NOVANTAS
PERSPECTIVE

Modeling Deposit Portfolio Rates:
Combining Replicating Portfolio Concepts with Regression Analysis to Improve PPNR Stress Testing and ALM Accuracy

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PPNR and ALM modeling teams know firsthand that the bar for deposit rate modeling has risen. Thanks to its criticality for projecting NII in rising (and falling) rate environments, senior executives, model validation groups, and regulators are all kicking the tires of traditional deposit rate modeling techniques. In this Perspective, we explain the Novantas regression-based approach and compare its performance to beta and replicating portfolio techniques.

THE OLD SOLUTION: BETAS

A simple deposit beta (or "repricing beta") measures the change in a portfolio rate as a percentage of the change in a single wholesale market interest rate. For example, a beta of 75% off 3-month LIBOR translates to an increase of 75 bp for every 100 bp increase in 3-month LIBOR. Calculation of a deposit beta usually takes the form of selecting a relevant period (of rising or falling market rates) and estimating a beta from the period.

Some banks use level-dependent betas, where betas vary by market rate band (e.g., 0–100 bp, 100–200 bp). This can account for banks changing pricing less when rates are lower and customers are perceived to be less price sensitive. Some banks use direction-dependent betas — for example with a higher beta for falling rates and a lower one for rising rates. Others use lagged effects, which can account for delays in price adjustments.
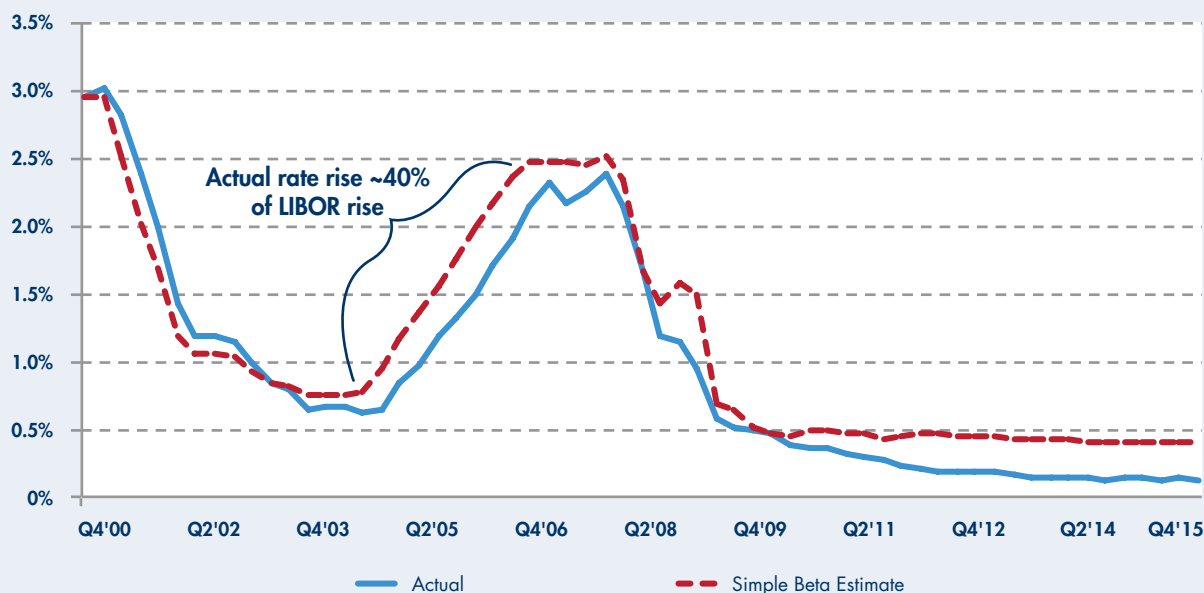
On the plus side, betas are easy to communicate between Treasury and businesses (where shared language can often be limited). But betas have a number of disadvantages. First, they are linear (or linear with kinks if level-/direction-dependent), failing to account for the convexity of the deposit book. Second, betas rely on a couple key judgments — what is the relevant market rate and what is the relevant period of comparison — which are not easily subjected to rigorous analysis. And third, betas do not take advantage of econometric techniques to analyze other available data.

As a result, betas have limitations in their ability to predict deposit rates across the full range of economic scenarios. For example, the graph below displays the overall savings deposit rate for FDIC commercial banks, along with a beta of 40% to 1-month LIBOR that was derived from a comparison period of 2004Q3 to 2006Q4. As can be seen, this simple beta produces periods of consistent over-prediction, sometimes reaching 50 bp.

ADVANCING THE SCIENCE: LEARNING FROM REPLICATING PORTFOLIOS

European banks have used replicating portfolios to analyze deposit portfolios for decades, and the practice is increasingly common in the United States and Canada. In the replicating portfolio approach, a basket of market instruments is created that

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Figure 1: Simple Beta Estimate of Industry Savings Rate

Actual rate rise ~40% of LIBOR rise

Legend: Actual — — Simple Beta Estimate

replicates the cash flows of a target asset or liability; then predictions about the basket of instruments are used to inform the valuation, pricing, hedging, etc. of the target asset or liability.

The basket of instruments in the replicating portfolio technique is a vector of market rates and corresponding weightings (e.g., 25% 3-month LIBOR, 25% 1-year Swap, 50% 5-year Swap). Determining the "best" vector requires an optimization criterion, such as the Sharpe ratio or the standard deviation of the historical margin between the vector and the deposit portfolio (or something else deemed appropriate based on planned applications) to choose among the permutations. For simplicity and ease of implementation (not to mention formerly limited computing power), banks add constraints such as a maximum number of rates, weights summing to 100% (helpful if the portfolio is being invested!), specifying rates in set intervals, and disallowing negative rates (often to preclude short selling), etc.

The replicating portfolio technique is popular because of its range of applications. The replicating portfolio can serve as a proxy to measure duration and convexity.[1] The replicating portfolio can be used to determine base repricing FTP rates and liquidity premiums for non-maturity deposits. Replicating portfolio techniques are common in the insurance industry, where they are used to measure the interest rate risk of insurance claims and premiums for hedging purposes[2,3] and are fundamental to the Black–Scholes option pricing model and other derivatives applications.[4]

THE NOVANTAS REGRESSION TECHNIQUE

The Novantas technique takes the replicating portfolio approach[5] and adds the rigor of regression analysis that makes it suitable for deposit rate estimation necessary for PPNR and ALM. Instead of assuming which market rates and weightings are used, Novantas creates a "batch" of models whose independent variables consist of every combination of tenor points from the yield

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1   Maes, Konstantijn and Thierry Timmermans. "Measuring the Interest Rate Risk of Belgian Regulated Savings Deposits." National Bank of Belgium Financial Stability Review. Vol. 3, Issue 1. 2005.

2   Schrager, David. "Replicating Portfolios for Insurance Liabilities." AENORM. Issue 59. 2008.

3   Koursaris, Adam. "A Primer in Replicating Portfolios." Barrie & Hibbert Insights. 2011.

4   Cherubini, Umberto. "Counterparty Risk in Derivatives and Collateral Policies: The Replicating Portfolio Approach." University of Bologna. 2005.

5   The Novantas regression technique is based on a static replicating portfolio approach where period-to-period balance changes are ignored; this is optimal for rate estimation but not for other replicating portfolio applications.

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curve. For a yield curve with 15 tenor points, this produces 100,000+ econometric models (after lags and moving average terms are considered). The models are then subjected to a rigorous statistical culling, prioritization, and review process to identify contender models. Here we filter the models to ensure adherence to agreed-upon statistical tests; verify that all rate drivers are statistically significant, conceptually sound, and intuitively influential; and sort models using an accuracy measure.[6] Finally, we review the contender models with the business for ultimate selection of a champion model.

This approach is superior to deposit betas both in terms of predictive power and in capturing the intuitive dynamic of non-linear rates. It is more analytic — business rationale is used to select the ultimate champion model, but there is no need to presuppose an index rate or define rate bands *ex ante*. And since the models are regressions, we can use an entire time series of data, ensure the statistical significance of drivers, and perform more rigorous statistical validation of the final product. [7,8]

Because this approach begins with the known intuition that deposit rates are determined based on wholesale market rates and then allows regression analysis to identify the contender models of the best fit rates and weightings, it is not data mining. Business rationale then comes back into the process to review and select the final model.

LIVE EXAMPLE: THE RESULTS

To demonstrate the difference between the approaches, we apply our regression-based approach to the industry savings rate time series used in the simple beta exercise presented earlier. Our "champion" (anonymized) model contains one short-term rate and one long-term rate, as follows:

	Market rate 1	Market rate 2
Point on curve	3-month LIBOR	2-year Swap (tractor)
Weighting	~25%	~20%

The graphic below presents the actual and predicted historical industry savings rate. Though the model under-predicts the industry rate in 2001 and misses during 2008 (when LIBOR spiked in reaction to the Lehman Brothers bankruptcy), it has encouraging fit elsewhere in the time series, which includes both rising and falling rate periods. The Mean Average Percent Error (MAPE, an accuracy measure where it is better to be closer to 0%) for the model is ~15%.

Compared to the simple beta approach, the regression approach yields superior predictive power on a historical basis. While both approaches miss during the 2001 falling rate period and during the Lehman bankruptcy, the regression approach provides better fit from late-2001 through mid-2008, when the savings rate declines, flattens out, rises gradually, and then falls precipitously. The regression approach also captures the gradual compression of savings rates during the post-crisis period of low and flat interest rates, which the simple beta fails to account for (given its reliance on a single short-term rate). The MAPE for the simple beta approach is ~60%, compared to the ~15% for the regression approach.

Another reason to support the regression approach is that we are assured of the statistical significance of market rate predictors and of the statistical validity of the regression output in other respects, such as multicollinearity. Importantly, the process for arriving at the final model is the result of a robust process and not dependent on artistry, save for applying expert judgment in the selection of the final model.
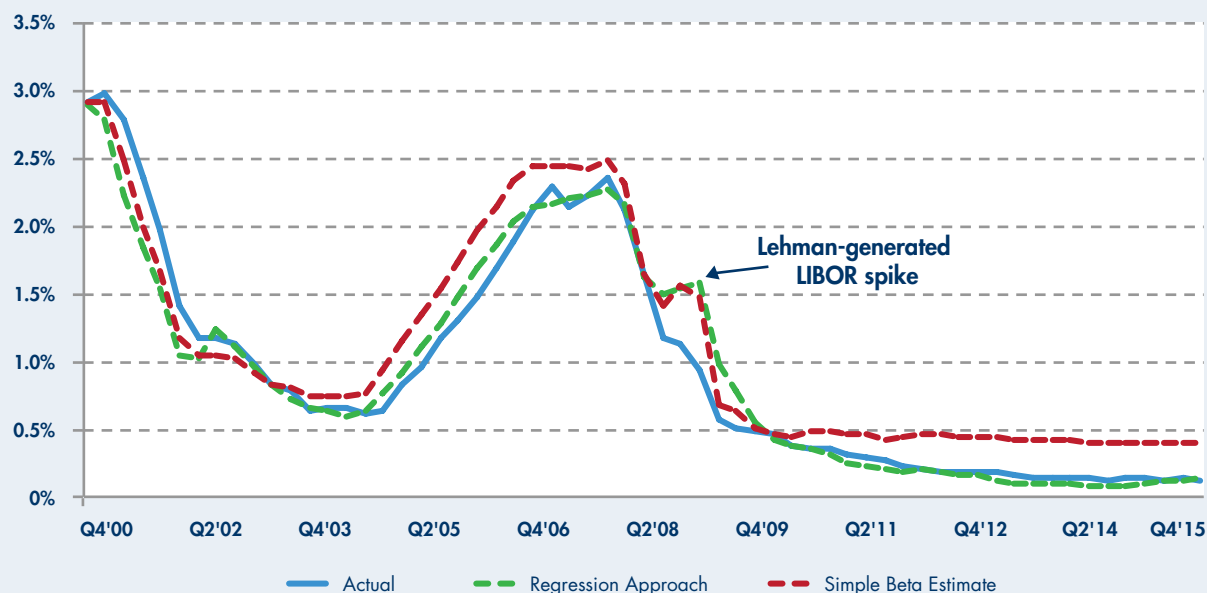
As an aside, we used a basic static replicating portfolio approach to model the industry savings deposit rate for an additional

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6   We prefer Mean Absolute Percent Error (MAPE), but Akaike Information Criterion (AIC) or Root-Mean-Square Error (RMSE) work as well.

7   The regression approach can be thought of as an unconstrained version of the replicating portfolio approach in that it does not constrain the coefficients of the rate drivers. If the objective is to estimate and forecast the deposit rate (and not to construct a hedge portfolio or optimize a spread over the deposit rate), these constraints become unnecessary.

8   This approach can also integrate the more nuanced features of the beta approaches discussed earlier (e.g., level-dependency). But while there may be a valid supporting hypothesis, we have found these features to be low value-add since the basic form of the model already captures non-linear deposit rate behavior. If these features are incorporated, adjustments to statistical testing and other evaluation criteria are needed
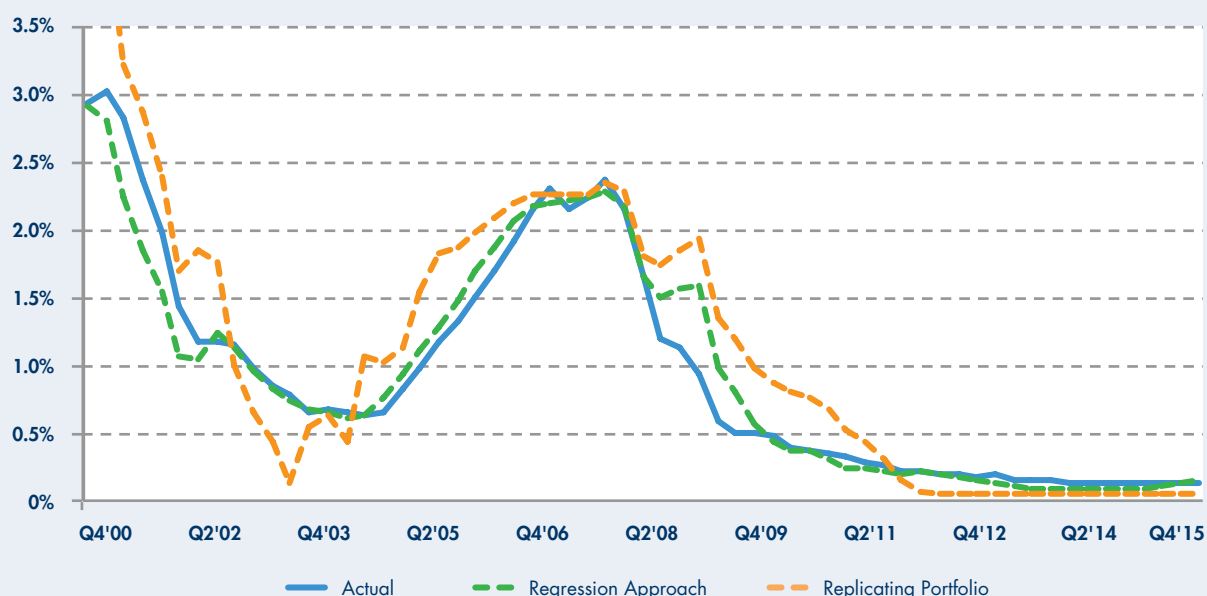
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Figure 2: Comparison of Beta and Regression-Based Estimates of Industry Savings Rate

Lehman-generated LIBOR spike

Legend: Actual — Regression Approach — Simple Beta Estimate

point of comparison. We considered all market rates, constrained the weights to fall between 0% and 100% in 5% increments and sum to 100%, and minimized the variance of the spread between the replicating portfolio and the portfolio rate. The best-fit vector contained one short-term and one long-term market rate, similar to the outcome of the regression approach:

	Market rate 1	Market rate 2
Point on curve	3-month LIBOR	5-year Swap (tractor)
Weighting	~30%	~70%

Figure 3: Comparison of Replicating Portfolio and Regression-Based Estimates of Industry Savings Rate

Legend: Actual — Regression Approach — Replicating Portfolio

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As is clear from the graphic above, the regression approach yields superior predictive power on a historical basis.[9] The constraints applied to the weightings ultimately lead to poor fit. This is unsurprising since the two approaches are designed for different applications: the replicating portfolio approach for minimizing variance of the spread over the deposit rate, and the regression approach for directly estimating and forecasting the deposit rate for PPNR and ALM uses.[10]

CONCLUSION

Several U.S. CCAR institutions have successfully replaced older techniques with deposit portfolio rate modeling approaches like the above. They have found that these advanced rate estimation techniques improve rate estimation accuracy in both PPNR and ALM settings. While we have laid out the basics above, the devil is always in the details — how to conceptualize promotional vs. back-book rates, how best to segment the portfolio, how lags and directions should be explicitly incorporated (if at all), how to deal with out-of-sample forecasts like negative rates in the Fed Severely Adverse,[11] how to rationalize overlays, how to identify the higher-priority statistical watchouts such as the tradeoff between cointegrated and differenced models, among other challenges. It has not always been smooth sailing, but resolving these issues ultimately produces more useful and defensible models, and promotes better understanding of deposit rate dynamics throughout the bank.

ABOUT NOVANTAS **Novantas is the industry leader in analytic advisory and solution services for financial institutions.** Our Global Treasury & Risk unit partners with banks to advance their analytic capabilities — bringing to bear our thought leadership, advanced modeling techniques, and extensive experience. The Novantas PPNR Modeling and Forecasting team has worked with more than a third of CCAR banks on PPNR modeling engagements, and is routinely in contact with almost all CCAR banks, many DFAST banks, major international banks in 10+ countries, and U.S. and international regulators.

CONTACT US We welcome your feedback and are happy to continue the conversation about this article or other Treasury and Risk viewpoints. Please reach out to the head of Novantas Global Treasury and Risk, Pete Gilchrist at pgilchrist@novantas.com; or the head of Novantas PPNR Modeling and Forecasting, Jonathan "Wes" West at jwest@novantas.com.

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9   We have facilitated an apples-to-apples comparison of the replicating portfolio results by subtracting the average spread of the rate basket and savings rate (~200 bp) from the rate basket. Additionally, the rate was floored at 5 bp, consistent with many banks' applications.

10   Furthermore, while the drivers in the replicating portfolio approach sum to 100% (representing a balanced and intuitive relationship between the deposit portfolio and the synthetic hedge portfolio) the regression approach coefficients sum to ~45%. That is, for every $100 of deposits, the regression equation specifies only ~$45 of hedge instruments. However, we would never invest the deposits in a replicating portfolio suggested by the regression equation since the regression approach is designed for a different application (i.e., rate estimation and forecasting).

11   Refer to our Perspective entitled "Making Sense of Negative Interest Rates in the 2016 CCAR Severely Adverse Scenario" for more detailed thinking on this issue.