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Improved Deposit Modeling: Using Moody's Analytics Forecasts of Bank Financial Statements to Augment Internal Data

Introduction

- » Moody's Analytics forecasts of bank financial statements uses data from as early as 1980, spanning several expansions and recessions.
- » Banks' internal deposit data often extend back 10 years or less, making realistic modeling difficult.
- » In this article, we demonstrate how to combine our forecasts of bank financial statements with internal data to produce forecasts that better reflect the macroeconomic environment posited under the various Comprehensive Capital Analysis and Review scenarios.

We have worked with several banks to model their deposits, and in most cases the banks' data extend back 10 years at most. Building a regression model that adequately captures the effects of deposit interest rates, macroeconomic variables, and policy decisions is difficult even with lengthy series and is virtually impossible with data that span just one economic cycle or less. Moody's Analytics service utilizes FDIC data extending as far back as 1980 to build industry-level forecasts for dozens of types of deposit accounts. Here we discuss a naive model for money market balances built using only an individual financial institution's data along with macroeconomic variables, and then we highlight various flaws with that model. We then show how our service can be used to produce more realistic forecasts. As an additional benefit, our forecasts of bank financial statements make model-building much easier and less time consuming.

Improved Deposit Modeling: Using Moody's Analytics Forecasts of Bank Financial Statements to Augment Internal Data

BY TONY HUGHES AND BRIAN POI

Executive Summary

Many banks face the problem of having limited deposit data that span just one economic cycle, and it is virtually impossible to build a robust forecasting model that correctly captures the effects of interest rates, macroeconomic variables and bank decisions in these cases. Our service provides industry-level forecasts for several hundred line items on banks' balance sheets and income statements, including dozens of deposit account categories. We show how to leverage our service to overcome banks' limited internal data.

In our preferred approach, we first use the historical data in our service to calculate the bank's deposits as a share of the industry-level aggregate balance. In many cases, the bank's market share is either stable or easier to model than the actual balance series. We build a forecast model of the bank's market share, and then we combine that forecast with the industry-level balance forecasts from our service to obtain balance forecasts for the bank under various economic scenarios.

In most industries, a firm forecasts its sales by first considering the overall size of the market and then determining what share of the market the firm can reasonably expect to capture. We adopt the same approach for bank deposits. Among other benefits, this approach guards against outlandish forecasts, since it makes clear that if a bank's deposit base is to grow faster than the industry's then the bank must enact policies that

will expand its market share. This approach also leverages the longer economic history embedded in our service to help ensure that forecast trajectories under alternative scenarios are consistent with similar historical macroeconomic environments.

Moody's Analytics forecasts of bank financial statements variables can also be used in simple regression or error-correction models that tie a bank's deposit balances to industry-level aggregates. Including the relevant series from our service in a model helps control for the multitude of interest rate and macroeconomic factors that affect deposits, allowing the modeler to focus her attention on factors that might cause her bank's deposits to grow at a different rate than the industry's.

Introduction

Financial institutions are required to produce forecasts of their income statements and balance sheets under alternative economic scenarios as part of the annual Comprehensive Capital Analysis and Review and Dodd-Frank Act Stress Test regulatory stress tests. In past years, many institutions' model development groups have focused their efforts on forecasting credit losses, new origination volumes, and other lending-related metrics for various consumer and commercial loan portfolios, as well as for deposit accounts. Less attention has been paid to forecasting noninterest revenues and expenses, though recent guidance from the

Federal Reserve indicates that these, too, will soon be scrutinized more closely.

For all of these categories, banks typically face significant data challenges. Focusing on deposits, some institutions have been forced to build stress-testing models using as little as five years of monthly data. A more typical figure is around 10 years, though this still represents only 120 observations with which to capture not only the effects of interest rates and macroeconomic conditions but also the effects of management actions and other policy decisions. For some banks the growth is entirely organic: Managers adjust deposit rates, the number of branches, and marketing efforts to boost new account generation and to prevent account attrition. For other banks growth also results from mergers and acquisitions activity that causes aggregate balances to jump. In those cases the modeler must either account for changes in how the portfolio is managed or use only post-merger data, making it all the more difficult to identify the impact of interest rate and macroeconomic factors. Though we focus here on deposits, these issues are relevant to any volume forecast constructed by a bank in its efforts to capture pre-provision net revenue.

Modelers in the industry generally have not dealt well with these challenges. Typically, modelers clean and reconcile the available internal data to the greatest extent possible and then build simple regression models incorporating a handful of economic drivers

to produce forecasts under various scenarios. These models often ignore management actions and M&A-related factors. If, however, these excluded effects are correlated with business cycle dynamics, then the measured impact of the economy on the portfolio will be incorrect. One cannot reasonably contend that bank managers do not consider and respond to economic conditions. Moreover, modelers cannot assume that managers will respond to future economic conditions in the same way they responded to previous economic conditions. In short, a model that ignores bank policy and M&A activity will not forecast well.

With just 120 observations, the difficulty of PPNR forecasting becomes obvious. We must account for all these management actions and idiosyncrasies and still be able to capture important supply- and demand-side interest rate and macroeconomic drivers.

An alternative approach is required. In our view, volume-related PPNR modeling efforts should begin with the development or use of industry-level forecasts under various scenarios. Forecasting PPNR series aligns closely with sales forecasting principles used in market research. Consider a vacuum cleaner manufacturer. If it wants to forecast sales of a particular model, it will start by forecasting the overall size of the market for vacuum cleaners. If the product in question is a niche model, the manufacturer might then seek to define and project the size of the market for the particular kind of cleaner in question while recognizing that there will be a high level of substitutability between kinds of vacuum cleaners. Once it has established these industry-level projections, the company will examine its market share and that of its key competitors. If the company can reasonably assume that its model will attract a higher proportion of customers, the company will project growth in its market share. Of course, its market share will also be affected by other management actions such as pricing, marketing, and supply chain limitations. Once the company has projected its market share, forecasting sales is a matter of arithmetic.

In the context of deposit services or commercial and consumer lending, the same

thought process can be applied. One can size the overall market for, say, money market deposit accounts using data from our service and determine its market share. The bank can then perform the same exercises as the vacuum cleaner company to project its market share under various economic scenarios and then combine those market share projections with our service's industry-level forecasts to obtain bank-level projections. In this paper we illustrate that technique.

Industry-level projections provide other benefits as well. The industry-level data are not affected by the management actions of an individual bank, so the industry-level models can be built with a focus on identifying the effects of interest rates and macroeconomic variables. M&A activity also has no impact on industry-level aggregates, so the industry-level models can ignore that activity as well. Having industry-level projections that capture the economic environment allows the modeler at an individual bank to focus on capturing the effects of management actions and M&A activity on market share and rely on Moody's Analytics sound industry-level forecasts of bank financial statements.

Another advantage of industry data is their length. Deposit-related series are generally available beginning in the early 1980s. Lending volume data on commercial loans and residential mortgages extend all the way back to 1947. Having such rich data means that our industry-level models capture the dynamics and peculiarities of many expansions and recessions.

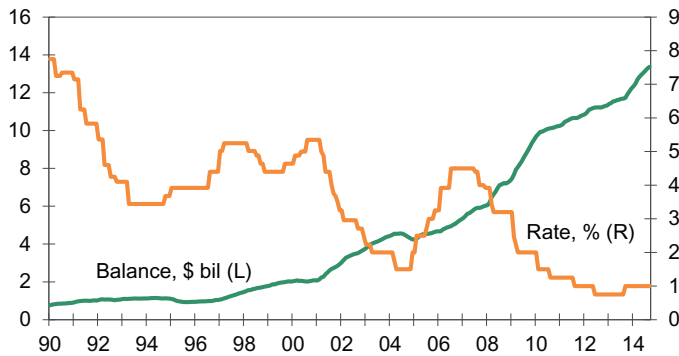
Modeling Money Market Deposits

Moody's Analytics has worked with the North Carolina State Employees' Credit Union (SECU) to perform various analyses of SECU's deposit base. In this article we focus on modeling SECU's aggregate money market account balances, but the techniques we discuss here can be used for a wide array of deposit accounts. SECU's balance and interest rate data are remarkably clean in that there are no sudden jumps or other anomalies in the data due to mergers, changes in computer systems, or other factors. Moreover, SECU has complete monthly data ex-

tending back to 1990. Other financial institutions with which we have worked often have less than 10 years' worth of data, and the data typically contain level shifts and outliers that we must accommodate. In some respects, the use of external industry data is less of an issue for SECU than it is for other banks since, strictly, we do not require data augmentation to build a useful model. Banks with poor data or short historical time series stand to gain even more than the results of the example presented here suggest.

We first build a model to forecast the credit union's money market account balances that does not use our service. This model is typical of those used in the industry, combining the credit union's balance and deposit rate data with macroeconomic variables. As we discuss more fully below, this model is about as good as one could hope to develop with just those data, and at first glance the resulting forecasts look plausible. Next we examine the corresponding industry-level money market forecasts from our service and discuss ways in which our model's forecasts are less plausible than initially thought. We then develop a model that uses our service to guide the credit union's balance forecasts while still capturing idiosyncrasies in the behavior of SECU's portfolio. We show that this model produces more sensible forecasts that better capture industry-wide trends that are likely to occur under alternative scenarios.

We use Moody's Analytics forecasts of bank financial statements as the source for our industry-level forecasts of deposit balances and focus on forecasting the credit union's market share. Many banks have deposit balances extended back less than 10 years, and it is rare to find an institution with uninterrupted data on deposits spanning two or more complete business cycles (SECU being an exception). Identifying the impacts of the macroeconomy and interest rates on balances is challenging even in ideal situations and is even more difficult when we have a short deposit history with which to work. We show below that a bank's market share is relatively easy to forecast, and we combine a market share forecast with the PPNR industry-level forecast to obtain portfolio-specific balance forecasts.

Chart 1: SECU Money Market Balance, Deposit

Sources: SECU, Moody's Analytics

We favor this market share-based approach to deposit forecasting because it aligns with how forecasting is so often done in other industries. It is certainly not the only way to use our service to produce deposit forecasts, however. We therefore discuss other ways in which our service can be incorporated into forecast models. Modelers may want to try a couple of different ways of incorporating our forecasts of bank financial statements and explore the sensitivity of their forecasts to the choice of model.

It is important that we are not asserting that an individual bank's deposit forecasts must behave exactly the same as our industry-wide forecasts. Rather, we use our forecasts as a stabilizing touchstone so that our bank-specific model can more accurately capture the effects of management decisions while accounting for industry-wide macroeconomic effects. A bank can grow its deposit base faster than the industry, but to do so requires the bank to take concrete actions. A bank cannot tenably expect above-average growth for an extended period without offering higher deposit rates, increasing its marketing spend, expanding its branch network or geographic footprint, adding sales staff, or taking other, more subtle, measures.

A Naive Model

SECU retained Moody's Analytics to develop balance forecast models for several non-maturity deposit accounts, including checking and money market accounts. SECU

is a credit union open only to people employed by the state government of North Carolina, so its deposit base consists almost entirely of small accounts held by individuals. SECU does not accept brokered deposits or other institutional funds. In this paper we

focus on the model we developed to forecast money market account balances, as money market balances represent about 60% of SECU's total non-maturity deposits.

SECU was an unusual client in that it was able to provide to us uninterrupted monthly balance and deposit rate data back to 1990. Many banks, having taken over other institutions with disparate information technology systems, often do not have access to such a rich dataset. Chart 1 plots SECU's balance and deposit rate for the last 25 years. (See Chart 1.)

SECU's money market balances have grown almost continuously. There is only one episode in which balances declined more than three months in a row, in 2004 when SECU lowered its interest rate on money market accounts to 1.5%, and even then the decline was modest. Deposit rates have been in a broad decline along with market-level interest rates, but we still see rising rates during periods of economic growth and falling rates during slowdowns.

A bank's ability to attract and retain deposits is partly determined by the deposit rates it pays, and that is particularly true for money market accounts. Retail money market accounts tend to have higher balances than standard checking accounts, and customers make fewer deposits and withdrawals from money market accounts. ATM networks, branch locations, automatic payroll deposits and bill-paying arrangements, and other convenience factors reduce the likelihood a customer will switch banks to reap only slightly higher

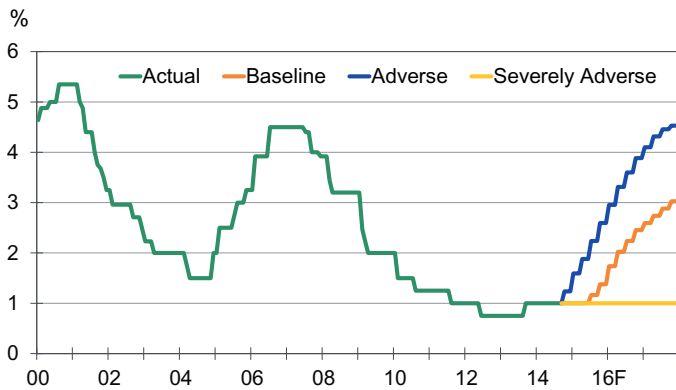
interest rates on checking accounts. Those factors do not have as much influence on money market accounts, and account holders will be more likely to switch institutions in search of higher deposit rates. Thus, to forecast a bank's money market balances accurately we must also forecast the bank's deposit rates under the same economic scenarios.

Asset liability management systems often require the user to specify a so-called β parameter that measures the sensitivity of the bank's deposit rate with respect to a change in a short-term market-level interest rate such as the yield on three-month Treasury bills. A β of 100% means that a 1-percentage-point increase in the market interest rate will cause the bank to raise its deposit rate by 1 point as well. Moody's Analytics used simple regression analysis to estimate SECU's β parameters for several types of accounts; for SECU's money market deposit rate we estimate β to be between 66% and 71% when using the three-month Treasury bill yield as our measure of market interest rates.

In principle, we could simply use the regression model we used to estimate the β parameter to forecast SECU's deposit rate as a function of the three-month Treasury bill yield. The problem is that Treasury bill yields have been essentially zero since late 2008, yet SECU has paid at least 75 basis points since then, and even raised its deposit rate to 1% in September 2013. Even if market-level interest rates begin to rise, SECU need not raise its deposit rate to remain competitive. Moreover, the spread between SECU's deposit rate and the three-month Treasury bill yield does not remain constant over the course of the business cycle. Forecasting deposit rates using a purely quantitative model is impossible, and using some degree of judgment is inevitable. Chart 2 shows our deposit rate forecasts under the three CCAR scenarios. We use the same deposit rate forecasts in our PPNR-based balance forecasts below as well. (See Chart 2.)

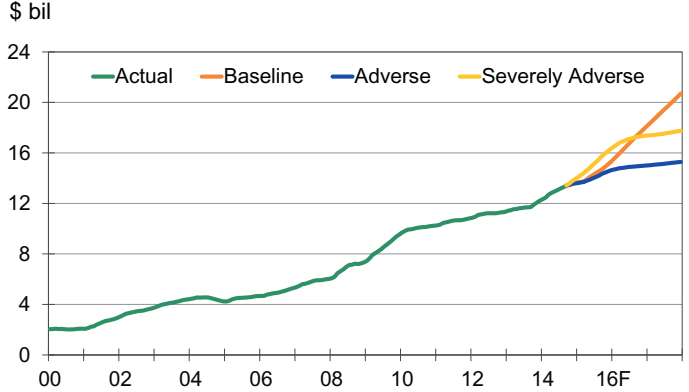
We also developed a linear regression model to predict balances as a function of SECU's deposit rate, the three-month Treasury bill yield, and other macroeconomic

Chart 2: SECU Money Market Rate Under CCAR



Sources: SECU, Moody's Analytics

Chart 3: Naive Money Market Balance Under CCAR



Sources: SECU, Moody's Analytics

factors. Although practitioners often remark that interest rate spreads determine deposit behavior, we still prefer to include both those interest rates in our models rather than just the spread between them. Most banks do not adjust retail deposit rates as quickly as short-term market-level interest rates move, and they look at a variety of market-level interest rates when setting deposit rates. Short-term market-level interest rates reflect economic conditions and therefore have a direct impact on balances other than through the interest-rate spread channel. We also included the 10-year Treasury note yield, the North Carolina employment rate, and year-over-year changes in the U.S. median existing-home price, North Carolina employment, North Carolina personal income, and North Carolina retail sales in our regression model.

A key concern of SECU throughout our engagement was whether the effects of

interest rates and macroeconomic factors varied depending on the current interest rate environment. Would depositors respond in the same way to a quarter-point increase in the deposit rate as they would to a quarter-point decrease? We therefore created a variable based on the federal funds rate to indicate rising- and falling-rate regimes, and we allowed the intercept and all slope coefficients of our regression model to vary across regimes. We found that this flexibility greatly increased the in-sample fit of our model and produced more plausible forecasts. (See Chart 3.)

Chart 3 shows our naive model forecasts for the three CCAR scenarios. Our next task is to identify the key shortcomings of these naive forecasts.

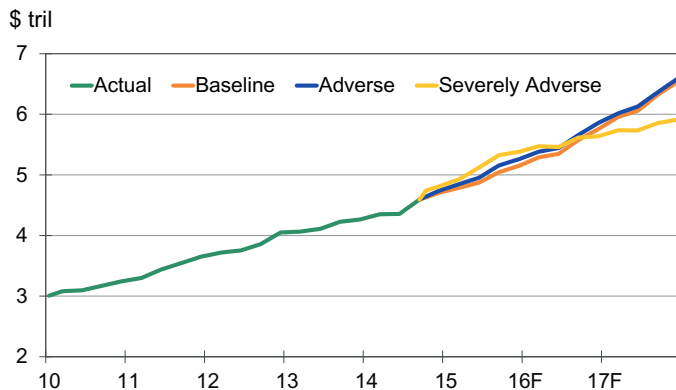
First, Chart 4 shows the industry-level forecasts for money market demand accounts of our service. Under the baseline scenario, balances grow in line with their historical trend. Under the severely adverse scenario, balances initially grow faster than under the other scenarios; we ascribe that behavior to precautionary saving on the part of households, a flight-to-safety effect that is prominent in most deposit volume

series. As the economy drags along and slowly recovers, balance growth becomes more lethargic. Most interesting is the adverse scenario, in which higher inflation and interest rates, which tend to have a positive impact on balances, are accompanied by higher unemployment, which tends to have a negative impact. In the adverse scenario, balances grow slightly faster than under the baseline scenario. Even though the higher unemployment and slower economic growth will drag down account holders' deposits of additional funds, the funds currently in the accounts will grow relatively rapidly thanks to the higher interest rates. (See Chart 4.)

In light of these industry-level forecasts, we see several deficiencies in our naive SECU forecasts. Our baseline forecast is overly aggressive, with balances growing an average of nearly 1.1% per month; prior to the Great Recession, balances had been growing closer to 0.95% per month. The severely adverse forecast also appears aggressive, with balances growing more than 1.2% per month throughout most of 2015 despite rising unemployment.

Most troubling is the naive forecast under the adverse alternative scenario. Under this set of assumptions, North Carolina unemployment rises by only half as much as under the severely adverse scenario. Growth in retail sales and personal income remains positive in the adverse scenario but declines in the severely adverse scenario. Inflation rises in the adverse scenario, but market interest rates increase even more,

Chart 4: PPNR Industry Money Market Forecasts



Sources: FDIC, Moody's Analytics

and the real return to Treasury bills is higher under the adverse scenario than under the severely adverse scenario, implying that the cost to holding cash in bank accounts is lower under the adverse scenario. Based on these factors, we find the balance forecast under this alternative scenario to be implausible.

We should not be too hard on ourselves when judging this naive model. The forecasts it produces, while perhaps too optimistic or pessimistic, as the case may be, are not entirely unreasonable. Without the benefit of seeing the industry-level forecasts in our service, and thinking carefully about how they should be constructed, we would be willing to use these forecasts, perhaps in conjunction with a management overlay that reflects other qualitative factors. These forecasts are certainly more credible than many we have seen used by other banks. Given SECU's internal data and just a palette of U.S. and North Carolina macroeconomic variables, our forecast model is as reasonable as one could expect to develop. The baseline and severely adverse scenario forecasts certainly reflect the different macroeconomic assumptions underlying them.

We now show how Moody's Analytics forecasts of bank financial statements can address the limitations we have noted above.

A Useful Decomposition

Let d_{it} denote bank i 's deposits at time t . In the naive forecasting approach we build a model of d_{it} as a function of interest rates and other macroeconomic variables. We may

instead choose to model the growth rate or some other transformation of d_{it} , but we nevertheless still use interest rates and other macroeconomic variables in a regression framework to obtain forecasts of d_{it} .

Now let D_t denote the industry-wide level of deposits at time t . D_t is collected by the Federal Reserve and FDIC, and our service includes forecasts of D_t for a variety of economic scenarios. We can write d_{it} as

$$(1) \quad d_{it} = s_{it} \cdot D_t$$

where s_{it} is the share of industry-wide deposits held by bank i at time t . Equation (1) leads to the approximation

$$(2) \quad \text{Growth in } d_{it} \approx \text{Growth in } s_{it} + \text{Growth in } D_t$$

Equation (2) shows that a bank's deposit growth stems from two sources: growth in industry-wide deposits and growth in the bank's market share.

When we build a naive model for d_{it} we are forcing our regressors to account for both changes in market share and overall industry growth. Policy variables such as deposit interest rates affect a bank's market share s_{it} , yet changes in those policy variables do not happen in a vacuum. Bank managers change their deposit rates in response to market conditions. As a result, a naive model will have difficulty identifying the true effect of a change in deposit rates unless the model also includes all variables that managers consider when setting rates and that have direct effects on balances.

That is impractical. With the relatively short datasets that are typically used in the industry (SECU suffers less of a constraint than most), good statistical practice dictates that we are limited in the number of regressors we include in our model.

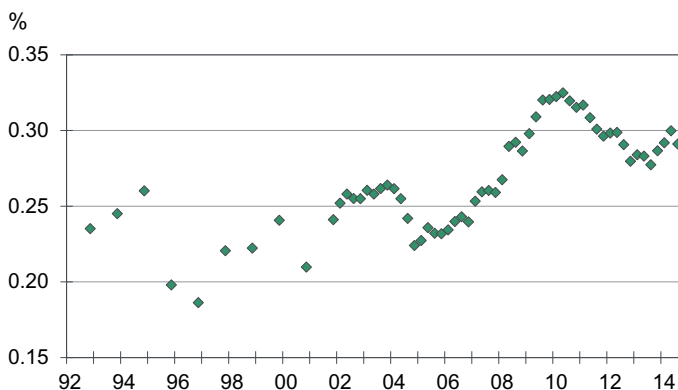
We propose modeling s_{it} directly and combining those forecasts with Moody's Analytics forecasts of bank financial statements for D_t . That approach offers several advantages. It relieves the modeler of the need to identify macroeconomic factors that drive industry-wide balances, allowing her to concentrate on identifying factors that affect market share. Identifying the causal impact of deposit rates now becomes possible. Moody's Analytics forecasts of bank financial statements contains nationwide aggregates, so for a smaller bank the model for s_{it} will incorporate not only policy variables such as deposit rates but also regional economic factors that may explain why bank deposits in the bank's footprint will grow more quickly or slowly than the rest of the nation's bank deposits. Still, controlling for differences in economic performance for a region versus the nation is an easier task than trying to identify the macroeconomic factors driving D_t when they are conflated with other internal drivers.

An Example

We again use our credit union's money market balances as an example. We first compute the market share s_{it} as SECU's aggregate money balance in quarter t divided by the FDIC's industry-level series "Domestic Deposits—Money Market Deposit Accounts." Prior to 2002, the FDIC reported these data only annually. Chart 5 shows SECU's market share, which has grown over the past 20 years in part because the credit union more than doubled the number of branches in its network. (See Chart 5.)

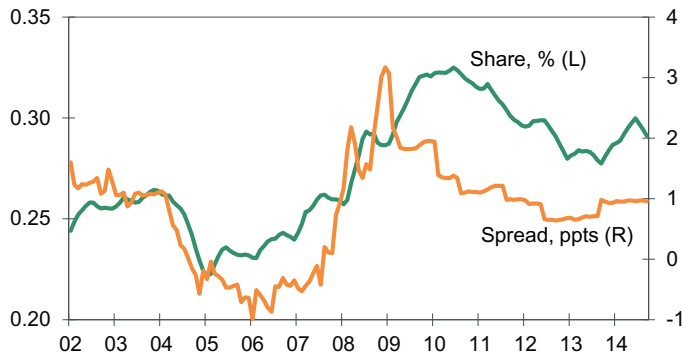
We have monthly data from SECU, although most macroeconomic series other than interest rates are available only at a quarterly frequency. Moreover, we have worked with other banks that have had monthly deposit data extended back only to 2005 or even 2008. To maximize our use of the available data and to make our example as applicable as possible, we therefore model SECU's market share at a monthly frequency. We convert the quarterly macroeconomic data and our forecasts of bank financial statements to monthly frequency using the data conversion tools available on the

Chart 5: SECU Money Market Bal., Industry Share



Sources: SECU, FDIC, Moody's Analytics

Chart 6: SECU Market Share and Deposit Rate



Sources: SECU, FDIC, Moody's Analytics

Moody's Analytics DataBuffet.com service. (See Chart 6.)

Chart 6 plots SECU's monthly market share since 2002 along with the deposit rate spread, defined as the difference between the deposit rate paid by the credit union on money market accounts and the yield on three-month Treasury bills. The chart neatly illustrates the magnitude of the credit union's market share growth during the Great Recession. In only five years, SECU's share rose by nearly half, from just more than 0.22% of industry-wide balances to more than 0.32% in 2010. Market share then waned somewhat as the recession wore on and as SECU's interest rate spread declined. This trend was reversed in 2013 when the credit union started to offer a 1% return on money market accounts—far more generous than that offered by other institutions. The chart illustrates clearly that market share is driven strongly by relative prices and that

interest rates tend to lead changes in observed market share. Still, Chart 6 implies that changes in SECU's market share are not entirely due to the interest rate spread. As we mentioned in our discussion of the naive model, banks consider a range of market-level

interest rates and other factors when setting deposit rates for their customers.

We developed an ordinary least-squares regression model of SECU's market share, and because its market share has been growing over time, we used the month-over-month change in s_{it} as our regressand. Regressors included SECU's deposit rate, the three-month Treasury bill yield, the month-over-month changes in U.S. personal income, the month-over-month change in North Carolina retail sales, and a set of quarterly indicators. SECU is a credit union based in North Carolina, so in modeling its market share we need to control for differences between macroeconomic conditions in that state and those in the broader U.S. Having both U.S. and North Carolina macroeconomic variables accomplishes this task. In addition, many of SECU's account holders are schoolteachers whose savings patterns may differ from those observed for the general population if

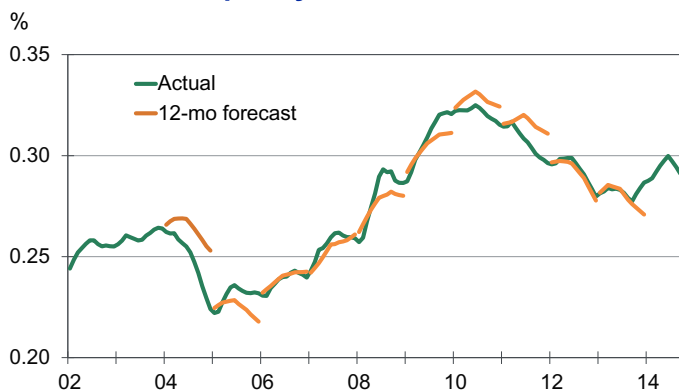
they are paid on a nine-month rather than a 12-month basis. Chart 7 shows 12-month dynamic forecasts begun in January of each year from 2004 through 2013 and indicates our model does a reasonable job of forecasting market share. Chart 8 shows our market share forecast for the three CCAR scenarios. (See Chart 7 and 8.)

During the financial crisis, SECU expanded its market share by holding its deposit rate much higher than market interest rates. Under the severely adverse scenario, SECU's market share in fact declines slightly. Market interest rates are already near zero, so the spread between SECU's rate and market interest rates simply cannot widen.

With our market share forecasts in hand, obtaining balance forecasts is simple. We simply apply equation (1), where D_t is the forecast for industry money market balances taken from our service. Chart 9 shows our balance forecasts under the three scenarios. (See Chart 9.)

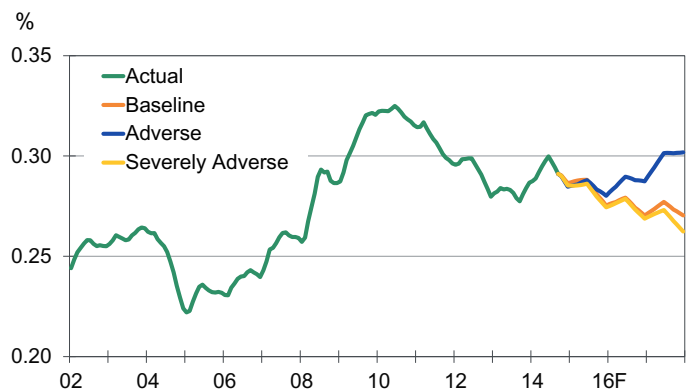
Under the baseline scenario, balances continue to grow at a moderate pace. Unlike our naive forecast, here the baseline forecast is not overly aggressive. The severely adverse scenario shows balances growing at first (likely because of precautionary savings) and then trending sideways as the economy muddles along and some savers deplete their accounts. In stark contrast to our naive forecast, under the adverse scenario here, balances grow more rapidly than under the baseline scenario. Indeed, the difference between the baseline and adverse scenarios is slightly greater for SECU than for the

Chart 7: In-Sample Dynamic Share Forecasts



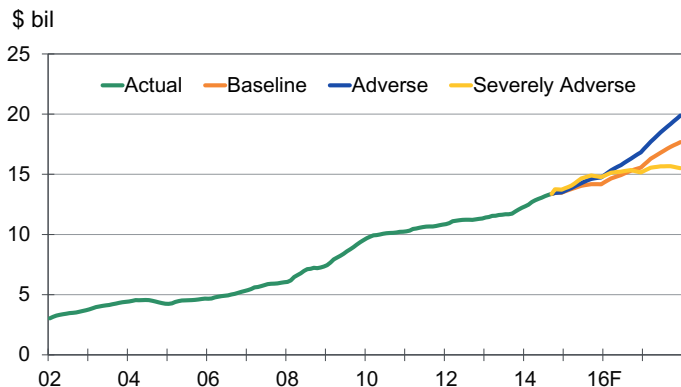
Sources: SECU, FDIC, Moody's Analytics

Chart 8: SECU PPNR-Based Market Share



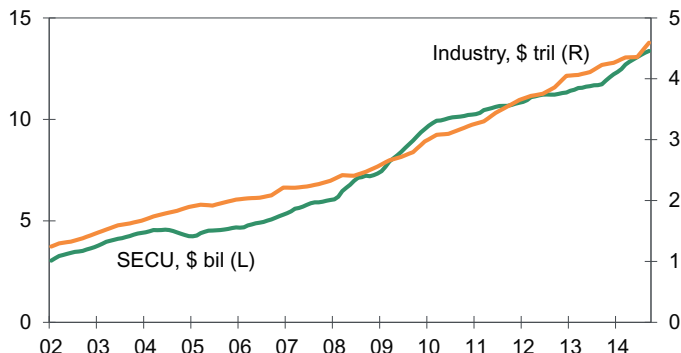
Sources: SECU, FDIC, Moody's Analytics

Chart 9: SECU PPNR-Based Balance Forecasts



Sources: SECU, FDIC, Moody's Analytics

Chart 10: SECU, Industry Money Market Balances



Sources: SECU, FDIC, Moody's Analytics

industry-level aggregate. As we said in the introduction, our goal was not to produce a bank-level forecast that exactly mirrored our forecasts of bank financial statements. Rather, we wanted to produce a set of forecasts that are consistent with industry-level trends but still reflect bank-specific idiosyncrasies. We have accomplished that task here.

Alternative Approaches

Forecasting a bank's market share and combining it with our industry-level forecasts is one way to forecast balances. Alternative approaches are also possible. Whenever we see two time series that are both trending higher over time, we can posit that the two variables may be cointegrated. A full discussion of cointegration is beyond the scope of this article but, briefly, two series are cointegrated if they exhibit common or shared trend behavior and deviations between the two series tend to correct themselves over time. In other words, two series are cointegrated if they both exhibit trends, but a linear regression of one on the other results in residuals that do not exhibit a trend. This concept is powerful, because a cointegrating relation is akin to an equilibrium existing between the variables. In this case, should such a relationship exist, it would imply that SECU's balances are driven by the same long-term forces as those operating on the industry data and that departures from equilibrium will be short term in nature. Short-term deviations will likely be due to vagaries observed in SECU's managerial strategies. (See Chart 10.)

If bank *i*'s deposit series d_{it} is cointegrated with the industry-level PPNR factor D_t , a natural modeling strategy would be to use an error-correction mechanism such as

$$(3) \Delta d_{it} = \alpha + \lambda(d_{i,t-1} - \gamma D_{t-1}) + \rho \cdot \Delta D_{t-1} + \mathbf{x}'_{it} \boldsymbol{\beta} + \epsilon_{it}$$

where $\lambda < 0$ is a parameter that determines how quickly the gap between d_{it} and D_t closes. The parameter ρ , presumably positive, implies that on average when the industry-wide series increases, so too will bank *i*'s deposits. Vector \mathbf{x}_{it} consists of other stationary variables such as deposit rates and macroeconomic variables thought to influence changes in bank *i*'s deposit balances. (If other nonstationary variables are to be included in equation (3), then other estimators of cointegrated systems would be required. Modelers who have worked with time series data will be familiar with these, but for simplicity we do not discuss them further here.)

Chart 10 shows both SECU's money market balance and the corresponding industry-level figure from the Moody's Analytics forecasts of bank financial statements.

We had explored using a simple ECM such as (3) to forecast SECU's deposit balance, but despite the suggestive appearance of Chart 10, we found that our ECM did not work well. Estimated values of the parameter λ were never practically or statistically different from zero, indicating that d_{it} and D_t are not cointegrated. The reason for this discrepancy is the observed increase in SECU's market share over the estimation window. Recall

that SECU is a credit union and therefore has different incentives than a traditional for-profit bank. If we had variables to include in (3) that could capture these differences in incentives, we strongly suspect our ECM approach would prove more valuable.

Though the forecasts we obtained from this model were poor in this instance, the approach may work well for other portfolios. Specifically, if market share is observed to be nontrending, or if the modeler wishes to devote more time to conducting a detailed analysis of industry trends, the ECM approach may yield fruitful analytics results.

If the bank's balance series is not cointegrated with the industry-level PPNR factor, then another alternative would be to fit an equation such as

$$(4) \Delta d_{it} = \alpha + \theta \cdot \Delta D_t + \mathbf{x}'_{it} \boldsymbol{\beta} + \epsilon_{it}$$

or a similar specification based on growth rates

$$(5) \% \Delta d_{it} = \alpha + \theta \cdot \% \Delta D_t + \mathbf{x}'_{it} \boldsymbol{\beta} + \epsilon_{it}$$

where, again, \mathbf{x}_{it} is a vector of covariates including the deposit rate and various macroeconomic variables.

Whether equation (3), (4) or (5) happens to work best for a particular bank, all accomplish the same basic goal. By directly tying the industry-level PPNR factor to the individual bank's deposit balance, we leverage the stability of the industry-level data

and the longer history available to forecast the firm-specific factor. Including D_t in the equation directly controls for industry-level balances and indirectly controls for macro-economic factors that affect both D_t and the bank's own balance d_{it} . Thus, these equations simplify the modeler's job, as she must now focus only on variables that might explain why her bank's deposits do not grow at the same rate as the broader industry. Particularly with the short series that many banks observe, the inclusion of D_t in the modeling structure greatly reduces the difficulty of modeling idiosyncratic deposit portfolios.

We mentioned in the introduction that some financial institutions prefer to use management judgment and rely on qualitative forecasts. This approach will sometimes be inevitable but should be avoided whenever possible. Even here our service can help in at least two ways. First, it provides an industry-level benchmark against which the institution's own projections can be compared. If an internal forecast, either qualitative or quantitative, implies a doubling of market share, stress-testers should expect questions about how such a positive outcome might be generated. Second, if a bank produces a plot of its market share and finds it to be stable over time, then its forecasts should follow a similar trajectory to the relevant series in our forecasts of bank financial statements. If the

bank honestly expects its market share to grow under a particular scenario, then it can combine those projected changes in market share with the Moody's Analytics forecasts of bank financial statements to obtain projections specific to the portfolio in question.

Conclusion

Current approaches to PPNR volume modeling for stress-testing have a severe credibility problem. Banks will typically source the small amount of internal data available and then correlate internal volume statistics with an array of macro drivers. This approach lacks a coherent behavioral framework, since the actions of managers are assumed either to be irrelevant or to be handcuffed to unfolding macroeconomic trends. For this reason, PPNR models, as currently specified in the industry, are unlikely to find favor with managers trying to understand complex portfolio behavior.

In this paper, we have introduced a different approach that uses a formal analysis of an institution's market share. We have applied these techniques to the important problem of stress-testing money market deposits for a large credit union. Nonetheless, we view these methodologies as being applicable across the breadth of volume forecasting related to PPNR calculation. For example, one could consider a bank's payroll expenses

as a share of all such expenses incurred by commercial banks. If the institution's industry payroll share is rising over time, while its profit share is stable, this will give considerable insight to managers grappling with the reins of the business.

Other advantages accrue from using our service. Banks can augment their (often poor-quality) internal data with external series that are often three, four or 10 times as long. If a bank has undergone mergers and has difficulty reconciling internal data systems as a result, industry data can be referenced that are not affected by such happenstances. Indeed, relevant economic drivers can be isolated using our forecasts of bank financial statements in an environment where any management action can be assumed to be irrelevant in shaping the trajectory of the series.

The results for SECU deposits show that use of Moody's Analytics forecasts of bank financial statements had a noticeable effect on stressed projections. Although it is true that our naive forecasts may have passed a validation review and regulatory muster, we want to hold ourselves to even higher standards. In our view, a true model validation will occur only when business executives willingly and productively use the model in their strategic planning exercises. We feel that the models presented here could pass this tougher test.

About the Authors

Tony Hughes is a Managing Director of research at Moody's Analytics. He serves as head of a small group of high caliber modelers, charged with identifying new business opportunities for the company. Prior to this appointment, he led the Consumer Credit Analytics team for eight years from its inception in 2007. His first role after joining the company in 2003 was as lead economist and head of the Sydney office of the company Moody's Economy.com.

Dr. Hughes helped develop a number of Moody's Analytics products. He proposed the methodology behind CreditCycle and CreditForecast 4.0, developed the pilot version of the Stressed EDF module for CreditEdge, and initiated the construction of the Portfolio Analyzer (ABS) product that provides forecasts and stress scenarios of collateral performance for structured securities worldwide. More recently, he championed and oversaw the development of AutoCycle, a tool that provides forecasts and stress scenarios for used car prices at the make/model/year level. He has a current development project related to quantifying counterparty network risks that can be applied to the assessment of systemic risk in the financial system.

In the credit field, Dr. Hughes' research has covered all forms of retail lending, large corporate loans, commercial real estate, peer-to-peer, structured finance and the full range of pre-provision net revenue elements. He has conducted innovative research in deposit modeling and in the construction of macroeconomic scenarios for use in stress-testing.

Dr. Hughes has managed a wide variety of large projects for major banks and other lending institutions. In addition, he has published widely, both in industry publications such as American Banker, Nikkei, GARP and the Journal of Structured Finance as well as several papers in peer reviewed academic journals. He obtained his PhD in econometrics from Monash University in Australia in 1997.

Brian Poi is a director in the Specialized Modeling Group at Moody's Analytics in West Chester Pennsylvania, where he develops new products for forecasting and stress testing purposes, leads external model validation projects, and supervises econometric model development for the Moody's Analytics U.S. economic forecast model. He also provides thought leadership and guidance on the use of advanced statistical and econometric methods in economic forecasting applications. In his prior role he developed a variety of credit loss, credit origination and deposit account models for use in both strategic planning and CCAR/DFAST environments. Before joining Moody's Analytics, Dr. Poi was an econometric developer and director of professional services at StataCorp LP, a leading provider of statistical analysis software. He received his PhD and MA in economics from the University of Michigan after graduating magna cum laude from Indiana University.

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Moody's Analytics added the economic forecasting firm Economy.com to its portfolio in 2005. This unit is based in West Chester PA, a suburb of Philadelphia, with offices in London, Prague and Sydney. More information is available at www.economy.com.

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