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Quantitative Easing and Bank Deposits

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Abstract

During the financial crisis of 2008, the Federal Reserve quickly reduced the federal funds target rate to virtually zero, requiring it to search for other mechanisms to provide additional monetary stimulus to the struggling economy. Beginning in late 2008 and continuing for the next six years, the Fed undertook a series of large-scale asset-purchase programs, dubbed quantitative easing, whereby it purchased Treasury notes and bonds, bonds issued by Fannie Mae and Freddie Mac, and mortgage-backed securities.

QE has supported the economy primarily by lowering interest rates on long-term Treasury and mortgage securities. Lending rates also declined with Treasury yields, prompting increased refinancing activity, facilitating debt restructuring, and incenting increased borrowing, all of which supported increased economic activity. Lower bond yields also drove some investors to shift their investment portfolios toward equities and other riskier assets, boosting their prices, and through the so-called wealth effect, increased consumer spending.

QE has a number of potential economic costs that have been well-debated and increasingly well-researched. There are concerns that QE distorts pricing in asset markets, resulting in overvalued equity and bond markets, and perhaps even bubbles. QE may also exacerbate the skewing of the income and wealth distribution as it increases the prices of assets mostly held by wealthy households. There is also a reasonable concern that the Fed will be unable to wind down the securities on its balance sheet without disrupting financial markets.

Another potential, not well-considered, problem created by QE is its impact on the deposits of banks and other depository institutions. The banking system relies on its deposit base as a source of low-cost, stable funding to pursue lending and other opportunities, and there is appropriate concern with how its deposits would react if the Fed were to increase the pace at which it unwinds QE as the economy continues its recovery.

The Fed plans to normalize its balance sheet by retaining the bonds it holds until they mature, a process we estimate will take more than a decade. But what if the Federal Reserve needed to remove its policy accommodation more quickly, in response to an overheating economy, political pressure, or some other event? Would the banking system's deposit base be at risk of declining sharply?

Our answer is "No."

Quantitative Easing and Bank Deposits

BY BRIAN POI, SAMUEL W. MALONE, TONY HUGHES & MARK ZANDI

During the financial crisis of 2008, the Federal Reserve quickly reduced the federal funds target rate to virtually zero, requiring it to search for other mechanisms to provide additional monetary stimulus to the struggling economy. Beginning in late 2008 and continuing for the next six years, the Federal Reserve undertook a series of large-scale asset-purchase programs, dubbed quantitative easing, whereby it purchased Treasury notes and bonds, bonds issued by Fannie Mae and Freddie Mac, and mortgage-backed securities. Together with other actions taken during the crisis, QE expanded the Federal Reserve's balance sheet from less than $900 billion in mid-2008 to nearly $4.5 trillion today.

Quantitative easing supported the economy primarily by lowering interest rates on long-term Treasury and mortgage securities. Lending rates also declined with Treasury yields, prompting increased refinancing activity, facilitating debt restructuring, and incentivizing increased borrowing, all of which supported increased economic activity. Lower bond yields also drove some investors to shift their investment portfolios toward equities and other riskier assets, boosting their prices, and through the so-called wealth effect, increased consumer spending. Moody's Analytics research indicates that quantitative easing has reduced the yield on the 10-year Treasury note by about 1 percentage point and lifted real GDP by almost 1.5 percentage points above what it otherwise would have been.

In theory, QE could also lift bank lending as the Federal Reserve's purchase of securities from banks increases their reserves. However, in practice, this has not been important as the banking system has been awash in reserves. Capital and liquidity have until more recently been significant constraints on bank lending, but QE does not directly help to alleviate these constraints.

QE has a number of potential economic costs that have been well-debated and increasingly well-researched. There are concerns that it distorts pricing in asset markets, resulting in overvalued equity and bond markets, and perhaps even bubbles. QE may also exacerbate the skewing of the income and wealth distribution as it increases the prices of assets mostly held by wealthy households. There is also a reasonable concern that the Fed will be unable to wind down the securities on its balance sheet without disrupting financial markets.

Another potential, not well-considered, problem created by QE is its impact on the deposits of banks and other depository institutions. The banking system relies on its deposit base as a source of low-cost, stable funding to pursue lending and other opportunities, and there is appropriate concern about how its deposits would react if the Federal Reserve were to increase the pace at which it unwinds QE as the economy continues its recovery.

The Federal Reserve plans to normalize its balance sheet by retaining the bonds it holds until they mature, a process we estimate will take at least until the end of 2028. But what if the Federal Reserve needed to remove its policy accommodation more quickly, in response to an overheating economy, political pressure, or some other event? Would the banking system's deposit base be at risk of declining sharply?

Our answer is "No."

We took a three-pronged approach to answering how the banking system's deposit base would respond to an unwinding of quantitative easing.

1. We considered different scenarios for the size of the Fed's balance sheet using the Moody's Analytics structural econometric model of the U.S. economy. Our model includes a direct link between the size of the Federal Reserve balance sheet and 10-year Treasury yields, which then affect all other aspects of the economy including the money supply and bank deposits. This analysis shows that even under extreme assumptions regarding the winding down of the Fed's balance sheet, bank deposits would continue to increase. In the most extreme case, bank deposits are at most 0.2% lower than the baseline after three years, with some types of deposits actually increasing relative to the baseline in response to higher interest rates. After five years, savings deposits would decline, at most, 1.2% relative to the baseline, while demand deposits would decline at most 0.5%.
2. We also constructed several vector autoregressive models that relate the

Table 1: Potential Impacts of Unwinding of Quantitative Easing

	Moody's Macro Model			VAR Model		
	Baseline	Deviation (%)		Baseline	Deviation (%)	
Variable	($ bil)	Mild	Extreme	($ bil)	Mild	Extreme
June 2018 Forecast Horizon						
M1	3,500	-0.01	-0.09	3,833	-0.82	-5.21
Demand deposits	1,279	-0.01	-0.11	1,549	-3.05	-19.04
Other checkable deposits	710.9	0	-0.06	657.7	0.61	5.28
M2	13,756	-0.02	-0.15	14,484	-0.14	-0.96
Savings deposits	6,510	0	-0.11	9,481	-0.17	-1.48
Retail money market deposits	824.7	0.02	0.05	515.9	0.31	2.08
Institutional money market deposits	2,062	0.06	0.24	1,745	-0.97	-8.65
June 2020 Forecast Horizon						
M1	3,804	-0.13	-0.67	4321	-1.35	-6.05
Demand deposits	1,382	-0.2	-1.06	1,700	-4.75	-18.97
Other checkable deposits	764.3	-0.09	-0.5	737.8	0.68	1.02
M2	15,141	-0.18	-0.95	16,392	-0.16	-0.29
Savings deposits	6,887	-0.22	-1.17	11,768	-1.37	-2.97
Retail money market deposits	938.6	-0.08	-0.48	502.2	1.57	14.38
Institutional money market deposits	2,407	-0.07	-0.53	1,923	-0.17	7.44

Source: Moody's Analytics

Federal Reserve balance sheet, bank deposits, and other macroeconomic and financial variables, without imposing any economic structure. These results are more variable, but the most plausible models indicate that bank deposits continue to increase regardless of the pace at which the balance sheet shrinks. The M1 and M2 monetary aggregates would be at most 5% to 6% below the baseline under the most severe balance sheet reduction scenario, with the gap diminishing thereafter.

3. Finally, we conducted a detailed analysis of the Japanese experience with quantitative easing. The Bank of Japan has conducted similar extraordinary monetary policy measures in an effort to revive its economy, which has been moribund for much of the past quarter century. Various types of regression analysis indicate that those measures have collectively raised deposit balances by 0.5% to 1.5% relative to where deposits would be without the extraordinary monetary policy. Assuming that the impacts of a reduction in the BOJ's balance sheet would be symmetric, that analysis suggests an unwinding of those measures would decrease deposits on the order of 1% relative to the baseline.

Table 1 summarizes our results. We show our baseline forecasts at three- and five-year horizons for several types of bank deposits assuming the Federal Reserve holds all bonds to maturity obtained using both the Moody's Analytics U.S. macroeconomic model as well as a vector autoregression model. Under this baseline, the Fed's balance sheet normalizes by 2028. We also show how deposits would deviate from this baseline if the Federal Reserve were to engage in a modest unwinding of its quantitative easing program so that its balance sheet returns to trend in 2025, and under the extreme scenario that the balance sheet returns to trend by 2017. While the results based on the VAR models are more variable, even in the most extreme scenarios, the impact on bank deposits is very modest.

This study uses macroeconomic analysis to assess the impact of quantitative easing on bank deposits. Macro approaches are advantageous in that they capture not only the direct increase in deposits that may occur as banks and other investors sell bonds to the central bank via QE, but also the indirect effects that the bond purchases by the central bank have on the macroeconomy. This is important, as after all the entire purpose of quantitative easing is to stimulate the economy.

Our analysis is not an accounting exercise, which would explicitly trace how the proceeds from bond sales to the central bank flow through the banking system. If the central bank purchases a bond, the seller's bank account is credited, and in theory one could trace what the seller does with those funds and, in particular, how much of those funds ultimately end up as bank deposits. This approach, while useful, would ignore the economic effects of the central bank bond purchases as well as the money multiplier effect if a bank were to use its increased deposits to fund more lending.

Of course, no macroeconomic model is perfect. Models that account for quantitative easing are still in their infancy, and only time will tell if the approach taken in the Moody's Analytics model is correct. We also used VAR models of the U.S. economy to obtain estimates of quantitative easing, yet despite thoughtful econometric work, robustness checks, and best intentions, VAR-based results are still sensitive to model specification, estimation window, and other factors; indeed, our VAR-based results are much more variable than either our macro model-based results or our quantitative results based on the Japanese experience.

The models are also only as accurate as the underlying data, and there are multiple sources of deposit data which may not tell precisely the same story. For our model building we used historical data available from the Federal Reserve's "H.6 Money Stock and Debt Measures." These data are available weekly and covers the M1 and M2 monetary aggregates as well as their primary components for both commercial banks and thrift institutions. But there are also deposit data available from the Fed's Financial Accounts, which provide a quarterly snapshot of assets and liabilities for all depository institutions.

Despite these caveats, given the multiple approaches that we took in our analysis, we are confident that while the normalization of the Fed's balance sheet will weigh on bank deposits, under almost any scenario this weight will be very modest.

Quantitative easing

After quickly reducing the federal funds target rate to virtually zero in the height of the 2008 financial crisis, the Federal Reserve sought additional tools it could use to further ease monetary policy and stimulate the reeling economy. In November of that year the Federal Reserve announced the first of its large-scale asset-purchase programs, commonly called quantitative easing, whereby it would purchase Treasury securities, agency debt, and government-backed mortgage securities.

The purpose of QE was to reduce long-term Treasury yields, and since Treasury yields serve as a benchmark for mortgage and other lending rates, to lower borrowing costs and stimulate economic activity.

This first round of QE, dubbed QE1, involved purchases of up to $100 billion in debt issued by Fannie Mae and Freddie Mac, which by that time were in government conservatorship, and $500 billion in mortgage-backed securities backed by those institutions. During the next two years, the program was expanded to encompass nearly $2 trillion in agency and Treasury debt. QE2 was announced in late 2010, and involved additional purchases of $600 billion in longer-term Treasury securities; and in 2011 Operation Twist was instituted, in which the Federal Reserve sold shorter-term debt it had previously purchased and invested the proceeds in longer-term Treasury securities.

Finally, QE3 was announced in September 2012, in which the Federal Reserve would purchase $40 billion in agency debt and $45 billion in longer-term Treasury debt per month indefinitely. All told, the three quantitative easing programs together with other actions taken during the financial crisis have expanded the Federal Reserve balance sheet from less than $900 billion just prior to the crisis to nearly $4.5 trillion by July 2015.

The Fed is now preparing financial markets that it will soon begin normalizing monetary policy, including raising short-term interest rates and ultimately allowing the size of its balance sheet to shrink. The Fed is expected to end its policy of reinvesting the proceeds of maturing and prepaying securities sometime next year.

While there are many implications of QE, one that has received little attention is the potential impact on bank deposits and other liabilities. Banks depend on deposits as a source of stable, low-cost funding for their lending operations. A critical question is how the normalization of the Fed's balance sheet will affect banks' deposit base. Prior to the financial crisis, quantitative easing had never been used in the U.S. and very rarely elsewhere. We are in uncharted waters.

Macroeconomic Model Approach

The Moody's Analytics model of the U.S. economy is a large-scale, simultaneous equation macroeconometric model containing more than 1,900 variables, including unpublished intermediate variables, designed to produce forecasts that run 30 years. The Moody's Analytics model is regularly used for forecasting, scenario analysis, and quantifying the economy-wide impacts of a range of policies. The Federal Reserve uses a similar model for its forecasting and policy analysis, as do the Congressional Budget Office and the Office of Management and Budget.

Our model represents a middle ground between models that are based solely on time-series statistical techniques and models that are based on so-called microfoundations and that make strong behavioral assumptions such as fully rational intertemporally optimizing households. Our model produces forecasts that are both accurate in the near term and consistent with long-run demographic and technological trends.

The link between QE and deposits in the macro model begins with 10-year Treasury yields, which are directly impacted by QE. The 10-year Treasury yield plays a central role in the model, impacting business investment, residential investment, and stock and housing values, and thus consumer spending via wealth effects. These variables in turn impact employment, unemployment, wages and personal incomes, and prices.

Short-term interest rates are also impacted by QE, although indirectly, as changes in unemployment and inflation impact the Federal Reserve's decisions regarding the federal funds rate target. Short-term rates and personal income are the principal drivers of deposits in the macro model. The macro model thus captures the numerous direct and indirect ways in which QE can impact bank deposits.

In the discussion that follows, the key interest rate and deposit equations in the macro model are presented along with the results of simulations of the model under different scenarios for how quickly the Federal Reserve returns its balance sheet to a more normal level.

Interest rate equations

In the Moody's Analytics macro model, the yield on 10-year Treasury securities is determined by the federal funds rate, stock market volatility, the amount of Treasury debt held by the public, and aggregate bank reserves on deposit at the Federal Reserve. Bank reserves are determined by required reserves as well as the total assets on the Federal Reserve's balance sheet, since to pay for its purchases of bonds, the Federal Reserve credits member banks' reserve accounts. Thus, the Federal Reserve's large-scale purchase of bonds impacts the 10-year Treasury yield in the model through its effect on the level of reserves in the banking system.

Explicitly, our fitted equation for the 10-year Treasury yield T in quarter t is

$$(1)\quad T_t = 0.819 \cdot T_{t-1} + 0.160 \cdot F_t - 0.095 \cdot V_t + 0.01 \cdot MA_4\left(\frac{D_{t-1}}{GDP_{t-1}}\right) - 0.02 \cdot MA_4\left(\frac{R_{t-1}}{GDP_{t-1}}\right)$$

where F_t is the federal funds rate, V_t is the volatility of the S&P 500 and captures flight-to-safety effects, D_t is publicly held government debt, GDP_t is nominal GDP, and R_t is total reserves. $MA_4(x_t)$ represents a four-quarter moving average of variable x_t. Total reserves R_t are modeled as

$$(2)\quad \text{dlog}(R_t) = 1.006 \cdot \text{dlog}(RR_t) + 2.652 \cdot \text{dlog}(B_t) - 0.037$$

where RR_t denotes required reserves and B_t represents total assets on the Federal Reserve's balance sheet. $\text{dlog}(x_t)$ represents the "dlog" transformation $\text{dlog}(x_t)=\log(x_t)-\log(x_{t-1})$, an approximation to the quarter-over-quarter relative change in x_t.

Lafakis and Sweet (2013) provide a comprehensive discussion on the economic impacts of quantitative easing. They used several different techniques, including event studies, vector autoregressions, and simulations from an early version of the Moody's Analytics macro model to determine the net impact of the Federal Reserve's large-scale asset purchases on the 10-year Treasury yield and other interest rates. They estimate that net maximum impact to be in the range of 64 to 156 basis points, with an average of about 100 basis points. Subsequent work by Moody's Analytics, including simulations using the newer equations for the 10-year Treasury yield and total reserves just discussed, confirms and refines our estimate of the net impact of quantitative easing to be a reduction of about 100 basis points for the 10-year Treasury yield versus where it would be without the interventions.

The yield on 10-year Treasury securities serves as a reference point for a broad range of other interest rates, including residential mortgages, auto loans, commercial and industrial loans, and commercial real estate loans. It also indirectly impacts the federal funds rate in the macro model. The funds rate is specified as a Taylor-rule like reaction function driven by the difference between the unemployment rate and the natural rate, the difference between inflation and the Fed's inflation target, and the volatility of the Standard & Poor's 500, which serves as a proxy for financial stability and is used by the Federal Reserve in its CCAR stress-testing scenarios. The federal funds rate in turn drives other short-term interest rates such as three- and six-month Treasury bills. The importance of the 10-year Treasury yield in the economy and thus in the macro model cannot be overstated.

Deposit equations

The Moody's Analytics macro model includes equations for the M1 and M2 money supply aggregates as well as most of their components, including currency, demand deposits, other checkable deposits, savings accounts, small time deposits, and retail money market funds.

The deposit equations include short-term interest rates and personal income as explanatory variables. Most checking accounts pay only nominal rates of interest, so these accounts tend to be negatively correlated with interest rates. This can be seen in the equation for demand deposits, in which they are negatively related to both the change and the level of the three-month Treasury bill yield (see Table 2).

In contrast, small time deposits and money market funds pay interest rates that are more competitive with rates available from other short-term saving vehicles, and as interest rates rise balances tend to increase as more people seek out these returns. Small time deposits, for example, are very strongly positively related to the yield on one-year Treasury notes (see Table 3). These accounts are also beneficiaries of increased volatility in the rest of the financial system. When savers are nervous about financial and economic conditions they tend to flock to the safety of these FDIC-insured deposit accounts. This is captured in the equations for these accounts with the volatility of the S&P 500.

Personal income is also a key driver in the deposit equations. Other checkable deposits are least sensitive to changes in personal income, while institutional money market funds are the most sensitive (see Table 4).

Table 2: Macro Model Demand Deposits Equation

Dependent variable: Difference of the log of demand deposits
Estimation method: Least squares
Estimation sample: 1985Q1 to 2015Q1
Observations: 121

Variable	Coefficient	t-statistic
Difference of the log of disposable income, 3-qtr MA	1.431	4.060
Difference of the log of 3-mo T-bill, 3-qtr MA	-0.052	-2.500
Log of 3-mo T-bill, 3-qtr MA	-0.010	-3.810
R-squared	16.1	
Durbin-Watson statistic	2.14	

Source: Moody's Analytics

Table 3: Macro Model Small Time Deposits Equation

Dependent variable: Difference of the log of small time deposits
Estimation method: Least squares
Estimation sample: 1990Q1 to 2015Q1
Observations: 100

Variable	Coefficient	t-statistic
Difference of the log of disposable income, 4-qtr MA	0.613	2.231
Difference of the log of 1-yr T-note, 4-qtr MA	0.163	6.682
Difference of the log of S&P 500, 4-qtr MA	-0.189	-2.233
Difference of the log of S&P 500 volatility, 4-qtr MA	0.141	5.325
R-squared	45.6	
Durbin-Watson statistic	0.97	

Source: Moody's Analytics

Table 4: Macro Model Institutional Money Market Fund Equation

Dependent variable: Difference of the log of institutional money market funds
Estimation method: Least squares
Estimation sample: 1985Q1 to 2015Q1
Observations: 121

Variable	Coefficient	t-statistic
Difference of the log of disposable income, 4-qtr MA	1.680	4.557
Log of 3-mo T-bill, 4-qtr MA	0.012	4.539
Log of S&P 500 volatility	0.021	2.066
R-squared	24	
Durbin-Watson statistic	1.46	

Source: Moody's Analytics

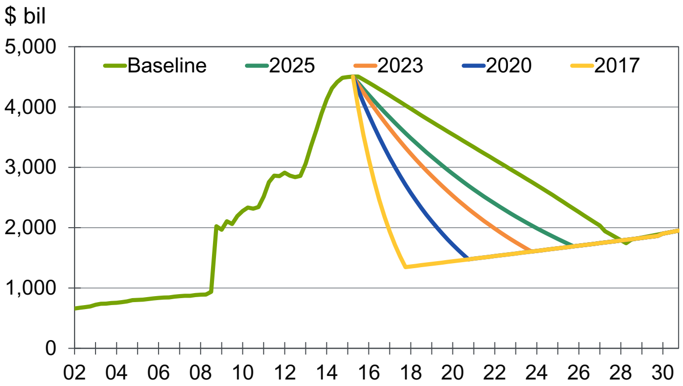
QE wind-down scenarios

To quantify the impact of the unwinding of the Federal Reserve's quantitative easing, we must specify alternative scenarios that describe how the Federal Reserve's balance sheet evolves. In the Moody's Analytics baseline economic scenario, the Federal Reserve is assumed to hold the bonds it now owns until maturity, but does not reinvest any proceeds. In this scenario, the balance sheet returns to a "normal" level of about $1.8 trillion by the end of 2028. That value corresponds to an extrapolation of the balance sheet's trend from 2000 through 2007 prior to the financial crisis.

In Chart 1 we show several alternative paths for the Federal Reserve balance sheet corresponding to more rapid resolutions of its quantitative easing. We specified these paths so that the balance sheet returns to its pre-2008 trend by the ends of 2025, 2023, 2020 and 2017. The 2017 scenario is unrealistically extreme, as it posits a reduction in the balance sheet of more than $3 trillion in under three years, yet we include it as a worst-case scenario.

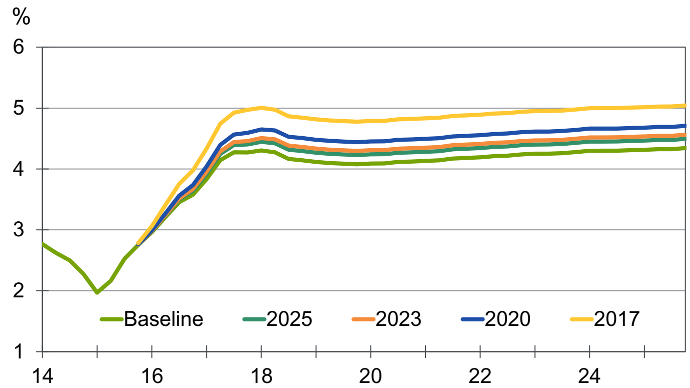
In the Moody's Analytics baseline scenario, the 10-year Treasury yield is forecast to ultimately rise to almost 4.5%, our estimate of the long-run equilibrium yield. That is, this is the yield that should prevail in the long run when the global economy is operating

Chart 1: Conjectured FRB Balance Sheet Paths



Sources: Federal Reserve Board, Moody's Analytics

Chart 2: Implied 10-Year Treasury Yields



Sources: Federal Reserve Board, Moody's Analytics

at full employment, growing at its potential, and inflation is at the target of global central banks. The slight decline in the baseline from 2018 through 2020 is attributable to a cyclical slowing in the economy in response to the previous normalization in monetary policy and a temporary improvement in the federal budget deficit and corresponding decrease in the amount of government debt held by the public as a percent of GDP.

Our baseline forecast for the 10-year Treasury yield also includes a qualitative overlay that incorporates the effects of quantitative easing programs that are still under way in Europe and Japan; those regions' efforts to stimulate their economies will tend to exert downward pressure on U.S. long-term interest rates even as the U.S. economy recovers. Equations (1) and (2) capture the effects of the U.S. quantitative easing program, but adapting them or otherwise expanding the Moody's Analytics macro model to fully account for extraordinary monetary policy decisions by both European and Japanese central banks has proved intractable.

We solved the Moody's Analytics macro model conditional on the alternative balance sheet scenarios shown in Chart 1 to determine how 10-year Treasury yields would respond. Chart 2 shows our baseline forecast for 10-year Treasury yields along with those for the four alternative scenarios. The 2025 balance sheet trajectory is only slightly more aggressive than the baseline of the Federal Reserve holding bonds to maturity, so the effect on interest rates is small, about 15 basis points at its maximum.

In the most aggressive alternative, our model indicates 10-year Treasury yields would rise about 70 basis points. This is smaller in magnitude than our approximately 100-basis point effect of quantitative easing for two reasons. First, the quantitative easing programs expanded the Federal Reserve balance sheet by nearly $3.6 trillion, while to return the balance sheet to its long-run trend level by the end of 2017 would require a shrinkage of only $3.1 trillion. Second, nearly $450 billion in assets on the balance sheet mature within one year and an additional $1.1 trillion mature in one to five years, reducing the amount of assets the Federal Reserve would need to actively sell in order to hit the trend level. Our interest focuses on deposit balances over the next three to five years, so we simply assume the differences in yields persist throughout the 2020s.

Simulation results

Table 5 highlights the results of our simulations, and the appendix contains charts showing deviations from the baseline for each of the deposit accounts. To put the changes in deposit accounts context, the first three rows of Table 5 show how real GDP, personal income and employment would differ in each of the alternative scenarios versus the baseline.

At a three-year horizon—to June 2018—an acceleration in the rate at which the Federal Reserve balance sheet is normalized results in lower economic activity, though the declines are relatively modest aside from the extreme scenario when normalization occurs by the end of 2017.

At a five-year horizon, GDP is 0.26% to 1.26% lower than it would be under the baseline normalization occurring in 2028. The longer-term results are a bit surprising, showing that deviations at a 10-year horizon are lower than at the five-year horizon.

Overall, the effects on deposits of a more rapid unwinding of the Federal Reserve's quantitative easing programs are modest. At a three-year time horizon, M1 money supply would decline only a few hundredths of a percentage point. Even in the extreme scenario of a normalization of the Federal Reserve balance sheet by the end of 2017, M1 would be only about 0.1% lower than under our baseline scenario. Five years out, demand deposits (which pay no interest) are about 1% lower in the most extreme case, but other checkable deposits (which typically do pay a small amount of interest) decline only half as much. Unlike real GDP, income and employment, balances 10 years out in these alternative scenarios are predicted to be lower than they are five years out; of course, any economic forecast 10 years into the future is subject to significant uncertainty, so whether these differences are practically important is arguable.

The M2 money supply measure includes money market funds and small time deposits; and these deposits are more sensitive to interest rates. Here at a three-year horizon these deposits are forecast to be marginally higher than under the baseline scenario as depositors capitalize on the higher interest rates available. This interest-rate effect eventually fades, however, and at longer horizons these accounts also show lower balances. Moreover,

Table 5: Simulation Results From Moody's Macro Model

Variable	Baseline ($ bil)	Alternative Scenario Deviations From Baseline (%) 2025	2023	2020	2017
June 2018 Forecast Horizon					
Real GDP	17,310	-0.11	-0.15	-0.26	-0.63
Real personal income	15,324	-0.02	-0.03	-0.05	-0.19
Nonfarm employment	145.6	-0.1	-0.14	-0.24	-0.58
M1	3,500	-0.01	-0.01	-0.03	-0.09
Currency in circulation	1,510	-0.02	-0.02	-0.04	-0.1
Demand deposits	1,279	-0.01	-0.01	-0.02	-0.11
Other checkable deposits	710.9	0	-0.01	-0.01	-0.06
M2	13,756	-0.02	-0.02	-0.04	-0.15
Savings deposits	6,510	0	-0.01	-0.01	-0.11
Small time deposits	728.3	0.09	0.12	0.21	0.48
Retail money market deposits	824.7	0.02	0.02	0.04	0.05
Institutional money market deposits	2,062	0.06	0.08	0.14	0.24
June 2020 Forecast Horizon					
Real GDP	17,948	-0.26	-0.38	-0.63	-1.26
Real personal income	15,706	-0.16	-0.23	-0.4	-0.83
Nonfarm employment	146.8	-0.26	-0.38	-0.64	-1.28
M1	3,804	-0.13	-0.18	-0.31	-0.67
Currency in circulation	1,658	-0.08	-0.12	-0.2	-0.43
Demand deposits	1,382	-0.2	-0.28	-0.48	-1.06
Other checkable deposits	764.3	-0.09	-0.13	-0.23	-0.5
M2	15,141	-0.18	-0.25	-0.43	-0.95
Savings deposits	6,887	-0.22	-0.31	-0.53	-1.17
Small time deposits	1,059	0.12	0.17	0.28	0.5
Retail money market deposits	938.6	-0.08	-0.12	-0.21	-0.48
Institutional money market deposits	2,407	-0.07	-0.1	-0.19	-0.53
June 2025 Forecast Horizon					
Real GDP	19,873	-0.18	-0.26	-0.42	-0.77
Real personal income	17,023	-0.18	-0.26	-0.42	-0.78
Nonfarm employment	152.2	-0.18	-0.26	-0.42	-0.78
M1	4,542	-0.23	-0.33	-0.53	-1.02
Currency in circulation	2,069	-0.2	-0.29	-0.48	-0.94
Demand deposits	1,611	-0.3	-0.43	-0.7	-1.32
Other checkable deposits	862.2	-0.15	-0.22	-0.36	-0.68
M2	18,909	-0.29	-0.42	-0.68	-1.3
Savings deposits	8,418	-0.37	-0.53	-0.87	-1.68
Small time deposits	1,733	-0.11	-0.15	-0.26	-0.55
Retail money market deposits	1,292	-0.19	-0.27	-0.44	-0.85
Institutional money market deposits	3,507	-0.35	-0.51	-0.84	-1.69

Source: Moody's Analytics

retail money market deposits and small time deposits account for less than 12% of M2. Institutional money market deposits are not part of M2, though they too increase in the near term in response to higher interest rates.

Another informative exercise we can perform with the Moody's Analytics macro model is to simulate how quantitative easing and the expansion of the Federal Reserve's balance sheet affected bank deposits during the financial crisis. We solved the model beginning in the third quarter of 2008, exogenizing the Federal Reserve balance sheet variable so that it continued to grow at its mean rate from 2000 through 2007, about 1% per quarter. The difference between the simulated and observed 10-year Treasury yields peaked at about 150 basis points in the third quarter of 2012 and remained in a range of 75 to 125 basis points since then. This simulation also shows that demand deposit accounts would be just over 1% lower today without quantitative easing. Savings deposits and other checkable deposits show smaller declines in the range of 0.5%.

Summary

The Moody's Analytics U.S. macroeconomic model was used to simulate how the monetary aggregates and deposit balances would behave if the Federal Reserve were to accelerate the rate at which it unwinds its quantitative easing programs.

The Moody's Analytics macro model allows us to simulate how changes in the size of the Federal Reserve's balance sheet affect 10-year Treasury yields and the rest of the economy. We used the model to simulate how much the 10-year Treasury yield would rise if the Federal Reserve's balance sheet returned to trend levels at the end of 2025, 2023, 2020 and 2017 rather than 2028 as projected if it simply holds its bonds to maturity. In the unrealistic case of a complete normalization by 2017, we determined that this would increase the 10-year Treasury yield by 70 basis points, with slower normalizations having much smaller impacts.

We then used our projected paths for the 10-year Treasury yield to simulate how deposits would react. Our results show that the effects on deposit balances would be relatively modest over all time horizons if the Federal Reserve were to speed up its normalization process. After five years GDP would be 1.28% lower than baseline if the Federal Reserve were to normalize its balance sheet by 2017, though such a rapid pace of asset sales is highly unlikely. Under more realistic rates of normalization, GDP would be on the order of 0.25% or 0.5% lower than under baseline. The effects on real personal income are more muted than those on GDP.

Under most scenarios of more rapid normalization, deposit balances would be less than half a percentage point lower than under the status quo after five years, with the three-year effects even smaller. Small time deposit and money market balances could actually rise a fraction of a percent in the early years of the forecast horizon, as the higher interest rates entice savers. However, those effects are fleeting as at longer horizons those types of deposits show minor declines relative to the baseline in line with the declines in GDP, real income and employment.

Vector Autoregression Approach

Vector autoregression models are an indispensable tool of applied econometrics that allow for flexible modeling of dynamic, linear relationships among variables in small- to medium-size systems. Pioneered by Sims (1980), VARs generalize univariate linear regression models with lags of the dependent variable included as regressors to accommodate multiple dependent variables.

Reduced-form VAR models such as those we use in this analysis allow for non-zero correlations among the stochastic error terms of the individual equations making up the VAR. The chief benefit of reduced-form VAR models is that they allow the data to "speak freely" in an atheoretical setting. Therefore, these models provide a natural complement to structural macroeconometric models like the Moody's Analytics macro model. Having said that, as we document below, different model specifications can lead to qualitatively different forecasts.

The main requirement for modeling a set of macroeconomic variables using a VAR model is that the variables be stationary. Roughly speaking, a variable is stationary if it does not exhibit trending behavior. Many economic and financial series, however, do exhibit trends, and in those cases we must be more careful before blindly fitting a VAR model. If two or more variables both exhibit trends but a linear combination among them results in a series that is stationary, the variables are said to be co-integrated. If the variables are not co-integrated, then we can simply difference those variables. If the variables are co-integrated, however, then a vector error correction model (Engle and Granger, 1987) may be more appropriate. VECMs account for the fact that short-run deviations among co-integrated variables are eventually corrected so that long-run relationships are maintained.

Even if variables are co-integrated, however, a VECM is not always the best approach. In this study, our primary interest is generating accurate forecasts of the monetary aggregates and bank deposits conditional on the same paths for the Federal Reserve's balance sheet that we used to simulate the Moody's Analytics macro model. Producing accurate forecasts is not the same as obtaining unbiased (or at least consistent) parameter estimates because of the familiar bias-efficiency trade-off in modeling. In practical terms, this means that a slightly misspecified VAR model may perform better than a correctly specified VECM in terms of forecast accuracy since the VAR has fewer parameters. That is particularly true if the rate at which short-run deviations are corrected in the VECM is slow compared with our forecast horizon.

In preliminary investigations we found only weak evidence of co-integrating relationships among the monetary aggregates, the Federal Reserve balance sheet, and the other macroeconomic and financial variables we consider. Since we are predominantly focused on a short three- to five-year forecast horizon of interest to commercial banks, we chose to fit VAR models with variables in first differences rather than fit VECMs.

In the remainder of this section we discuss our VAR specifications and their implications for deposit balances under alternative scenarios for normalization of the Federal Reserve's balance sheet.

Model implementation, variable selection and channels

Fitting a VAR requires the modeler to decide what variables to include in the system of equations. Including too few variables results in a model that does not adequately capture all the channels by which changes in one variable affect the other variables in the system; this is somewhat analogous to the omitted variable bias problem in univariate regression models. Including too many variables leads to a proliferation of parameters, few if any of which can be precisely estimated.

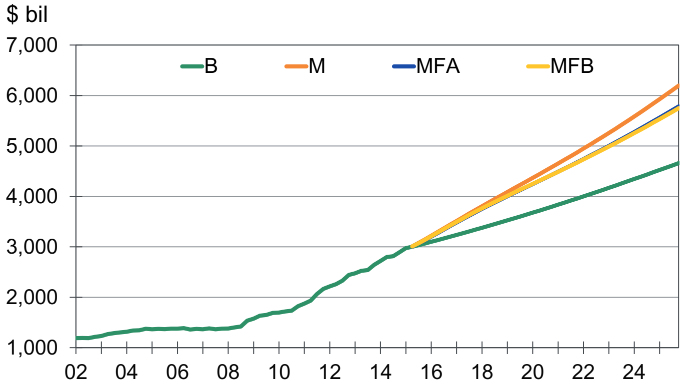
We transformed trending variables into stationary series using the difference of logs or dlog transformation $\mathrm{dlog}(x_t)=\log(x_t)-\log(x_{t-1})$. Most of the variables we consider are available at a monthly frequency, so we built our models using monthly data; for the macroeconomic variables that are available only quarterly we used a cubic interpolation function to convert them to monthly frequency. We considered four VAR models.

- B: A basic bivariate VAR containing just a monetary aggregate or deposit series and the size of the Federal Reserve balance sheet.
- M: A five-variable macroeconomic VAR containing both variables in model B along with real GDP growth, consumer price inflation as measured by the CPI, and the term spread defined as the difference between the yield on 10-year Treasury notes and three-month Treasury bills.
- MFA: An eight-variable macrofinancial VAR containing all of the variables in model M along with three financial variables: shadow banking system assets, the return on the Dow Jones total stock market index, and the logarithm of the CBOE VIX volatility index.
- MFB: Another eight-variable VAR containing all of the variables in model MFA except that the VIX index is replaced with a size-weighted average expected default frequency or EDF across financial institutions. This measure equals the weighted average default probability of U.S. financial institutions with more than $10 billion in assets, and captures systemic risk channels through which changes in the size of the Federal Reserve's balance sheet could affect monetary aggregates and bank deposits.

Details of each of the variables used in these model are provided in the appendix.

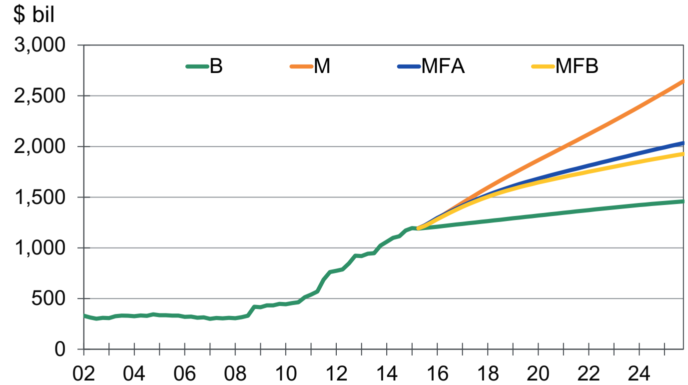
Fitting a VAR also requires the modeler to select the number of lags to include. As is common practice we used the Schwartz-Bayesian and Hannan-Quinn information criteria and found that for most model speci-

Chart 3: VAR Forecasts, M1



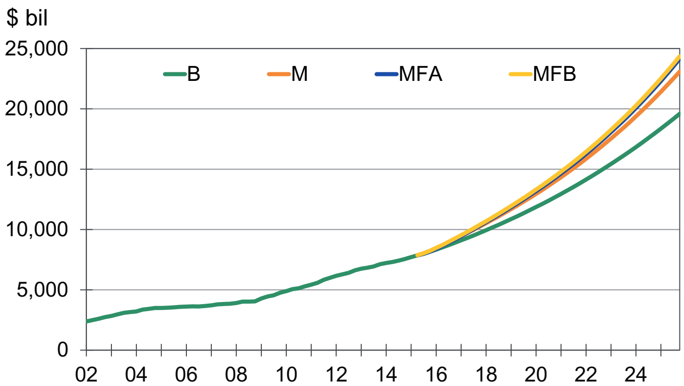
Source: Moody's Analytics

Chart 4: VAR Forecasts, Demand Deposits



Sources: Federal Reserve Board, Moody's Analytics

Chart 5: VAR Forecasts, Savings Deposits



Sources: Federal Reserve Board, Moody's Analytics

fications and criteria, two to four lags were optimal. We chose to settle on three lags. That is consistent with the work of Adrian and Shin (2010), who fit macrofinancial VAR models using quarterly data and found that one lag was optimal. Our qualitative results are little changed if we use different lag lengths; see the appendix for details.

Just as we did with the Moody's Analytics macro model, we obtain forecasts from our VAR models conditional on the five paths of the Federal Reserve balance sheet. We measure the effect of more rapid Federal Reserve balance sheet normalizations by calculating deviations from a baseline forecast that is formed conditional on the Moody's Analytics baseline projection of the balance sheet.

In our VAR analysis we include a single deposit series or monetary aggregate in each model that we fit. For example, we fit model MFB with the variables discussed above, using M1 as our monetary aggregate, and we obtain forecasts for M1 conditional on our paths for the Federal Reserve balance sheet. We then fit model MFB using demand deposit balances in place of M1 and obtain our forecast paths for aggregate demand deposit balances. We do this to evade the curse of dimensionality of VAR models. Our estimation sample spans July 1997 through March 2015, yielding 213 observations. Our eight-equation VARs contains 25 parameters per equation, already at the limit of our comfort zone.[1] Adding more deposit series to the same model would either raise the number of parameters further or force us to eliminate other variables in our VAR that may help explain the link between quantitative easing and deposit balances.

It is important to note that our forecasts for deposit balances no longer aggregate. That is, for a given path for the Federal Reserve balance sheet, our forecasts for currency, demand deposits, and other checkable deposits need not be consistent with each other or with the M1 money supply.

1 Harrell (2001, p. 61) recommends having no more than $N/10$ or even $N/20$ regressors in a single-equation linear regression model with a continuous regressand, where N is the sample size. His guidance is based on cross-sectional data, and the inherent correlation of time-series data implies the effective sample size is smaller than the number of observations, suggesting the more stringent $N/20$ threshold should be followed. Despite that, VAR models are frequently fitted with a relatively large number of parameters.

Chart 3, Chart 4 and Chart 5 show the four models' forecasts under the baseline scenario for the M1 money supply, demand deposits, and savings deposits, respectively. The two macrofinancial VAR models invariably produce similar forecasts, while for most types of deposits, model M produces the most aggressive forecasts. Model B tends to produce more conservative forecasts for most deposit categories than do the other three models.

Chart 4 shows that our forecasts are sensitive to the VAR specification used. However, our main concern in this exercise is how forecasts for a preferred model change in response to different Federal Reserve balance sheet scenarios, rather than comparison of forecast levels across different VAR models for any given scenario. For this purpose, we view the MFA and MFB models as delivering the most plausible forecast levels across scenarios, while allowing us to most reliably examine the partial effects of interest.

Chart 5 suggests that all four of our models produce forecasts for savings deposits that are too high. Both of the macrofinancial VARs' forecasts imply annual savings deposit growth rates near 11% through 2025.

Results

Table 6 summarizes the results based on the MFA model for all of the deposit series we considered in the previous section. These

Table 6: Simulation Results From Macrofinancial VAR MFA (3 Lags)

Variable	Baseline ($ Bil.)	Alternative Scenario Deviations From Baseline (%)			
		2025	2023	2020	2017
June 2018 Forecast Horizon					
M1	3,833	-0.82	-1.32	-2.73	-5.21
Currency in circulation	1,581	-0.15	-0.23	-0.47	-1.26
Demand deposits	1,549	-3.05	-4.84	-9.85	-19.04
Other checkable deposits	657.7	0.61	1	2.14	5.28
M2	14,484	-0.14	-0.23	-0.49	-0.96
Savings deposits	9,481	-0.17	-0.25	-0.48	-1.48
Small time deposits	492	9.68	15.48	34.09	116.57
Retail money market deposits	515.9	0.31	0.42	0.75	2.08
Institutional money market deposits	1,745	-0.97	-1.61	-3.45	-8.65
June 2020 Forecast Horizon					
M1	4,321	-1.35	-2.23	-4.72	-6.05
Currency in circulation	1,793	-0.31	-0.5	-1.05	-1.89
Demand deposits	1,700	-4.75	-7.76	-15.96	-18.97
Other checkable deposits	737.8	0.68	1.18	2.62	1.02
M2	16,392	-0.16	-0.27	-0.6	-0.29
Savings deposits	11,768	-0.41	-0.66	-1.37	-2.97
Small time deposits	638	18.57	32.04	80.38	160.53
Retail money market deposits	502.2	1.57	2.45	5.04	14.38
Institutional money market deposits	1,923	-0.17	-0.47	-1.33	7.44
June 2025 Forecast Horizon					
M1	5,649	-2.18	-2.75	-3.17	-3.18
Currency in circulation	2,445	-0.59	-0.96	-1.07	-1.06
Demand deposits	2,000	-7.30	-8.78	-9.63	-9.65
Other checkable deposits	970	0.64	0.08	-0.36	-0.35
M2	22,443	-0.12	-0.01	0.18	0.18
Savings deposits	20,044	-0.89	-1.58	-1.84	-1.83
Small time deposits	1,279	36.28	61.18	68.98	69.47
Retail money market deposits	531.7	4.54	8.33	12.28	12.62
Institutional money market deposits	2,809	2.12	5.32	10.15	10.28

Source: Moody's Analytics

results are qualitatively similar to the results based on simulations of the Moody's Analytics macro model in that more aggressive reductions in the Federal Reserve balance sheet imply larger decreases for deposits that pay relatively low interest rate and in that interest-sensitive deposits like small time deposits may actually increase due to higher interest rates.

Most striking, though, are the magnitudes of the differences among scenarios. In the most benign alternative scenario, in which the Federal Reserve balance sheet returns to its pre-crisis trend at the end of 2025 rather than 2028, demand deposit balances are 3.1% lower than baseline after just three years and 4.8% lower than baseline after five years. Small time deposits are forecast to be 9.7% higher than baseline after three years and 18.6% higher after five years; these deposits currently represent just 3% of M2, however.

The forecasts are consistent in the sense that more extreme reductions in the size of the Federal Reserve balance sheet cause larger reductions in deposits that pay lower interest rates and may cause more interest-sensitive balances to increase more quickly. Also, the sensitivities of M1 and M2 to changes in the balance sheet are lower than for some of their constituents. Changes in the rate at which the Federal Reserve unwinds quantitative easing will affect interest rates, and that in turn will motivate some households and firms to shift from lower-yielding accounts (such as demand deposit accounts) to accounts that offer higher yields (such as NOW accounts). While funds may shift from one type of account to another, the net effect on money supply aggregates is lower.

Results for models B, M and VFB are qualitatively similar and are relegated to the appendix. All suggest large negative divergences relative to the baseline for demand deposit accounts and large gains for small time deposits (a relatively small category) and other checkable deposits.

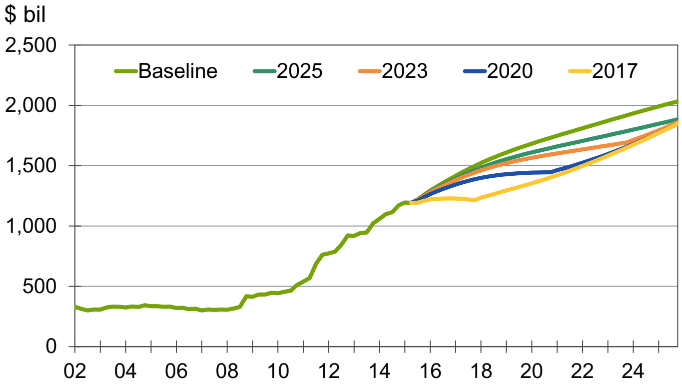
Of the four models we fit, we are inclined to give the most weight to the results from models MFA and MFB and the least weight to model B. Bivariate model B strikes us as misspecified because it implies a direct link between the Federal Reserve balance sheet and deposit balances. It does not provide any mechanism whereby changes in the balance sheet have real effects on the economy that in turn affect deposits. Models MFA and MFB are similar in that they both allow for financial system mechanisms in addition to economic effects, the only difference between the two being the way in which risks to the financial system are measured.

Chart 6 puts the deviations from baseline for demand deposits under the alternative scenarios in proper context. Even in the extreme case where the Federal Reserve returns its balance sheet back to trend by the end of 2017, demand deposit balances never drop below their May 2015 level. Instead, balances simply grow for a few years at about the same rate as they did in the early 2000s. Chart 7 shows the case of savings deposits and puts the small increases reported in Table 6 in context.

Summary

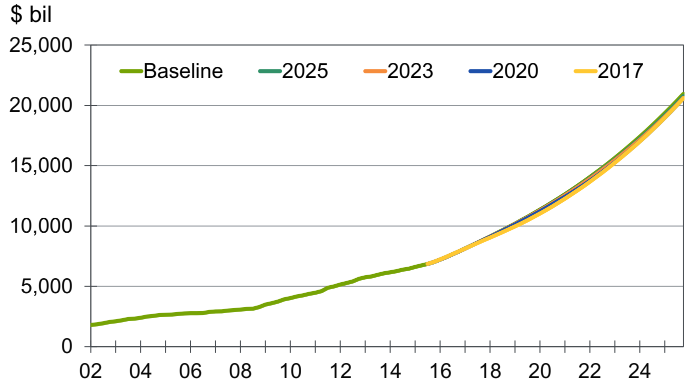
Our VAR model results indicate a more pronounced impact on deposits from an accelerated pace of Federal Reserve balance sheet normalization than do our results from simulations of the Moody's Analytics macro model. Models with monetary aggregates M1 and M2 both show that balances would be lower under more rapid rates of normalization relative to the base-

Chart 6: VAR MFA Forecasts, Demand Deposits



Sources: Federal Reserve Board, Moody's Analytics

Chart 7: VAR MFA Forecasts, Savings Deposits



Sources: Federal Reserve Board, Moody's Analytics

line. Individual deposit types exhibit higher sensitivity to balance sheet normalization, with deposits that pay relatively low interest rates experiencing declines and deposits that pay relatively high rates experiencing increases in scenarios where the balance sheet normalizes more quickly. Importantly, while the results include some large percentage changes, those percentage changes are relative to the baseline scenario. In our preferred macrofinancial models, MFA and MFB, deposit balances continue to increase; the only difference among scenarios is whether the rate of growth is more rapid or more sluggish.

The Japanese Experience

The Japanese experience with quantitative easing provides many clues as to the likely effect of a reversal of QE in the United States. Japanese economic history parallels that of the U.S. in the sense that a severe financial bubble was followed by stagnation in the economy that prompted the implementation of extremely loose monetary policies by the central bank. Fortunately given our endeavors in this study, Japan's experiences have occurred up to 18 years ahead of those of the U.S., allowing us to use the former East Asian powerhouse as a "canary in the coal mine" for the current U.S. situation.

The Bank of Japan first tested the quantitative easing waters in 2001, almost nine years earlier than the Federal Reserve. Importantly for our study, the Bank of Japan also experimented with unwinding prior quantitative easing. In 2006, with the world economy still strong and with Japan enjoying a modest improvement in economic fortunes, the Bank of Japan actually decreased the size of its balance sheet appreciably. This experiment was short-lived because the global financial crisis hit soon after it was implemented. Nonetheless, Japan is the only case in recorded history of a central bank unwinding quantitative easing.

To be sure, there are many differences between Japan and the U.S. experience that complicate any comparisons. After the Japanese bubble burst in 1990, the country never suffered a truly disastrous recession until 2008. Rather, Japan experienced frequent mild recessions over an extended period of time with only modest growth in between. Japanese unemployment has remained below 5.5% in the post-1990 period, compared with a peak of 10% in the U.S. in the Great Recession.

Supporting Japan throughout much of the period since 1990 was the generally rapid growth experienced in the rest of the global economy. For long stretches, Japan was able to pursue a "beggar thy neighbor" policy involving a depressed currency and rapid export growth without the threat of retaliation from abroad. The U.S. does not enjoy the luxury of pursuing policies of that ilk.

Of course, Japan has also struggled with its own unique problems. The country has a rapidly aging population and an exceptionally high dependency ratio. It enjoys very little immigration. The Japanese political system is normally sclerotic and dysfunctional; reform is often illusive. These factors suggest that even if Japan had been able to avoid using quantitative easing over the past 20 years, it still would have experienced slower growth and worsening economic fortunes.

While the Japanese and U.S. economies and experiences are different, Japan still represents the only available advance warning system when it comes to analyzing the effect of regime changes in current U.S. monetary policy.

To depict the extraordinary actions of the Bank of Japan in implementing its monetary policies, we rely primarily on the monetary base. The monetary base includes notes and coins in circulation as well as reserve balances held at the Bank of Japan. Series for just reserve balances are available, though these are almost perfectly correlated with movements in the broader monetary base statistics. Results presented here are virtually unchanged when alternative variables are used to capture Bank of Japan groundswells.

Except where otherwise noted, we use a Bank of Japan series that measures the sum of deposits and certificates of deposits held by all banks in Japan as our measure of bank deposits. For linguistic simplicity we refer to this sum as "deposits" with the understanding that those deposits include CDs.

Monthly data on the monetary base are available from January 1990 through May 2015, and monthly data on deposits are available from January 1991 through May 2015.

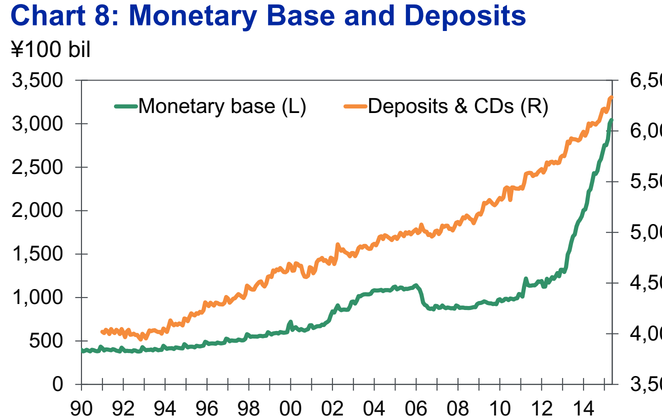
Simple trend analysis

Chart 8 shows Japan's monetary base and aggregate deposits for the last 25 years. The monetary base clearly shows the various regimes of Japanese monetary policy. Up until 2001 the monetary base grew at a slow but steady pace in line with nominal GDP. In 2001, as the first quantitative easing program is kicked off, the monetary base ratchets higher, rising nearly 70% by late 2005. During 2006, quantitative easing policy is reversed (our main focus here) and the monetary base rapidly declines by about 25%. After that the monetary base resumes its slow but steady pace through early 2011, even as the global financial crisis emerged and raged outside the windows of the Bank of Japan. In March 2011 a major earthquake and tsunami disrupted commerce, forcing the Bank of Japan to take emergency actions to resuscitate the economy. Finally, in early 2013 so-called Abenomics was introduced, including a large-scale resumption of quantitative easing that dwarfs anything seen previously seen.

The regimes just outlined define a set of dummy variables that we use throughout our analysis:

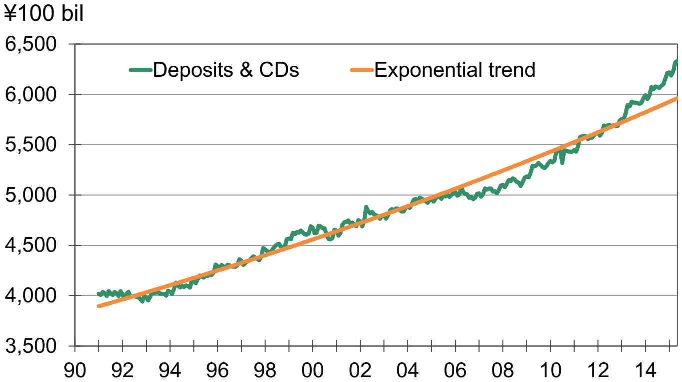
1. DUMDURING defines the period from January 2002 through December

Chart 8: Monetary Base and Deposits



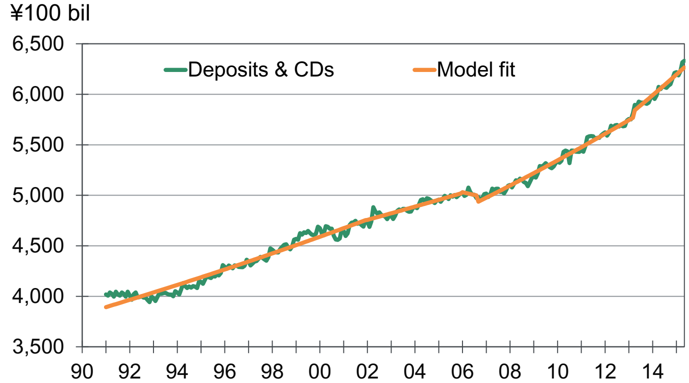
Sources: Bank of Japan, Moody's Analytics

Chart 9: Deposits and Exponential Trend



Sources: Bank of Japan, Moody's Analytics

Chart 10: Deposits and Interacted Trend Model



Sources: Bank of Japan, Moody's Analytics

2005 when the Bank of Japan was expanding its balance sheet or maintaining its bloated size.

2. DUMDOWN defines the period from January 2006 through August 2006 when the Bank of Japan actively reduced its balance sheet.
3. DUMINTER defines the period from September 2006 through March 2013 during which the Bank of Japan was neither actively using quantitative easing to boost growth and inflation nor actively unwinding quantitative easing.
4. DUMABE defines the period since March 2013 and indicates the period of Abenomics.

We emphasize that we do not wish to engage in a "fishing expedition" trying to discern structural breaks based on dubious statistical data mining procedures. A rudimentary understanding of recent Japanese monetary history is sufficient to identify breaks pertinent to the path of deposits. If additional breaks exist in the data, they will become apparent as we progress through our analysis.

Before we dive into more rigorous econometric analyses, we first confirm that the dummy variables we defined identify changes in the deposit series' trend.

Chart 9 plots the deposit series along with an exponential trend line and shows that the rate of growth in deposits varies. Particularly obvious are the periods from 2006 through early 2013 when further quantitative easing was not being pursued and the period since 2013 and the rise of Abenomics.

Table 7 shows the estimates from a regression of the logarithm of deposits on a trend term, the four dummy variables, and the interactions between the dummy variables and the trend term. All of the parameter estimates on the dummy variables and interactions are significant, indicating that our dummies do in fact capture Bank of Japan regime shifts. Moreover, this simple model explains more than 99% of the variation in log deposits.

Interpreting the effects of dummy variables can be difficult when they are interacted with other variables, so we instead show the in-sample fit of our simple trend model in Chart 10. Ignoring some anomalies in the 1990s, our model picks out changes in the trend of deposits very well. Despite the devastation of the 2011 tsunami, it did not measurably affect the trajectory of deposits.

Chart 11 shows clearly the effect of the 2006 Bank of Japan policy to reduce the size of its balance sheet. The behavior of depositors is somewhat persistent; balances in April 2006 still grew strongly, three months after the tightening had begun. Deposits then fell about 2.5% before resuming growth—at an accelerated pace—after the Bank of Japan shifted course and stopped actively reducing its balance sheet.

We can obtain a simple estimate of the effect of the 2006 reversal in quantitative

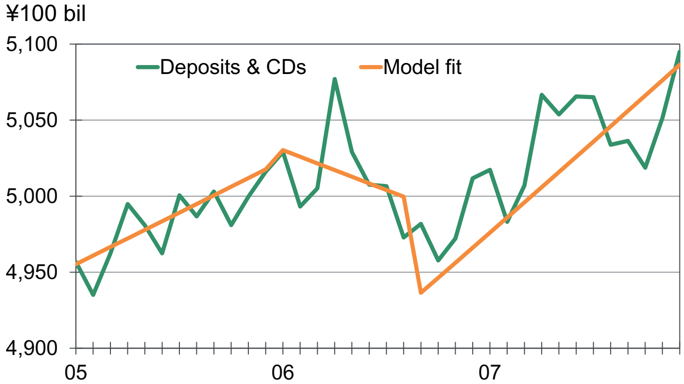
Table 7: Exponential Trend Model

Dependent variable: Log of total deposits
Estimation method: Ordinary least squares
Estimation sample: 1991M1 to 2015M5
Observations: 293

Variable	Coefficient	t-statistic
Constant	15.1565	1971.61
@TREND	0.00152	19.10
DUMDURING	0.05494	2.97
@TREND*DUMDURING	-0.00039	-3.09
DUMDOWN	0.44221	3.59
@TREND*DUMDOWN	-0.00240	-3.79
DUMINTER	-0.14320	-10.23
@TREND*DUMINTER	0.00047	5.10
DUMABE	-0.35531	-4.74
@TREND*DUMABE	0.00127	4.75
R-squared (%)	99.3000	
Newey-West HAC estimator bandwidth	6.0000	

Source: Moody's Analytics

Chart 11: Interacted Trend Model: 2005-2007



Sources: Bank of Japan, Moody's Analytics

easing by extrapolating the trend as it stood at the end of 2005. The observed series intersects this extrapolated trend around the middle of 2009. Over this period we find that Japanese deposits were, on average, around 0.5% lower than suggested by the extrapolated trend line. While any persistent decline in deposits is potentially a bad outcome for banks, our instinct is that a 0.5% decline in total deposits relative to the baseline over a period of more than three years is not economically significant. A 0.5% decline would be well within the margin of error in predicting the effect of almost any proposed management action regarding deposit strategy.

The Bank of Japan was able to reverse quantitative easing in 2006 without having to make any outright sales of its previously purchased debt instruments. Yamaoka and Syed (2010) attribute this to two factors. First, when the Bank of Japan first instituted its quantitative easing program, it made clear that the program would terminate in March 2006; and by that time markets had stabilized so that extending the program was unwarranted. Second, the Bank of Japan had purchased asset-backed securities and commercial paper with short maturities so that its debt holdings would shrink relatively quickly as those securities matured. Moreover, toward the end of the quantitative easing program private investors returned to these markets, and Bank of Japan purchases were trivial; Chart 8 shows that the monetary base grew only marginally in 2004 and 2005.

Table 8: FMOLS Estimation of Total Deposits on the Monetary Base

Dependent variable: Total deposits
Estimation method: Fully modified ordinary least squares
Estimation sample: 1991M1 to 2015M5
Observations: 293

Variable	Coefficient	t-statistic
Constant	3041388.58	58.62
Monetary base	2.52	25.03
DUMDURING	1126778.55	5.88
MonBase*DUMDURING	-1.81	-8.79
DUMDOWN	1724567.76	3.94
MonBase*DUMDOWN	-2.28	-5.15
DUMINTER	604733.01	5.43
MonBase*DUMINTER	-0.85	-6.05
DUMABE	2329804.98	17.86
MonBase*DUMABE	-2.22	-19.52
R-squared (%)	98.9	
Long-run covariance estimator bandwidth	6	

Source: Moody's Analytics

Econometric analysis

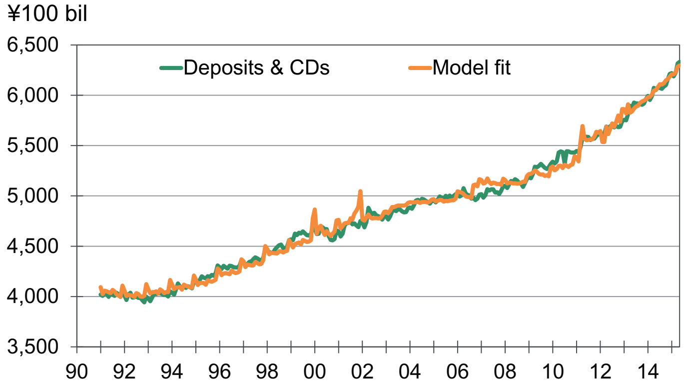
Analysis of historical trends as we have done thus far is useful because of its simplicity and ease of exposition. We next use more rigorous techniques to obtain a deeper understanding of the relationship between shifts in the monetary base and the behavior of deposits.

We first consider a simple regression of deposits on the monetary base to determine whether the two variables are co-integrated. The residuals from this regression suggest that the two series are unlikely to be co-integrated. The Engle and Granger (1987) augmented Dickey-Fuller statistic is -2.51, while MacKinnon's (2010) relevant 5% critical value is -2.86. The residuals from a "log-log" specification also suggest the series are not co-integrated. These results agree with our findings in the vector autoregression (VAR) analysis conducted on U.S. data that found at-best weak evidence of co-integration between the size of the Federal Reserve balance sheet and measures of bank deposits. One possibility is that the structural breaks in the series induced by the central bank actions reduce the power of our co-integration tests.

We next consider a simple regression of deposits on the monetary base but where the slopes and intercepts in the regression are allowed to vary across the regimes we have identified. Here we assume the dates of the regimes are known with certainty and do not alter our statistical analysis to account for uncertainty in those dates. This is a strong but reasonable assumption given the nature of the shifts in Japanese monetary policy through this era. Does anyone really doubt that the implementation of Abenomics was a structural break for the Japanese economy? Table 8 shows these regression results.

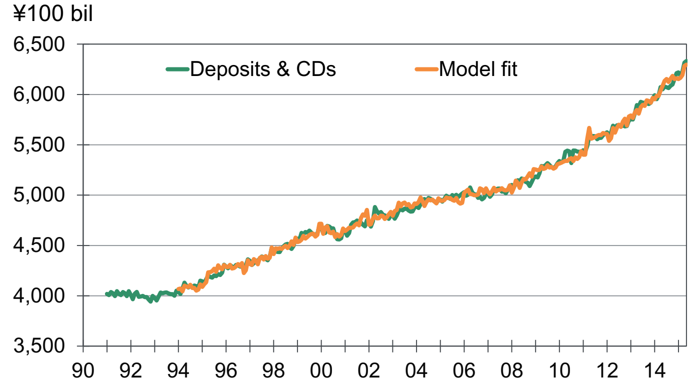
To allow for the possibility that deposits and the monetary base series are in fact co-integrated but that our simple tests lacked power due to the structural breaks, we use the Phillips and Hansen (1990) fully modified ordinary least-squares (FMOLS) estimator. This estimator provides consistent estimates whether the series are co-integrated, integrated but not co-integrated, or both stationary; see Phillips (1993).

Chart 12: Simple FMOLS Model Forecasts



Sources: Bank of Japan, Moody's Analytics

Chart 13: Macro FMOLS Model Forecasts



Sources: Bank of Japan, Moody's Analytics

Chart 12 shows that the in-sample fit is good, and our model captures the changes in trend. Our model considers only the dates at which monetary policy was changed along with variations in the monetary base to explain aggregate deposit behavior. Despite the simplicity of our modeling, we have explained almost all the variation in the deposit variable. One weakness of this model is that it does not forecast deposits from 2006 through 2011 as well as it does other periods; we return to that issue later when we explore models that include macroeconomic drivers.

One of the primary benefits of looking at Japan is that it contains periods where quantitative easing has been instituted and periods where it has been unwound. U.S. banks face the question of whether the responses of deposit balances to monetary policy are symmetric. Are the effects of the unwinding of quantitative easing on deposits the same magnitude but opposite directions of the effects when quantitative easing was begun?

The results in Table 8 help shed light on the answer. Prior to the implementation of quantitative easing, changes in the monetary base were strongly and positively correlated with observed changes in deposits. The coefficient on the monetary base variable is 2.5, meaning a ¥1 billion increase in the monetary base is associated with a ¥2.5 billion increase in deposits. During all subsequent regimes, the multiplier is lower. During the balance sheet expansion and maintenance phase, the multiplier is just ($0.71=2.52-1.81$). When the Bank of Japan actively shrunk its balance sheet the multiplier was close to zero ($0.24=2.52-2.28$) but still positive, implying that shrinking the monetary base would shrink deposits. Even throughout the phenomenal Abenomics period, the multiplier has been lower ($0.3=2.52-2.22$) than in the period prior to extraordinary monetary policy measures. Remarkably, the multiplier during the Abenomics period is close to the multiplier during the balance sheet shrinkage period.

Robustness

While our simple model performs well, we nevertheless explore whether the model's fit can be improved and whether its results are robust to alternative specifications. We first refit our model and include an array of macroeconomic factors that may influence deposits. Table 9 shows our results.

Many of these macroeconomic drivers are statistically significant in explaining the evolution of deposits in Japan. Most are correctly signed, though the interest rate variables are likely acting more as general indicators of economic health rather than as indicators of increased potential income for depositors. If the economy improves to the point where short- and long-term rates rise, investors will shift funds out of deposits and into other vehicles.

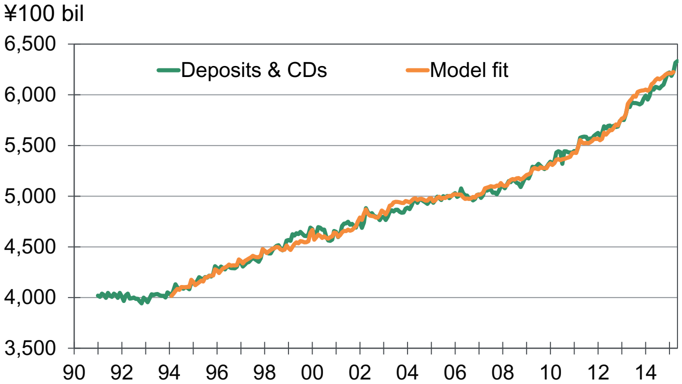
Chart 13 plots the in-sample forecasts. The weakness of our earlier model, whereby the model did not fit the data from 2006 through 2011 as well as for other periods, is now rectified.

The conclusions we previously drew regarding the monetary base multiplier remain true. The overall magnitude of the multiplier is now somewhat lower than before (1.57 versus 2.52) as the macroeconomic variables now account for some of the variation in deposits. The monetary base variables are all significant; the coefficients all indicate the same ordering when considering the various eras. The pre-quantitative easing period still has the largest multiplier, followed by the intervening period from late 2006 through 2011; and the period during which quantitative easing was unwound had the smallest multiplier.

These results show that reversing quantitative easing had less of an impact on deposits than implementing quantitative easing in the first place. The sideways movement of deposit balances during 2006 can be well explained by other drivers of the Japanese economy and was not directly caused by the extraordinary actions of the Bank of Japan. Of course, deposits may be affected indirectly: The Bank of Japan's actions affect the overall economy, which in turn affects deposits. We explore this channel later.

Our second robustness check concerns our use of the FMOLS estimator. Our initial analysis found that the monetary base and deposit series were not correlated, but we conjectured that the multiple regime changes over the past 13 years would reduce the power of our test. We therefore used the FMOLS estimator that has an asymptotically normal distribution even if the series are not co-integrated. However, if in fact the series are not co-integrated then regular OLS regression after transforming variables to stationarity is also consistent and is much

Chart 14: Macro OLS Model Forecasts



Sources: Bank of Japan, Moody's Analytics

simpler to boot. In addition, the principle of compounding implies that many series may need to be converted to logarithmic form in order to obtain linear trends. Here we refit our model that includes macroeconomic variables using the OLS estimator, transforming all nonstationary variables using the dlog transformation.[2]

Chart 14 plots the in-sample forecasts for this model and shows that it performs worse than the model fitted via FMOLS. This model over-predicts balances for 19 consecutive months from 1996 through 1998 and under-predicts for 22 consecutive months around the turn of the century. A few years later it again over-predicts for 28 consecutive months. We could continue, but suffice it to say that Chart 14 compares poorly to Chart 13. We conclude that the model fit using the FMOLS estimator is preferable to the one fit using the OLS estimator.

Our final robustness checks involve using alternative measures of bank deposits. We have been using a series that measures total bank deposits, including CDs, because that series extends back to 1991, well before the Bank of Japan began its quantitative easing programs. The Bank of Japan also publishes data on bank deposits (as close as we could find to U.S. demand deposits) and CDs separately, though these data extend back only to April 2003, after the Bank of Japan had already begun its quantitative easing programs. Quantitative easing involves exchanging cash for bonds; most of that cash is not directly invested in CDs, so we suspect changes in the monetary base have a more direct impact on deposits sans CDs.

Tables 10 and 11 show the results of fitting our model including macroeconomic variables to the shorter deposits and CD series using the FMOLS estimator. In line with our reasoning regarding how cash from bond sales is invested, our model does a much better job predicting deposits, explaining over 98% of the variation in that series, than it does predicting CDs, explaining just over 93% of that series' variation. Given that we are fitting a model of trending variables in levels, an R^2 of 93.2% is hardly spectacular.

Because our sample starts in 2003, the parameter on the monetary base variable now reflects its multiplier during the period where the Bank of Japan first expanded its balance sheet via quantitative easing. We are loath to compare these estimates of the multiplier to those obtained using the combined bank deposits and CD series because of the shorter estimation window. Nevertheless, the parameter estimates us-

Table 9: FMOLS Estimation of Total Deposits on the Monetary Base and Macroeconomic Variables

Dependent variable: Total deposits
Estimation method: Fully modified ordinary least squares
Estimation sample: 1994M2 to 2015M3
Observations: 254

Variable	Coefficient	t-statistic
Constant	2836670.95	3.65
Monetary base	1.57	11.82
DUMDURING	462456.08	3.26
MonBase*DUMDURING	-0.82	-4.77
DUMDOWN	1235771.69	5.44
MonBase*DUMDOWN	-1.43	-5.97
DUMINTER	285552.39	3.03
MonBase*DUMINTER	-0.27	-2.07
DUMABE	1592201.60	11.05
MonBase*DUMABE	-1.27	-9.17
Consumer Price Index	7666.94	1.12
Total employment	126.03	1.91
Exports	0.02	2.14
Imports	0.02	1.75
Tokyo Stock Index	-7.64	-0.23
Machinery orders	-0.38	-4.36
Business conditions index	-83.36	-0.12
10-yr government bond yield	-22819.27	-1.33
Discount rate	-120943.63	-5.11
Nominal GDP	-7.19	-3.34
¥/$ exchange rate	-2571.77	-4.45
R-squared (%)	99.3	
Long-run covariance estimator bandwidth	5	

Source: Moody's Analytics

2 We used the first difference of the Business Conditions Index because it takes on negative values.

Table 10: FMOLS Estimation of Bank Deposits on the Monetary Base and Macroeconomic Variables

Dependent variable: Bank deposits excluding certificates of deposits
Estimation method: Fully modified ordinary least squares
Estimation sample: 2003M4 to 2015M3
Observations: 144

Variable	Coefficient	t-statistic
Constant	-1430157.12	-0.85
Monetary base	3.96	7.52
DUMDOWN	4619643.47	7.39
MonBase*DUMDOWN	-4.04	-7.13
DUMINTER	3261953.25	5.61
MonBase*DUMINTER	-2.49	-4.71
DUMABE	4826481.51	7.91
MonBase*DUMABE	-3.71	-6.94
Consumer Price Index	-605.39	-0.04
Total employment	179.56	1.54
Exports	0.05	3.56
Imports	0.00	-0.25
Tokyo Stock Index	73.62	0.69
Machinery orders	0.25	1.87
Business conditions index	-955.41	-0.91
10-yr government bond yield	-125071.71	-2.84
Discount rate	-10.54	-2.96
Nominal GDP	-190172.53	-2.39
¥/$ exchange rate	434.92	0.23
R-squared (%)	98.5	
Long-run covariance estimator bandwidth	5	

Source: Moody's Analytics

Table 11: FMOLS Estimation of Bank Deposits on the Monetary Base and Macroeconomic Variables

Dependent variable: Certificates of deposits
Estimation method: Fully modified ordinary least squares
Estimation sample: 2003M4 to 2015M3
Observations: 144

Variable	Coefficient	t-statistic
Constant	1158156.68	2.81
Monetary base	0.18	1.39
DUMDOWN	194431.18	1.27
MonBase*DUMDOWN	-0.16	-1.17
DUMINTER	229432.77	1.62
MonBase*DUMINTER	-0.18	-1.40
DUMABE	97706.00	0.66
MonBase*DUMABE	-0.09	-0.69
Consumer Price Index	-12334.27	-3.43
Total employment	48.62	1.70
Exports	0.00	-0.84
Imports	0.01	2.55
Tokyo Stock Index	-41.71	-1.61
Machinery orders	-0.09	-2.67
Business conditions index	1280.21	4.98
10-yr government bond yield	-14571.86	-1.36
Discount rate	-0.68	-0.79
Nominal GDP	-24614.58	-1.27
¥/$ exchange rate	-668.88	-1.44
R-squared (%)	93.2	
Long-run covariance estimator bandwidth	5	

Source: Moody's Analytics

ing only deposits now show that the monetary base multiplier is close to 4. During the period in 2006 when the Bank of Japan shrank its balance sheet, the multiplier was negative ($-0.08=3.96-4.04$) implying that at the margin a reduction in the balance sheet corresponds to an increase in deposits; that coefficient is not statistically significant from zero, however ($p \approx 0.26$).

The dummies representing the periods of no change in the Bank of Japan's balance sheet and Abenomics both confirm our conclusion that the longer extraordinary monetary policies drag on, the smaller the direct effect they have on deposit balances. The multipliers of the monetary base on CD balances are all practically zero, confirming our suspicion that changes in the monetary base affect non-maturity deposits more than time deposits.

Japanese VAR model

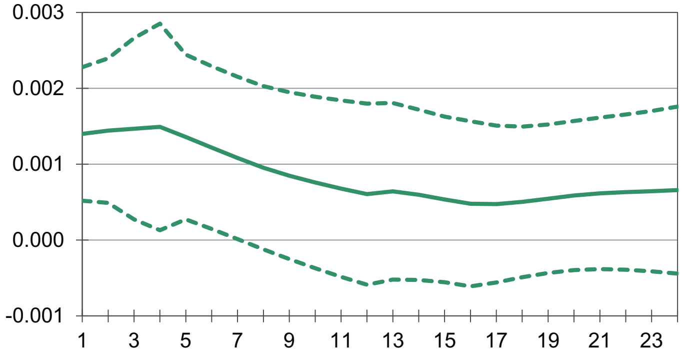
Similar to our VAR analysis of the U.S. economy, we also use a VAR model of the Japanese economy to explore the impact of changes in the monetary base on deposits, controlling for various channels through which that mechanism may work. We noted earlier that deposits fell about 2.5% from April 2006 to October 2006 when the Bank of Japan actively unwound previous quantitative easing. We want to see whether that decline is due to the unwinding or due to concurrent macroeconomic conditions.

Our VAR contains deposits (including CDs), the monetary base, GDP, the CPI, and the term interest rate spread defined as the difference between the 10-year bond yield and the yield on overnight uncollateralized loans. GDP was converted to monthly frequency using cubic interpolation. Based on preliminary analysis, our final specification contains lags 1, 4, and 12. Nonstationary variables are transformed to stationarity using the year-over-year relative change approximated as $\tilde{x}_t = \log(x_t) - \log(x_{t-12})$. To make our counterfactual analysis most realistic, we use only data through the end of 2005 to fit our model; if we used more recent data, then our analysis of the 2006 unwinding would reflect information that was not known when the unwinding was initiated.

Chart 15 shows how deposits respond to an orthogonalized shock to the monetary base. It shows that a positive shock to the monetary base does raise deposit balances a small amount; after about seven months, however, that effect is not statistically different from zero. Previous analysis involving structural breaks suggests that this

Chart 15: Deposit Response to Monetary Base

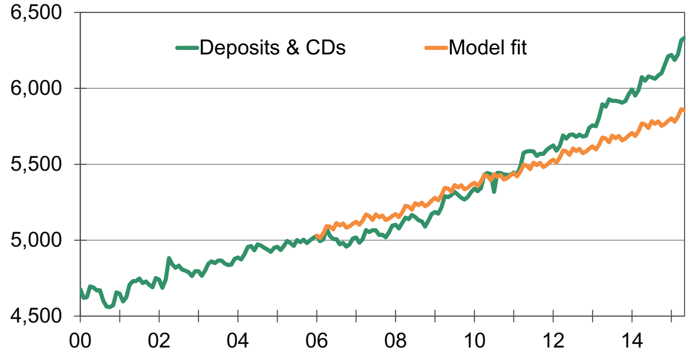
Orthogonalized 1 S.D. shock



Source: Moody's Analytics

Chart 16: VAR Model Forecast

¥100 bil



Sources: Bank of Japan, Moody's Analytics

response function varies over time; this chart merely gives the average effect over the pre-2006 period.

Next we construct a forecast for deposits using the information set available at the end of 2005; see Chart 16.

Projections produced on the eve of the Bank of Japan's unwinding actions point to higher levels of deposits than actually occurred. Using this approach, we find that actual deposits were lower than our model predicts until 2010. Over this period, deposits were on average 1.5% lower than our model forecasts made conditional on information only through the end of 2005 before the unwinding actions. This effect is about three times stronger than the effect observed using the exponential trend analysis. Our VAR analysis uses 12th-order lags, reducing the estimation sample size, and has significantly more parameters than the exponential trend model, so the VAR forecasts are almost certainly more variable than the exponential trend model's, but perhaps less biased.

Conclusion

We have used three different approaches to tease out the impact of changes in Japan's monetary base on deposits. The simplest approach, using an exponential trend model, suggests that there exists prima facie evidence that declines in the monetary base are associated with coincident declines in deposits. This work indicates that deposits are about 0.5% lower as a result of the Bank of Japan's actions taken in 2006 to unwind its previous quantitative easing program.

We then considered the direct effects of changes in the monetary base under a number of different periods in Japan's recent economic history. We found, with very robust results, that changes in the monetary base were only weakly correlated with changes in deposits during the period where the Bank of Japan was actively unwinding previous quantitative easing. While changes in the monetary base do affect deposit holdings, our results suggest that these effects have been greatest at times when the Bank of Japan has pursued a more "traditional" policy stance of neither engaging in quantitative easing nor actively unwinding it.

Finally, our VAR modeling suggests that when indirect effects are also considered, the unwinding actions employed by the Bank of Japan in 2006 had a larger impact of about 1.5%.

Our conclusion is that the decrease in the monetary base in 2006 had a weak direct effect on deposits and a moderate indirect effect. Overall we find that Japanese deposits did respond to the 2006 unwinding of quantitative easing. However, it is difficult to conclude these effects are of economic consequence for a large bank, especially given the margin of error in any statistical analysis.

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Appendix: Supplementary material omitted from the main text

Supplementary VAR Model Information

Table 12: Variables Used in U.S. VAR Analysis

Variable Definitions

Variable Name	Level Series Definition	Source
FRB balance sheet	FRB: Assets - Total assets ($ mil, NSA)	U.S. Board of Governors of the Federal Reserve System (FRB): H.4.1 Factors Affecting Reserve Balances [RESPPA_N.WW]
10-yr Treasury yield	Interest Rates: Treasury Constant Maturities Nominal - 10 yr (% p.a., NSA)	U.S. Board of Governors of the Federal Reserve System (FRB): H.15 Selected Interest Rates [RIFLGFCY10_N.M]
3-mo Treasury yield	Interest Rates: Treasury Constant Maturities Nominal - 3 mo (% p.a., NSA)	U.S. Board of Governors of the Federal Reserve System (FRB): H.15 Selected Interest Rates [RIFLGFCM03_N.M]; Moody's Analytics (ECCA) Estimated - from JAN34 TO DEC81 based on ((365*IRTB3MM.US/100)/(360-(IRTB3MM.US/100*180)))*100
Term spread	irg10ym minus irgt3mm	See below.
Real GDP	Gross Domestic Product (Chained 2009 $ bil, SAAR)	U.S. Bureau of Economic Analysis (BEA): National Income and Product Accounts (NIPA): [Table 1.1.6, 1.2.6, 1.3.6, 1.4.6, 1.5.6, 1.7.6, 1.8.6, 1.17.6]
CPI	CPI: Urban Consumer - All items (1982-84=100, SA)	U.S. Bureau of Labor Statistics (BLS): Consumer Price Index (CPI)
Shadow banking system	Size of shadow banking system	See next table
Dow Jones	Dow Jones U.S. total stock market index, USD - Closing price (Index, NSA)	S&P Dow Jones Indices LLC: U.S. Total Stock Market Indices [Index ID = DWCF]
VIX	CBOE Volatility Index SP500 [VIX] - Close (Index)	SIX Financial Information
Size-weighted EDF	Weighted average default probability of U.S. financial institutions with asset values above $10 bil, with weights proportional to book assets.	Moody's Systemic Risk Monitor 1.0, Moody's CreditEdge
M1	Money Stock: M1 ($ bil, NSA)	U.S. Board of Governors of the Federal Reserve System (FRB): H.6 Money Stock Measures [M1_N.M]
Currency	Money Stock: Currency	U.S. Board of Governors of the Federal Reserve System (FRB): H.6 Money Stock Measures [MCU.M]
Demand deposits	Money Stock: Demand deposits ($ bil, NSA)	U.S. Board of Governors of the Federal Reserve System (FRB): H.6 Money Stock Measures [MDD_N.M]
Other checkable deposits	Money Stock: Other checkable deposits - Total ($ bil, NSA)	U.S. Board of Governors of the Federal Reserve System (FRB): H.6 Money Stock Measures [MDO_N.M]
M2	Money Stock: M2 ($ bil, NSA)	U.S. Board of Governors of the Federal Reserve System (FRB): H.6 Money Stock Measures [M2_N.M]
Savings deposits	Money Stock: Savings deposits - Total ($ bil, NSA)	U.S. Board of Governors of the Federal Reserve System (FRB): H.6 Money Stock Measures [MDU_N.M]
Small time deposits	Money Stock: Small-denomination time deposits - Total ($ bil, NSA)	U.S. Board of Governors of the Federal Reserve System (FRB): H.6 Money Stock Measures [MDTS_N.M]
Retail money market deposits	Money Stock: Retail money funds ($ bil, NSA)	U.S. Board of Governors of the Federal Reserve System (FRB): H.6 Money Stock Measures [MMFGB_N.M]
Institutional money market deposits	Money Stock: Institutional money funds ($ bil, NSA)	U.S. Board of Governors of the Federal Reserve System (FRB): H.6 Money Stock Measures [MMFIN_N.M]

Source: Moody's Analytics

Table 13: FRB Financial Account Components of Shadow Banking System

Series Definition	Source
Financial Accounts: Property-casualty insurance companies - Asset - Credit Market Instruments ($ mil, NSA)	U.S. Board of Governors of the Federal Reserve System
Financial Accounts: Life insurance companies - Asset - Credit Market Instruments ($ mil, NSA)	U.S. Board of Governors of the Federal Reserve System
Financial Accounts: Private pension funds - Asset - Credit Market Instruments ($ mil, NSA)	U.S. Board of Governors of the Federal Reserve System
Financial Accounts: Money market mutual funds - Asset - Credit Market Instruments ($ mil, NSA)	U.S. Board of Governors of the Federal Reserve System
Financial Accounts: Issuers of asset-backed securities - Asset - Credit Market Instruments ($ mil, NSA)	U.S. Board of Governors of the Federal Reserve System
Financial Accounts: Finance companies - Asset - Credit Market Instruments ($ mil, NSA)	U.S. Board of Governors of the Federal Reserve System
Financial Accounts: Real estate investment trusts - Asset - Credit Market Instruments ($ mil, NSA)	U.S. Board of Governors of the Federal Reserve System
Financial Accounts: Security brokers and dealers - Asset - Credit Market Instruments ($ mil, NSA)	U.S. Board of Governors of the Federal Reserve System
Financial Accounts: Holding companies - Asset - Credit Market Instruments ($ mil, NSA)	U.S. Board of Governors of the Federal Reserve System
Financial Accounts: Funding corporations - Asset - Credit Market Instruments ($ mil, NSA)	U.S. Board of Governors of the Federal Reserve System
Financial Accounts: Mutual funds - Asset - Credit Market Instruments ($ mil, NSA)	U.S. Board of Governors of the Federal Reserve System
Financial Accounts: Closed-end funds - Asset - Credit Market Instruments ($ mil, NSA)	U.S. Board of Governors of the Federal Reserve System
Financial Accounts: Exchange-traded funds - Asset - Credit Market Instruments ($ mil, NSA)	U.S. Board of Governors of the Federal Reserve System

Source: Moody's Analytics

Sensitivity to lag length

We refit model MFA using four, six and 12 lags. The following three tables show the results. Our broad conclusions remain the same. Monetary aggregates M1 and M2 show mild declines relative to the baseline in the alternative scenarios, although individual components of those aggregates show more heterogeneous responses. The results based on six lags are a bit perplexing. M1 is forecast to decline relative to the baseline under all four alternative scenarios, yet all of its components are expected to rise relative to the baseline save demand deposits in one scenario.

Table 14: Simulation Results From Macrofinancial VAR Model MFA (4 Lags)

Variable	Baseline ($ bil)	Alternative Scenario Deviations From Baseline (%) 2025	2023	2020	2017
June 2018 Forecast Horizon					
M1	3,734	-0.6	-0.98	-2.04	-3.24
Currency in circulation	1,527	-0.11	-0.16	-0.31	-0.81
Demand deposits	1,611	-2.15	-3.43	-7.05	-12.23
Other checkable deposits	615.1	0.96	1.55	3.27	8.4
M2	13,946	-0.52	-0.83	-1.73	-3.88
Savings deposits	9,022	-0.08	-0.11	-0.19	-0.69
Small time deposits	465.4	12.02	19.27	43.05	157.79
Retail money market deposits	508.3	-1.74	-2.75	-5.64	-14.09
Institutional money market deposits	1,756	-2.3	-3.66	-7.48	-19.07
June 2020 Forecast Horizon					
M1	4,165	-1.15	-1.88	-3.96	-5.46
Currency in circulation	1,714	-0.31	-0.5	-1.03	-2.34
Demand deposits	1,753	-3.96	-6.41	-13.15	-18.02
Other checkable deposits	679.4	0.97	1.69	3.81	1.61
M2	15,594	-0.71	-1.19	-2.56	-2.53
Savings deposits	10,993	-0.45	-0.7	-1.42	-3.96
Small time deposits	640.5	24.45	42.73	112.34	258.47
Retail money market deposits	483.6	-1.71	-2.95	-6.47	-3.58
Institutional money market deposits	1,965	-1.6	-2.91	-6.61	1.52
June 2025 Forecast Horizon					
M1	5,254	-2.5	-3.31	-5.22	-5.75
Currency in circulation	2,293	-0.71	-1.24	-1.58	-1.49
Demand deposits	1,952	-7.88	-10.46	-14.99	-16.01
Other checkable deposits	847.5	0.26	-0.69	-3.12	-3.6
M2	20,713	-0.86	-0.85	-0.46	-0.36
Savings deposits	18,003	-1.3	-2.38	-3.38	-3.37
Small time deposits	1,679	50.52	90.13	106	105.38
Retail money market deposits	473.7	0.4	2.12	9.52	11.47
Institutional money market deposits	3,002	1.82	5.2	16.39	16.58

Source: Moody's Analytics

Table 15: Simulation Results From Macrofinancial VAR Model MFA (6 Lags)

Variable	Baseline ($ bil)	Alternative Scenario Deviations From Baseline (%) 2025	2023	2020	2017
June 2018 Forecast Horizon					
M1	4,265	-0.23	-0.42	-0.98	-0.46
Currency in circulation	1,560	0.03	0.06	0.13	0.47
Demand deposits	2,371	0.24	0.16	-0.08	6.41
Other checkable deposits	675.9	0.96	1.51	3.12	7.98
M2	14,171	-0.11	-0.19	-0.4	-0.51
Savings deposits	9,820	0.83	1.33	2.79	7.34
Small time deposits	366.5	6.68	10.43	22.06	69.23
Retail money market deposits	399.5	-2.2	-3.37	-6.7	-16.73
Institutional money market deposits	1,337	-2.55	-3.99	-8.04	-19.52
June 2020 Forecast Horizon					
M1	5,277	0.15	0.17	0.2	4.44
Currency in circulation	1,759	-0.05	-0.07	-0.13	-0.86
Demand deposits	3,860	2.87	4.37	8.86	33.27
Other checkable deposits	789.8	1.72	2.84	6.13	9.49
M2	15,963	-0.12	-0.21	-0.48	-0.13
Savings deposits	12,328	1.19	2	4.37	4.87
Small time deposits	451.7	16.06	27.06	65.18	164.1
Retail money market deposits	310.5	-4.11	-6.61	-13.5	-22.21
Institutional money market deposits	1,166	-4.49	-7.23	-14.75	-21.07
June 2025 Forecast Horizon					
M1	8,750	1.65	3.82	5.86	7.19
Currency in circulation	2,384	-0.25	-0.51	-0.83	-0.89
Demand deposits	13,862	13	25.92	42	55.28
Other checkable deposits	1,136	3.05	4.43	5.04	5.01
M2	21,678	-0.09	0.07	0.16	0.15
Savings deposits	22,310	1.69	2.06	1.65	1.64
Small time deposits	935.6	37.71	69.27	94.93	95.5
Retail money market deposits	198.5	-7.58	-11.87	-12.72	-14.17
Institutional money market deposits	923.7	-9.19	-13.35	-17.11	-19.59

Source: Moody's Analytics

Table 16: Simulation Results From Macrofinancial VAR Model MFA (12 Lags)

Variable	Baseline ($ bil)	Alternative Scenario Deviations From Baseline (%) 2025	2023	2020	2017
June 2018 Forecast Horizon					
M1	3,523	-1.5	-2.33	-4.69	-9.74
Currency in circulation	1,535	0.03	0.09	0.27	1.34
Demand deposits	1,430	-3.99	-6.18	-12.25	-23.59
Other checkable deposits	690	2.62	4.05	8.31	22.43
M2	14,271	-0.14	-0.2	-0.34	-0.45
Savings deposits	9,723	1.79	2.82	5.88	16.7
Small time deposits	398.8	6.96	11.09	24	75.21
Retail money market deposits	359.7	-6.15	-8.99	-16.75	-38.14
Institutional money market deposits	1,506	-3.61	-5.52	-10.82	-25.47
June 2020 Forecast Horizon					
M1	3,679	-3.74	-5.94	-12.05	-21.77
Currency in circulation	1,669	-0.95	-1.44	-2.85	-9.59
Demand deposits	1,406	-8.69	-13.67	-26.62	-42.46
Other checkable deposits	841.6	4.46	7.48	16.75	30.28
M2	15,854	-0.47	-0.74	-1.52	-4.3
Savings deposits	12,205	1.72	3.05	6.98	5.35
Small time deposits	415.1	12.42	21.18	50.66	87.62
Retail money market deposits	102.9	-17.02	-25.77	-46.26	-76.16
Institutional money market deposits	1,462	-2.55	-4.67	-10.56	-7.33
June 2025 Forecast Horizon					
M1	3,808	-8.16	-12.55	-17.12	-15.71
Currency in circulation	2,008	-2.76	-4.91	-7.32	-7.97
Demand deposits	1,116	-18.4	-27.11	-35.58	-34.89
Other checkable deposits	1,199	4.15	6.52	-2.45	-0.87
M2	20,826	-0.97	-1.7	-1.65	-3.89
Savings deposits	20,009	1.06	0.68	-5.08	2.65
Small time deposits	458.6	18.16	27.83	20.64	12.49
Retail money market deposits	93.4	-13.82	-23.77	9.89	53.31
Institutional money market deposits	1,663	0	1.58	19.19	-9.71

Source: Moody's Analytics

Alternative Models

In the main text we presented the results based on model MFA using three lags. Here we present the results for models B, M, and MFB using three lags.

Table 17: Simulation Results From Basic VAR Model B (3 Lags)

Variable	Baseline ($ bil)	Alternative Scenario Deviations From Baseline (%) 2025	2023	2020	2017
June 2018 Forecast Horizon					
M1	3,422	-1.26	-2.03	-4.21	-8.3
Currency in circulation	1,536	-0.5	-0.79	-1.63	-3.95
Demand deposits	1,268	-3.39	-5.41	-11.03	-20.44
Other checkable deposits	569.6	-0.13	-0.21	-0.44	-0.87
M2	14,202	-0.46	-0.73	-1.53	-3.35
Savings deposits	9,608	-0.23	-0.35	-0.72	-2.01
Small time deposits	485.3	10.01	16.02	35.37	122.45
Retail money market deposits	616.6	1.49	2.34	4.85	13.26
Institutional money market deposits	2,103	-2.63	-4.15	-8.42	-19.36
June 2020 Forecast Horizon					
M1	3,725	-1.84	-3.06	-6.51	-6.86
Currency in circulation	1,722	-0.77	-1.27	-2.71	-3.34
Demand deposits	1,322	-4.87	-8.01	-16.56	-17
Other checkable deposits	614.1	-0.19	-0.32	-0.69	-0.73
M2	15,902	-0.69	-1.14	-2.45	-2.81
Savings deposits	11,996	-0.45	-0.74	-1.55	-2.63
Small time deposits	624.7	19.6	33.86	85.56	175.6
Retail money market deposits	649.6	2.59	4.27	9.33	14.33
Institutional money market deposits	2,306	-4.1	-6.69	-13.82	-17.14
June 2025 Forecast Horizon					
M1	4,573	-2.61	-2.8	-2.8	-2.8
Currency in circulation	2,284	-1.19	-1.51	-1.51	-1.51
Demand deposits	1,441	-6.77	-7.02	-7.02	-7.02
Other checkable deposits	740.6	-0.27	-0.29	-0.29	-0.29
M2	21,045	-1.02	-1.2	-1.2	-1.2
Savings deposits	20,593	-0.9	-1.4	-1.69	-1.73
Small time deposits	1,376	40.11	68.58	81.91	84.54
Retail money market deposits	750.9	4.51	6.75	7.15	7.17
Institutional money market deposits	2,866	-6.33	-8.18	-8.2	-8.2

Source: Moody's Analytics

Table 18: Simulation Results From Macro VAR Model M (3 Lags)

Variable	Baseline ($ bil)	Alternative Scenario Deviations From Baseline (%) 2025	2023	2020	2017
June 2018 Forecast Horizon					
M1	3,895	-0.66	-1.07	-2.24	-3.76
Currency in circulation	1,578	-0.25	-0.39	-0.82	-2.01
Demand deposits	1,635	-2.09	-3.38	-7.02	-11.59
Other checkable deposits	676.1	0.7	1.12	2.35	5.73
M2	14,135	-0.48	-0.76	-1.57	-3.54
Savings deposits	9,631	-0.24	-0.37	-0.76	-2.1
Small time deposits	449.7	9.36	14.95	32.84	112.25
Retail money market deposits	444.6	-0.45	-0.72	-1.51	-3.72
Institutional money market deposits	1,538	-2.62	-4.16	-8.49	-19.5
June 2020 Forecast Horizon					
M1	4,455	-0.94	-1.58	-3.4	-3.27
Currency in circulation	1,792	-0.39	-0.65	-1.38	-1.74
Demand deposits	1,900	-2.91	-4.85	-10.25	-9.27
Other checkable deposits	771.4	1	1.68	3.66	3.91
M2	15,724	-0.73	-1.21	-2.6	-3.16
Savings deposits	12,069	-0.4	-0.66	-1.4	-2.04
Small time deposits	568.7	17.77	30.61	76.28	149.68
Retail money market deposits	390.7	-0.42	-0.73	-1.63	-0.46
Institutional money market deposits	1,530	-3.44	-5.72	-12.03	-11.38
June 2025 Forecast Horizon					
M1	6,033	-1.34	-1.28	-1.47	-1.53
Currency in circulation	2,446	-0.62	-0.8	-0.83	-0.84
Demand deposits	2,567	-3.91	-3.43	-3.7	-3.82
Other checkable deposits	1,051	1.38	1.55	1.3	1.25
M2	20,652	-1.11	-1.39	-1.38	-1.36
Savings deposits	20,915	-0.7	-1.02	-1.1	-1.12
Small time deposits	1,090	34.86	58.65	66.17	68.26
Retail money market deposits	328.2	0.12	0.7	2.31	2.85
Institutional money market deposits	1,745	-3.95	-3.88	-1.21	-0.74

Source: Moody's Analytics

Table 19: Simulation Results From Macrofinancial VAR Model MFB (3 Lags)

Variable	Baseline ($ bil)	Alternative Scenario Deviations From Baseline (%) 2025	2023	2020	2017
June 2018 Forecast Horizon					
M1	3,843	-0.83	-1.33	-2.75	-5.25
Currency in circulation	1,589	-0.16	-0.25	-0.52	-1.35
Demand deposits	1,528	-3.21	-5.09	-10.34	-20.13
Other checkable deposits	674.1	0.77	1.25	2.65	6.69
M2	14,269	-0.26	-0.42	-0.87	-1.92
Savings deposits	9,608	-0.23	-0.35	-0.72	-2.01
Small time deposits	473.3	10.14	16.2	35.72	124.2
Retail money market deposits	457.1	-0.21	-0.37	-0.83	-1.98
Institutional money market deposits	1,603	-1.62	-2.6	-5.36	-13.26
June 2020 Forecast Horizon					
M1	4,324	-1.37	-2.26	-4.78	-6.11
Currency in circulation	1,805	-0.3	-0.49	-1.04	-1.69
Demand deposits	1,658	-5.02	-8.18	-16.78	-20.04
Other checkable deposits	762.4	0.93	1.58	3.49	2.32
M2	16,028	-0.38	-0.64	-1.38	-1.55
Savings deposits	11,996	-0.45	-0.74	-1.55	-2.63
Small time deposits	628.9	20.13	34.79	88.22	187.32
Retail money market deposits	420.4	0.45	0.63	1.16	6.41
Institutional money market deposits	1,687	-1.48	-2.59	-5.72	-1.4
June 2025 Forecast Horizon					
M1	5,618	-2.29	-2.89	-3.5	-3.58
Currency in circulation	2,468	-0.56	-0.87	-0.98	-1
Demand deposits	1,900	-7.82	-9.5	-10.57	-10.71
Other checkable deposits	1,018	0.93	0.56	-0.25	-0.32
M2	21,556	-0.53	-0.61	-0.51	-0.47
Savings deposits	20,593	-0.9	-1.4	-1.69	-1.73
Small time deposits	1,398	41.17	71.35	84.29	86.1
Retail money market deposits	398.2	2.59	5	8.87	9.81
Institutional money market deposits	2,257	-0.06	1.62	6.71	7.3

Source: Moody's Analytics

About the Authors

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Brian Poi is a director of Consumer Credit Analytics at Moody's Analytics in West Chester PA, where he develops a variety of credit loss, credit origination and deposit account models for use in both strategic planning and CCAR/DFAST environments. He is equally adept at developing primary models as well as playing the role of validator for models developed elsewhere. Dr. Poi also provides thought leadership and guidance on the use of advanced statistical and econometric methods in economic forecasting applications. 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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Tony Hughes

Tony Hughes is a Managing Director in the Economic and Consumer Credit Analytics group 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 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.

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A trusted adviser to policymakers and an influential source of economic analysis for businesses, journalists and the public, Dr. Zandi frequently testifies before Congress on topics including the economic outlook, the nation's daunting fiscal challenges, the merits of fiscal stimulus, financial regulatory reform, and foreclosure mitigation.

Dr. Zandi conducts regular briefings on the economy for corporate boards, trade associations and policymakers at all levels. He is on the board of directors of MGIC, the nation's largest private mortgage insurance company, and The Reinvestment Fund, a large CDFI that makes investments in disadvantaged neighborhoods. He is often quoted in national and global publications and interviewed by major news media outlets, and is a frequent guest on CNBC, NPR, Meet the Press, CNN, and various other national networks and news programs.

Dr. Zandi is the author of Paying the Price: Ending the Great Recession and Beginning a New American Century, which provides an assessment of the monetary and fiscal policy response to the Great Recession. His other book, Financial Shock: A 360º Look at the Subprime Mortgage Implosion, and How to Avoid the Next Financial Crisis, is described by the New York Times as the "clearest guide" to the financial crisis.

Dr. Zandi earned his BS from the Wharton School at the University of Pennsylvania and his PhD at the University of Pennsylvania. He lives with his wife and three children in the suburbs of Philadelphia.

About Moody's Analytics
Economic & Consumer Credit Analytics

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Moody's Analytics added Economy.com to its portfolio in 2005. Now called Economic & Consumer Credit Analytics, this arm 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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