we noted in the introduction, under CECL banks are required to establish a credit loss allowance based on the expected lifetime losses on the loan when they originate the loan. As a result, banks will book an immediate loss, with no compensating gain, for each loan they make. Therefore, banks struggling to maintain profitability in a downturn will have a strong incentive to stop lending to riskier borrowers. The procyclicality of CECL caused by its impact on net income is an important topic for future research.

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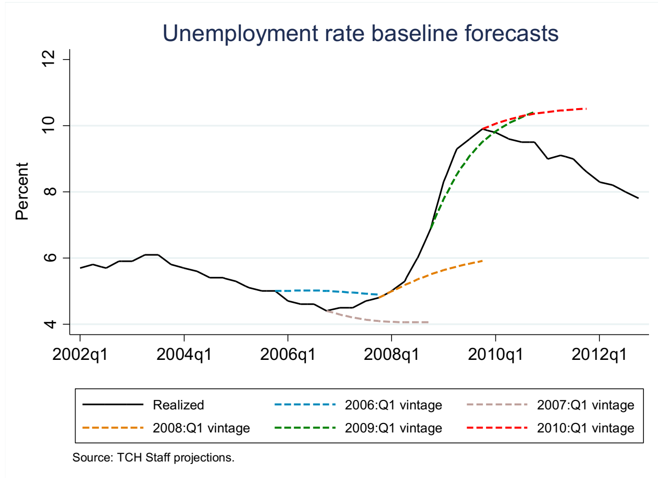
Figure 1



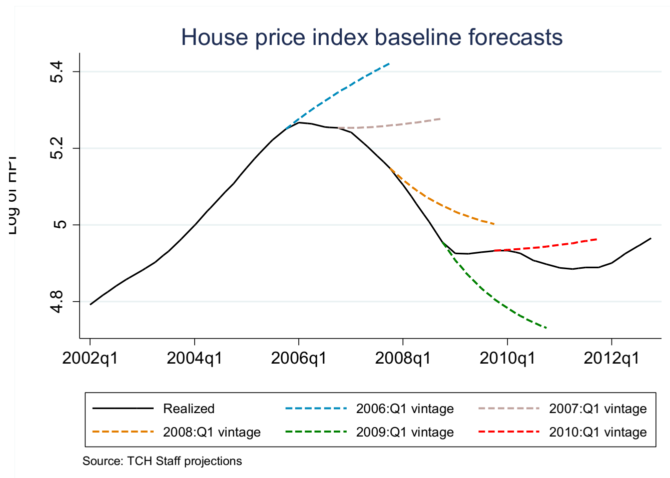


Figure 2

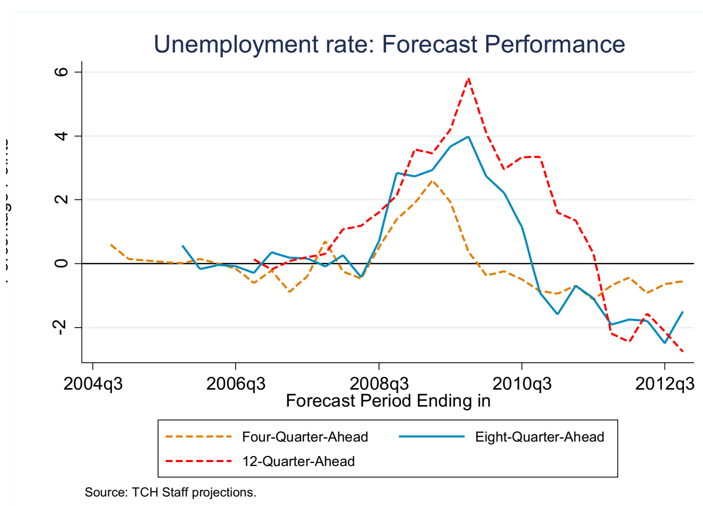


Figure 3

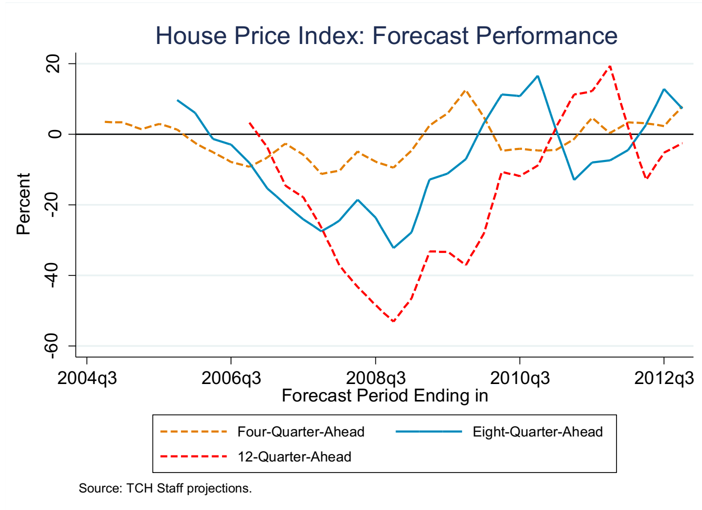


Figure 4

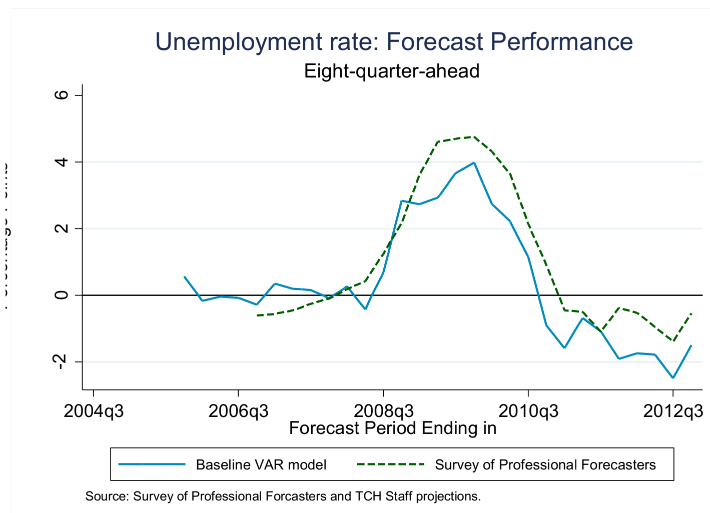
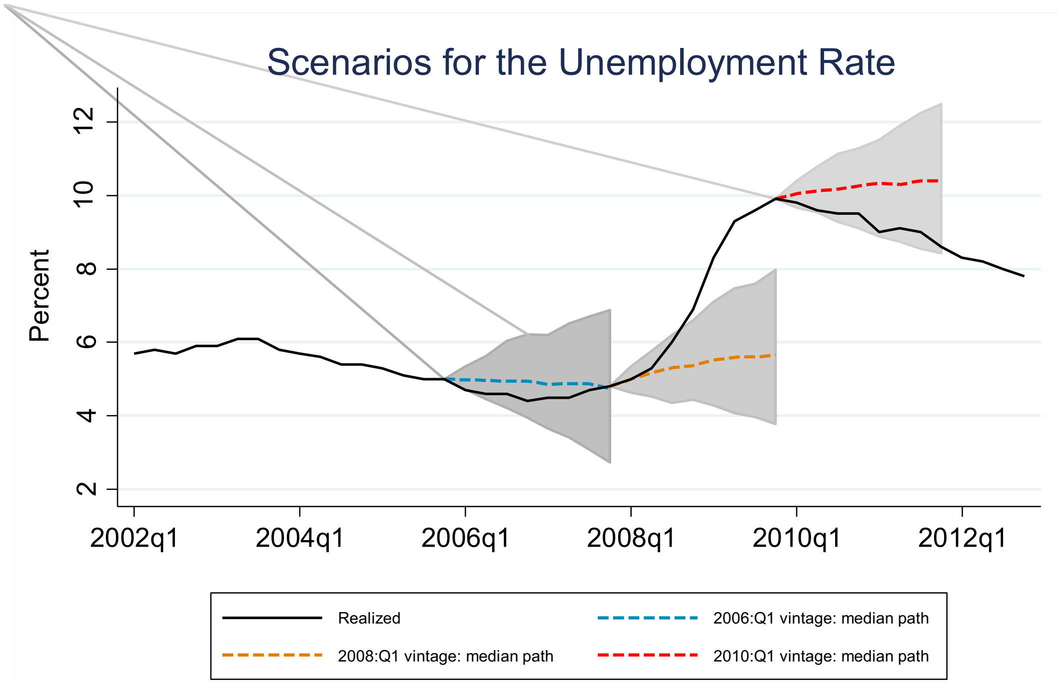
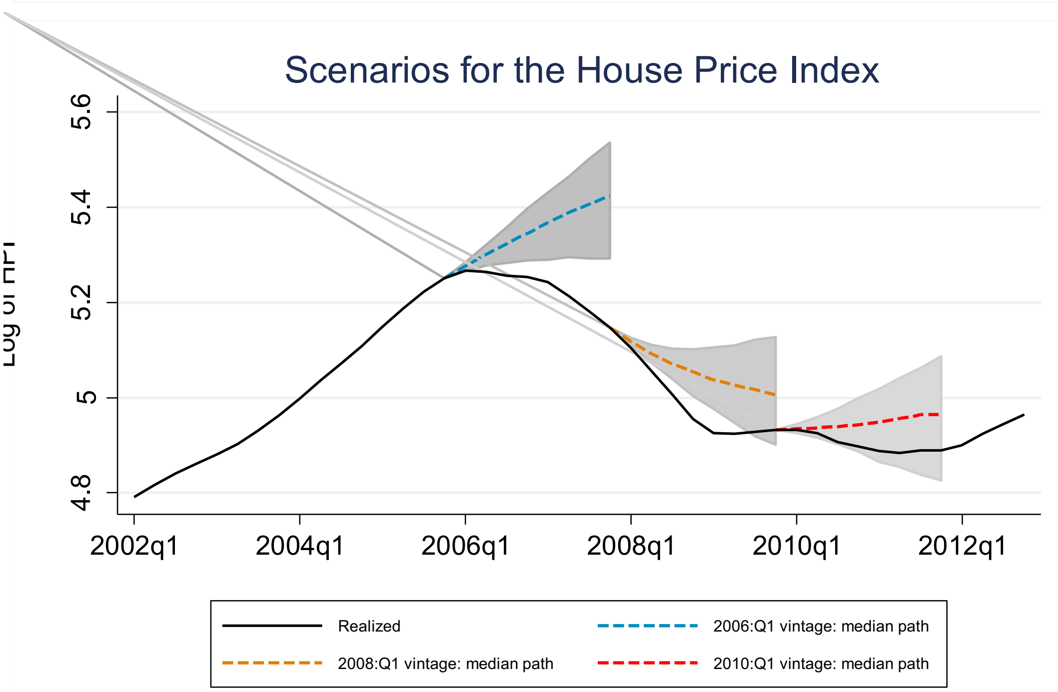


Figure 5



Source: TCH Staff projections.

Note: Scenarios generated using a VAR in first-differences. The shaded area represents the 10th lowest and the 190th highest values of the series across all 200 macroeconomic scenarios



Source: TCH Staff projections.

Note: Scenarios generated using a VAR in first-differences. The shaded area represents the 10th lowest and the 190th highest values of the series across all 200 macroeconomic scenarios

Figure 6: Illustration of the Forecasting Horizon for a Loan Portfolio

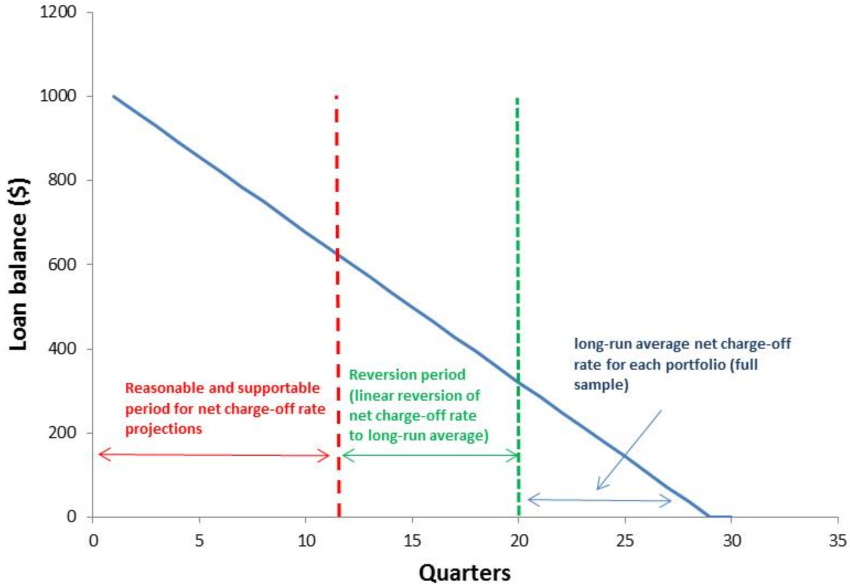
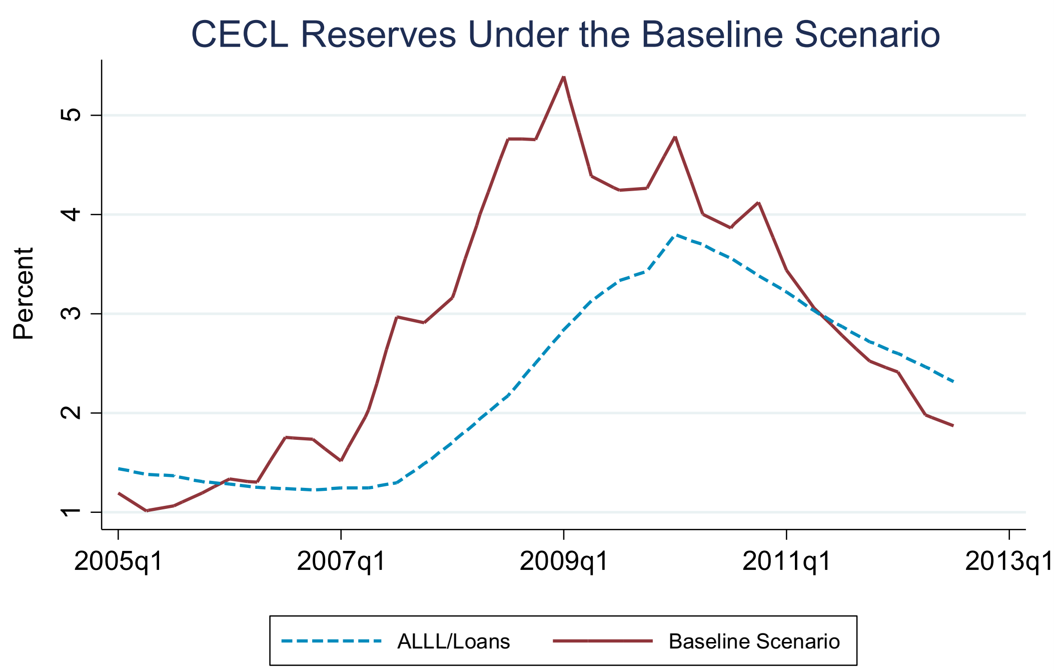


Figure 7



Source: TCH Staff projections.

Note: Projections generated using a VAR in first differences.

Figure 8: CECL Allowances under Perfect Foresight for the House Price Index

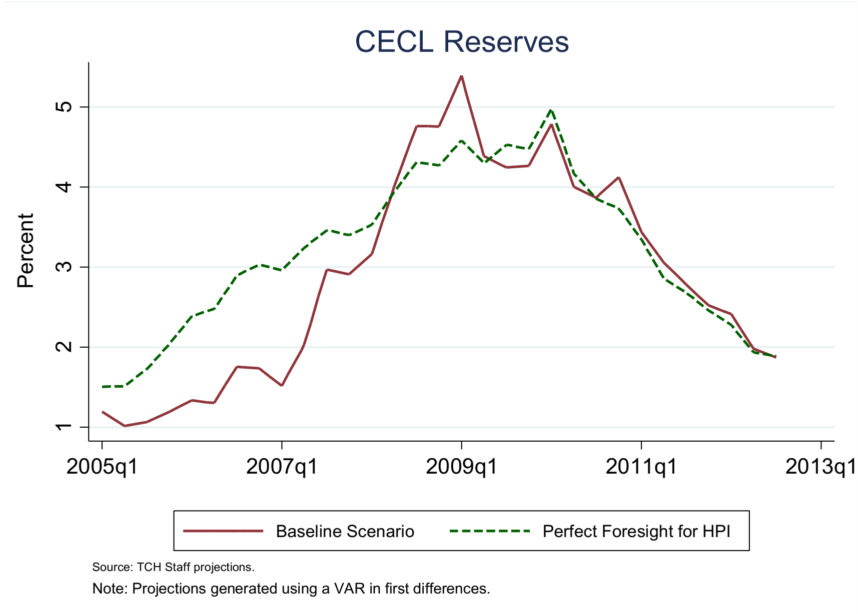
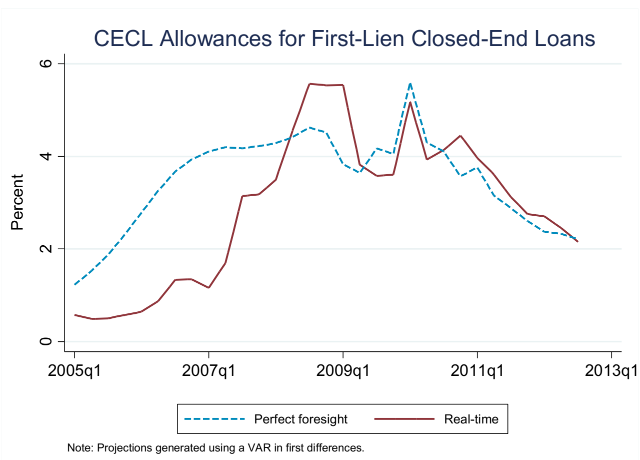


Figure 9



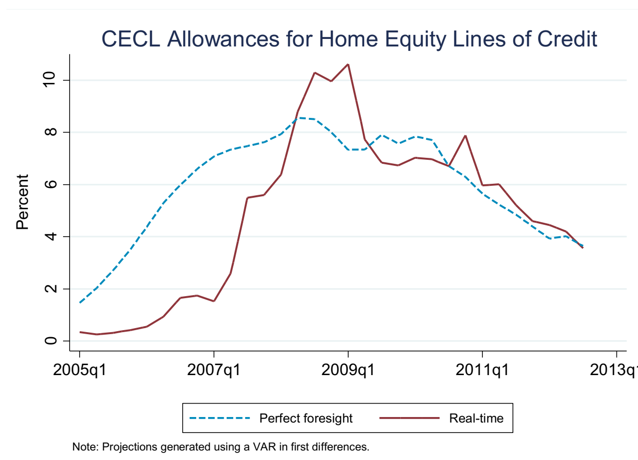


Figure 10

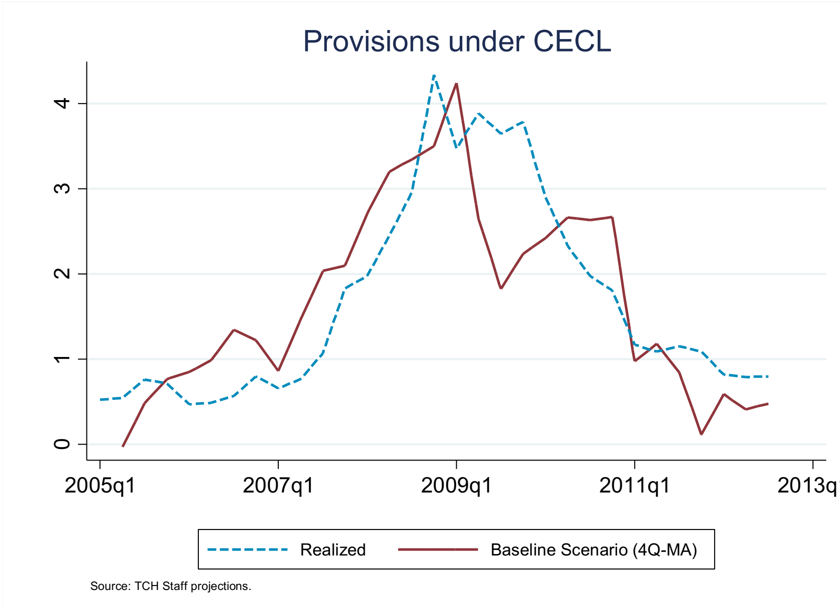


Figure 11

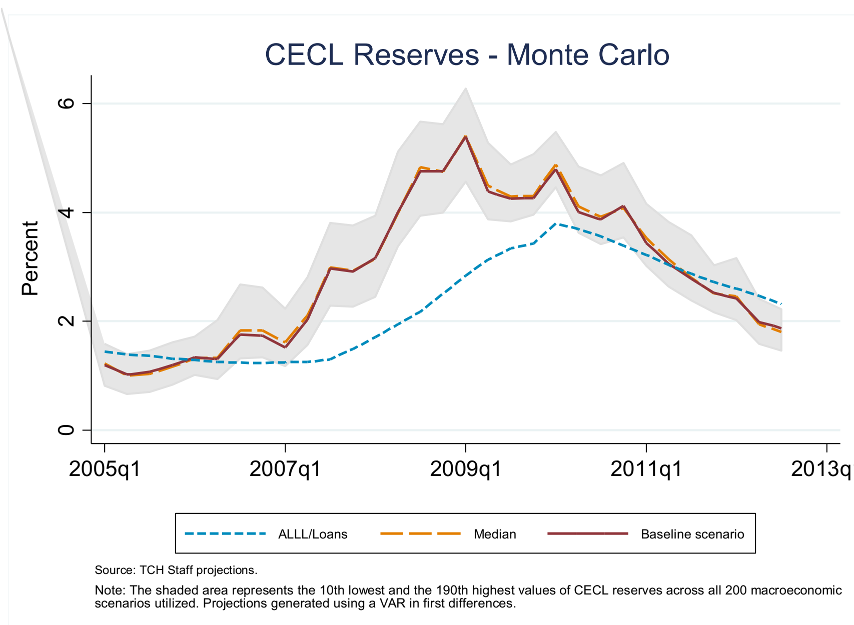
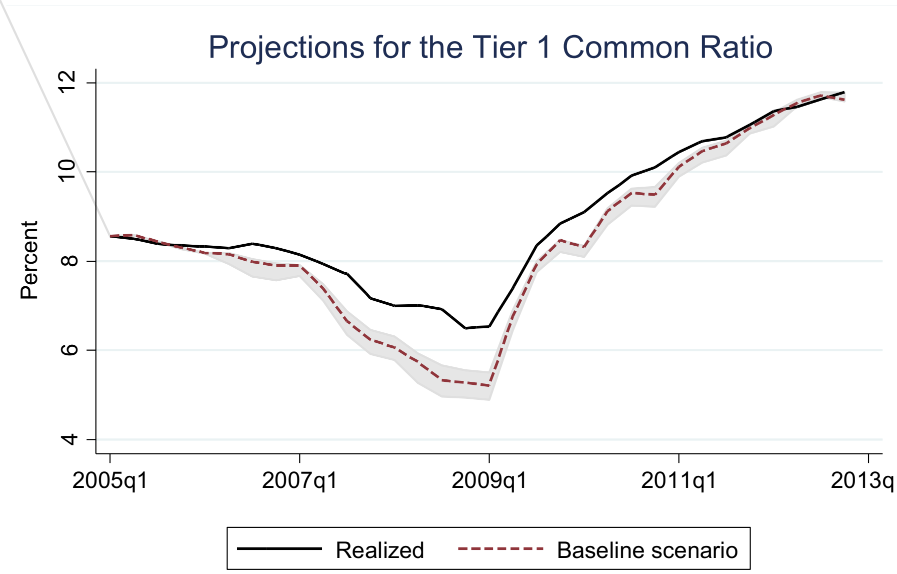


Figure 12



Source: TCH Staff projections.

Note: The shaded area represents the 10th lowest and the 190th highest values of CECL reserves and the Tier 1 common capital ratio across all 200 macroeconomic scenarios utilized.

Table 1: Loan portfolios and Macroeconomic Series

Loan Portfolio	Macro series
Commercial and industrial	Unemployment rate
Construction	CRE prices
Nonfarm nonresidential	CRE prices
Multifamily	CRE prices
First-lien mortgages	House prices
Junior-lien mortgages	House prices
HELOCs	House prices
Other real estate	CRE prices
Credit cards	Unemployment rate
Other consumer loans	Unemployment rate, Time Trend
Leases	Unemployment rate
Foreign governments	Unemployment rate
Agriculture	Unemployment rate
Depository institutions	Unemployment rate
Other loans	Unemployment rate

Table 2: Summary Statistics for Net Charge-off Rates

	Mean	SD	Min	Median	Max
Commercial and Industrial	0.8	0.7	0.1	0.5	2.8
Construction CRE	1.2	1.9	-0.2	0.1	8.5
Multifamily CRE	0.4	0.5	0.0	0.1	2.4
Nonfarm-nonresidential CRE	0.4	0.5	-0.1	0.1	2.1
First-lien mortgages	0.4	0.5	0.0	0.1	2.8
Junior-lien mortgages	1.6	2.1	-0.1	0.5	9.4
HELOCs	0.7	0.9	0.1	0.2	3.5
Other real estate	0.4	0.5	0.0	0.2	2.8
Credit cards	4.9	1.7	2.8	4.4	11.0
Other Consumer loans	1.7	0.8	0.5	1.6	4.6
Leases	0.4	0.4	0.0	0.3	1.8
Foreign Governments	0.5	3.4	-7.4	0.0	25.0
Agriculture	0.2	0.2	0.0	0.1	1.0
Depository Institutions	0.2	0.4	-0.5	0.0	2.3
Other Loans	0.3	0.4	-0.1	0.2	1.9

Table 3: Expected Loan Life and Length of Reversion Period

Loan Portfolio	Life of loan (in quarters)*	Reversion period (in quarters)
Commercial and industrial	15	8
Construction	11	13
Nonfarm nonresidential	14	7
Multifamily	30	10
First-lien mortgages	34	15
Junior-lien mortgages	30	18
HELOCs	30	18
Other real estate	19	7
Credit cards	7	9
Other consumer loans	16	6
Leases	28	6
Foreign governments	10	1
Agriculture	8	3
Depository institutions	8	1
Other loans	10	8

Note: The life of loan is the expected number of quarters it takes for the loan balance to reach zero.

Table 4: Model Estimates of Net Charge-off Rates

Explanatory Variable	Dependent Variables: Net Charge-off Rates														
	C&I	**CLD**	**MF**	**NFNR**	**FL**	**JL**	**HLC**	**OTHRE**	**CC**	**CON**	**LEA**	**FG**	**AG**	**DI**	**OTHL**
Lagged NCO rate	0.8006***	0.7929***	0.7723***	0.8159***	0.8904***	0.8506***	0.9099***	0.5732***	0.8574***	0.6262***	0.6454***	0.5746***	0.6005***	0.3618***	0.5679***
	(0.0659)	(0.0888)	(0.1065)	(0.0957)	(0.0793)	(0.0829)	(0.0492)	(0.1547)	(0.0453)	(0.0918)	(0.075)	(0.1670)	(0.1301)	(0.1361)	(0.1296)
Change in UR (annualized)	0.1256***								0.3365***	0.1800***	0.0999***	0.0887	0.0252**	0.0567	0.1084***
	(0.0313)								(0.0776)	(0.0339)	(0.0201)	(0.1359)	(0.0114)	(0.0383)	(0.0383)
Change in CRE Index								-0.0086*							
								(0.0049)							
Change in CRE Index x (X < 0 Dummy)		-0.0590**	-0.0143**	-0.0121**				-0.0069							
		(0.0297)	(0.0065)	(0.0048)				(0.0171)							
Change in HPI					-0.0031	-0.0204	-0.0045								
					(0.0024)	(0.0132)	(0.0040)								
Change in HPI x (X<0 Dummy)					-0.0129*	-0.0523**	-0.0247***								
					(0.0076)	(0.0220)	(0.0077)								
time trend										0.0054***					
										(0.0016)					
Constant	0.1618***	0.0789	0.0354**	0.0302	0.0337*	0.2265*	0.0407	0.1644***	0.7194***	0.3507***	0.1621***	0.1332	0.0872***	0.1172***	0.1482***
	(0.0436)	(0.0511)	(0.0170)	(0.0189)	(0.0185)	(0.1256)	(0.0327)	(0.0562)	(0.2046)	(0.1062)	(0.0319)	(0.2015)	(0.0203)	(0.0383)	(0.0438)
Observations	107	107	107	107	107	107	107	107	107	107	107	107	107	107	107
Adjusted R2	0.83	0.89	0.78	0.81	0.89	0.85	0.95	0.56	0.91	0.76	0.65	0.36	0.43	0.18	0.61

Note: Sample period is between 1991:Q1 and 2017:Q4. Net charge-off rates (annualized percent): C&I = commercial and industrial; CLD = construction commercial real estate; MF = multifamily real estate; NFNR = non-farm non-residential commercial real estate; FL = first lien residential real estate; JL = junior lien residential real estate; HLC = home equity lines of credit; CC = credit card; CON = other consumer; LEA = leases; OTHRE = other real estate; FG = loans to foreign governments; AG = agriculture loans; DI = loans to depository institutions; OTHL = other loans. The table reports the estimated coefficients of each model and robust standard errors are reported in parenthesis. * p-value < 0.10; ** p-value < 0.05; and *** p-value < 0.01.