Commemorating 100 Years of Research

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Bank Consolidation and Merger Activity Following the Crisis

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Commemorating 100 Years of Research

By Esther L. George

This year, the Federal Reserve Bank of Kansas City will commemorate the centennial of its flagship research publication, the *Economic Review*. Esther L. George, the Bank’s President and Chief Executive Officer, highlights how the publication has evolved over time.

Should Monetary Policy Monitor Risk Premiums in Financial Markets?

By Taeyoung Doh, Guangye Cao, and Daniel Molling

The severity of the 2007-08 financial crisis and subsequent slow recovery reignited interest in whether monetary policy should play a more active role in preventing financial instability. Some policymakers have suggested adjusting interest rates in response to risk premiums in financial markets could mitigate financial instability by discouraging excessive risk-taking. Taeyoung Doh, Guangye Cao, and Daniel Molling perform a statistical analysis to assess whether risk premiums can predict future economic growth and whether monetary policy can influence risk premiums. The results suggest monitoring a broad range of risk premiums in financial markets and adjusting policy in response may be worthwhile if monetary policy makers are concerned about tail risks associated with financial instability.

Bank Consolidation and Merger Activity Following the Crisis

By Michal Kowalik, Troy Davig, Charles S. Morris, and Kristen Regehr

The number of U.S. banks has declined sharply over the past 30 years. Since the end of the 2007-09 recession, voluntary mergers between unaffiliated banks have been the primary reason for this decline. Banks merge for a number of business-related reasons, such as to achieve economies of scale, enhance revenues and cut costs through operational efficiencies, and diversify by expanding their business lines or geographic reach.

Michal Kowalik, Troy Davig, Charles S. Morris, and Kristen Regehr analyze the financial characteristics of acquired banks with assets of $1 billion or less from 2011 to 2014 and find these banks had much in common. Acquired banks tended to be smaller and have a lower return on assets, more cash, less capital, and lower regulatory ratings than their
non-acquired peers. The results suggest post-crisis mergers have, on average, led to more efficient banks and a sounder banking system. The authors note, however, that these benefits could be offset if mergers reduce competition in local banking markets and thereby communities’ access to credit.

What Could Lower Prices Mean for U.S. Oil Production?

By Nida Çakır Melek

U.S. oil and natural gas production has grown significantly since 2005, reflecting a move toward shale gas and tight oil extraction. Since 2011, the most productive tight oil and shale gas fields accounted for nearly all of the growth in U.S. energy production, due largely to extensive use of hydraulic fracturing and horizontal drilling. High energy prices made these costly technologies profitable to apply on a large scale. However, oil prices and rig counts declined sharply in 2014, calling into question whether the boom in U.S. oil production can continue.

Nida Çakır Melek examines how falling oil prices, declining rig counts, and gains in rig and well efficiency could affect 2015 oil production. Her analysis suggests production could decline from 0.7 to 8 percent in 2015 despite highly productive new wells and increasing rig efficiency. For production to increase in 2015, rig efficiency and initial well production would need to increase markedly or the decline in rig counts would need to halt.
For the past 100 years, researchers at the Federal Reserve Bank of Kansas City have studied and analyzed the regional, national, and international economies to better inform the central bank’s policymaking process.

Today, Bank economists are still dedicated to researching areas such as macroeconomics and monetary policy, banking and payments systems, and regional and agricultural economics. While their work provides important context for the Fed to better understand what is happening in the economy, the Bank also has made it a priority throughout its history to share this information broadly with the public. This research can provide useful insights not only for policymakers and research economists, but also for consumers, businesses, workers, students, and financial market participants.

This year, the Kansas City Fed will commemorate the centennial volume of the *Economic Review*, the Bank’s flagship economic research publication. At its inception in 1916, the publication, which was first titled the *Report of Conditions in District 10*, focused on topics providing information about the economy of the Tenth Federal Reserve District. Over time, the publication’s scope expanded to include economic analysis of a broad range of issues affecting the national and international economies.

The Kansas City Fed opened its doors on November 16, 1914, with a handful of employees conducting daily bank business. As the Bank grew during the following years, staff collected economic and financial data about the regional economy, but it wasn’t until the 1930s that a formal department was dedicated to research and analysis: the Research and Statistical Department.
The department’s mission expanded in the late 1930s when the Bank began employing Ph.D.-level economists. During this time, the bank’s research publication was renamed *The Monthly Review: Agricultural and Business Conditions*, which began publishing articles on employment, farm income, and bank operations. In 1978, the name changed again, to the *Economic Review*, and its content reflected a new focus on independent and original research by staff economists. This gave economists the opportunity to create valuable new insights into important public policy questions while evaluating regional, national, and international economies with state-of-the-art economic and statistical techniques.

In the same way technology has remade the global marketplace over the past 100 years, it profoundly influenced the way the Federal Reserve conducts research. Data, once painstakingly collected and analyzed, can now be gathered, transferred, and analyzed within days, hours, or even seconds thanks to computerization and the Internet. The Kansas City Fed has established itself as a leader in this area by providing high-capacity computing services for researchers using large and complex data sets that make up the raw data for innovative research.

Technology has also changed the way the Fed presents economic information. For decades, we have shared Kansas City Fed economists’ research with the public through the *Economic Review* and other free print publications. The Web has allowed us the opportunity to share research in the digital arena, and we continue to explore and expand upon these opportunities.

Throughout the changes of the past century, the Kansas City Fed pursued its mission—to conduct and produce reliable, timely, and significant economic research on issues relevant to the Federal Reserve and the public. The *Economic Review* will remain at the forefront of change as the Kansas City Fed continues to evolve.

Esther L. George,
President and Chief Executive Officer
Federal Reserve Bank of Kansas City
The recent financial crisis has reignited interest in whether monetary policy should respond to financial stability concerns such as asset price bubbles. Before the crisis, many believed monetary policy should respond to these concerns only to the extent they significantly alter the future outlook for inflation or unemployment. Proponents of this view regarded promoting financial stability by raising the cost of borrowing more than the outlook for inflation or unemployment warranted as undesirable because it might conflict with macroeconomic stability. However, the severity of the 2007-08 financial crisis and subsequent slow recovery challenged this view.

Recently, some policymakers have argued that monetary policy can and should play a more active role in preventing financial instability. Adjusting interest rates in response to risk premiums in financial markets could be an effective way to mitigate financial instability and the resulting macroeconomic instability. For example, if investors are underpricing adverse future outcomes, central banks could raise interest rates to increase the cost of risk-taking. Despite the importance of this suggested policy change, thorough investigations of the idea remain scarce.

Monitoring risk premiums might provide additional information about future macroeconomic outcomes that conventional indicators related to output and inflation do not typically reveal. As risk-averse
investors become more or less concerned about relatively unlikely but potentially disastrous macroeconomic outcomes, risk premiums might change to reflect their perceptions. For example, a sudden spike in credit risk premiums could indicate an impending severe recession not evident from past and present macroeconomic indicators. Policymakers could mitigate the risk of a recession by choosing a more accommodative policy stance in response. On the other hand, unusually low risk premiums could reflect excessive risk-taking and call for a tighter monetary policy stance.

To reduce the probability of an adverse macroeconomic outcome, policy responses to risk premiums must meet two key conditions. First, for policymakers to have a chance to prevent a bad outcome, risk premiums must be useful in predicting future changes in economic growth. Second, monetary policy must be able to change risk premiums. If sudden shifts in risk premiums are predictable and monetary policy can affect them, then a policy stance more reactive to risk premiums could reduce the probability of a sharp decline in future macroeconomic activity. This article investigates whether risk premiums help predict future economic growth and whether monetary policy can affect risk premiums.

To assess predictability, a statistical analysis estimates the predictable portion of various risk premiums and real gross domestic product growth. The analysis indicates a prolonged period of low risk premiums can increase the probability of a severely adverse macroeconomic outcome, although the overall impact on expected future GDP growth is generally small.

Monetary policy could offset the adverse future economic effect of low risk premiums. A statistical analysis shows that an unexpected tightening of monetary policy increases risk premiums in the future. However, such policy tightening is expected to reduce GDP growth by raising the cost of borrowing and reducing aggregate spending. Thus, while a policy response to risk premiums could prevent an expected decline in future economic activity, it would come at the cost of lower economic activity in the near term.

Overall, the analysis suggests that if policymakers are concerned about tail risks such as the probability of a severely adverse macroeconomic outcome, adjusting short-term interest rates in response to various estimated risk premiums could be appropriate, especially if the risk
premiums are low for a sustained period. In contrast, if policymakers are predominantly concerned about the most likely macroeconomic outcome, monitoring estimated risk premiums and adjusting the monetary policy stance accordingly may be of little benefit.

The first section of the article discusses how monitoring risk premiums might help prevent financial instability. The second section analyzes the predictability of future macroeconomic outcomes and estimated risk premiums as well as the response of risk premiums to the stance of monetary policy.

I. Financial Stability, Risk Premiums, and Monetary Policy

As the recent financial crisis has shown, asset booms and busts are important factors in macroeconomic fluctuations. Given that many central banks are mandated to stabilize macroeconomic volatility, a natural question is whether they should also respond to asset price volatility. The pre-crisis consensus view was that central banks should respond to changes in asset prices only to the extent they affect forecasts of macroeconomic objectives (Bernanke and Gertler). However, these forecasts typically focus on the most likely outcomes and ignore tail risks. As a result, most forecasters substantially underestimated the probability of the recent financial crisis and the severity of the subsequent recession.

Arguments against monetary policy responses to asset price movements

The standard theoretical argument that monetary policy should stabilize fluctuations in macroeconomic variables hinges on the idea that when prices are sticky—that is, slow to adjust—more productive firms are prevented from producing and selling more output by adjusting their prices when the aggregate inflation is fluctuating. By adjusting short-term interest rates, the central bank can reduce fluctuations in the aggregate inflation and reduce the negative effects of sticky prices on aggregate output. This argument for interest rate policy assumes perfect financial markets in which the risk of any macroeconomic state is correctly assessed and priced. As a result, financial decisions by themselves are unlikely to generate any inefficiency in resource allocation.

Even if financial markets are assumed to be imperfect by introducing limits on external financing, agents in the economy can correctly
price the risk of possible future macroeconomic outcomes in state-contingent contracts. Therefore, the risk premiums that arise from this financial friction fully reflect the social cost of borrowing and do not distort resource allocation.\(^2\) Hence, this framework does not support a case for monetary policy affecting mispriced risk premiums.

In addition, the pre-crisis consensus view is based on the belief that while monetary policy may influence the level of aggregate demand, it does not contribute significantly to asset price booms and busts (Smets). The implication of this belief is that responding to indicators of aggregate demand is enough to stabilize the effect of volatile asset price movements on the real economy.\(^3\) Furthermore, some researchers have argued that responding to asset prices rather than more conventional macroeconomic indicators of real activity can be less effective in inducing macroeconomic stability. For instance, Bernanke and Gertler suggest the central bank’s response to stock price movements can generate more volatility in inflation than an aggressive response to inflation and output gap measures. Since movements in stock prices are often hard to justify by economic fundamentals, they are much noisier signals of the central bank’s inflation and output objectives. Responding to noisier signals of those objectives makes them harder to achieve.

The pre-crisis consensus view does not rule out other policy tools to promote financial stability. Proponents often argue that regulatory approaches—for example, reducing the leverage in the financial system through capital requirements or restrictions on the liability side of financial intermediaries—might promote financial stability more effectively (Yellen).

Proponents of this view not only provided theoretical justifications but also empirical support: when the Internet stock bubble burst in the United States during the late 1990s, it did not majorly disrupt the economy (Fischer). However, the near meltdown of the financial system in the 2007-08 crisis and the subsequent slow recovery have seriously challenged this view.

**Arguments for monetary policy responses to asset price movements**

The alternative view that monetary policy can and should aim to reduce asset price volatility starts from the observation that financial market frictions can create inefficient credit booms and busts. Moreover, such inefficient booms and busts do not necessarily arise
from the regulated financial sector, which limits the power of macro-prudential regulation to prevent inefficient credit allocations. While financial market frictions can take various forms, a common theme is that asset prices may not guarantee the most efficient resource allocation in the economy. Borrowers (for example, entrepreneurs) may take more risk than socially desirable if frictional financial markets prevent them from fully internalizing the social cost of borrowing. For example, suppose borrowing is constrained by collateral requirements, so borrowers have to sell collateral during a bad macroeconomic state. Borrowers trying to liquidate their collateral to repay loans may not take into account the negative effects of their behavior on the net worth of others holding the same type of assets as collateral. This is often called a fire-sale externality and can result in inefficient overborrowing where borrowers underprice the social cost of their actions (Lorenzoni; Stein 2012). As a result, asset prices become more volatile.

Efficiency in such an environment could be improved in two ways. Although the conventional view would be to take a macroprudential approach—restricting borrowing against illiquid collateral—policy-makers could consider asset price volatility in their decisions, setting the cost of borrowing to fully reflect the fire-sale externality during a liquidity crisis. When the overall risk of asset prices is likely underpriced, interest rate policy could be less accommodative. Risk premiums help determine if a risk is underpriced. When a risk premium is significantly lower than economic risk factors imply, a future drop in asset values is more likely. Such a sudden shift can have substantial negative effects on the economy.

Evaluating the arguments

The relative merit of each method crucially depends on whether policymakers can identify the source of potential vulnerability in the financial system. If inefficient credit booms and busts appear in certain sectors of the economy, a targeted approach limiting lending to these sectors might be more effective than using monetary policy to change the overall cost of borrowing. The recent financial crisis has shown that excessive leverage and reliance on short-term funding in the financial sector can lead to financial instability. If these factors are expected to be important in the future, setting regulatory limits on leverage and short-term funding as well as enhancing underwriting standards to
prevent future crises might be more effective than adjusting the monetary policy stance.

However, predicting which sector will drive financial fragility in the future is difficult. The advantage of monetary policy in handling financial instability concerns is that it “gets in all of the cracks” (Stein 2014). While many are critical of using monetary policy to reduce asset price volatility because it is a “blunt tool” that affects the overall economy, such an approach might address financial instability concerns more effectively when the sources of future vulnerabilities are uncertain.

In addition, the pre-crisis consensus view assumes that macroeconomic stability pursued by monetary policy can be easily separated from financial stability pursued by regulations. This assumption is based on the belief that monetary policy, by altering the cost of borrowing, influences consumers’ and businesses’ decisions on current versus future spending. This line of thinking downplays the effect of monetary policy on financial intermediaries’ risk-taking. In contrast, recent research on monetary policy transmission channels suggests a higher interest rate increases the market price of risk and induces financial intermediaries to shrink their balance sheets (Adrian and Shin). Such changes tend to precede a decrease in real activity in the future. Hence, it is difficult to separate financial instability concerns related to financial intermediaries’ risk-taking from macroeconomic stability objectives.

A key challenge in using monetary policy to target financial instability concerns is gauging shifts in the market price of risk that require attention. A few candidates can act as credible indicators for the market price of risk. The next section discusses various measures of risk premiums as suitable indicators of shifts in the market price of risk.

II. An Empirical Analysis of Macroeconomic Outcomes, Risk Premiums, and Monetary Policy

Monetary policy influences the risk-taking of investors across a broad set of asset markets. As a result, any analysis of the market price of risk must include multiple risk premium measures. See the Box for a cautionary tale about what can happen when policymakers rely on a single risk premium measure.
In 2010 and 2011, Sweden’s Riksbank raised its policy rate seven times, from near zero to 2 percent. Several members of the executive committee at the Riksbank cited rising housing prices and high household debt levels among the justifications for raising the policy rate even though inflationary pressures were perceived as low when the decision for the first rate hike occurred (minutes from the June 2010 monetary policy meeting). After the rate increases, house prices began to fall in late 2011, growth to households slowed, and inflation eventually fell well below 2 percent. However, GDP growth also began to slow, and the Riksbank eventually reversed all of its policy rate increases. This new decline in GDP growth was likely due in large part to the poor economic performance of the eurozone, Sweden’s largest trading partner.

While this episode could be regarded as evidence against using monetary policy to address financial instability concerns, it is not inconsistent with the idea that monetary policy should respond to movements in broader measures of financial stability. In fact, corporate bond risk premiums in Sweden did not diverge much from economic fundamentals and only began to increase in 2011 after most of the policy rate increases took effect, as the chart on the next page shows.\(^4\) Premiums continued to increase after the Riksbank halted its rate increases in August 2011. The Swedish experience suggests that monetary policy should consider broader measures of financial stability such as aggregate asset market risk premiums rather than leverage in the housing sector itself. A targeted macroprudential approach might be more effective if the goal is to contain excess in that particular sector.
Risk premium measures

This article considers six risk premium measures. First, the article discusses measures of risk premiums from three different financial markets: the aggregate stock, bond, and derivative markets. The article then evaluates each premium’s ability to predict one-year-ahead real GDP growth.

The first risk premium is the equity risk premium (ERP) that measures the additional compensation that investors demand for investing in stocks rather than bonds free from default risk. Chart 1 shows the empirical measure of the ERP from Duarte and Rosa since 1990. Next, three measures of risk premiums are obtained from bond market data. Chart 2 shows the historical evolution of a measure of the term premium (TP), the additional compensation for duration risk incurred by holding long-term Treasury bonds. Chart 3 shows two measures of the credit risk premium: the excess bond premium (EBP) and the macro risk premium (MRP). The EBP measures additional compensation for the default risk incurred by investing in corporate bonds above and beyond what can be explained by changes in the expected default probability. Similarly, the MRP measures additional compensation for both the duration risk and the default risk above and beyond what can be explained by changes in the expected path of short-term risk-free rates and default probability. All these measures are generally countercyclical,
**Chart 1**

**Equity Risk Premium**

Note: Gray bars represent NBER-defined recessions.
Source: Duarte and Rosa.

**Chart 2**

**Term Premium**

Note: Gray bars represent NBER-defined recessions.
Source: Kim and Wright; Federal Reserve Board.
Chart 3
Macro Risk Premium and Excess Bond Premium

Note: Gray bars represent NBER-defined recessions.
Sources: Adrian, Moench, and Shin; Gilchrist and Zakrasjek.

Chart 4
Variance Premiums—VIX and MOVE

Note: Gray bars represents NBER-defined recessions.
Sources: Drechsler and Yaron; authors’ calculations.
rising during the recession periods identified by the National Bureau of Economic Research (NBER). The pattern is most pronounced in the ERP but also observed in the TP, EBP, and MRP.

Finally, two variance risk premium estimates (VP_VIX, VP_MOVE) from derivative markets measure the additional compensation for fluctuations in the return variance either in equity markets or Treasury bond markets. Chart 4 shows the historical evolution of the two variance risk premium estimates through past episodes of financial market turmoil. These variance risk premiums typically spike with major disruptions to financial markets, suggesting they are good proxies for the overall risk aversion of investors. Table 1 describes the risk premium measures used in the analysis, and the Appendix details how each risk premium measure is constructed.

From the perspective of financial stability, what is important is a shift in the overall market price of risk that can shift various risk premiums at the same time. To analyze the co-movement of these risk premiums, it is useful to look at their correlation matrix. The correlation matrix in Table 2 shows that the variance risk premium from equity options (VP_VIX) is nearly uncorrelated with risk premium measures other than the EBP. Additionally, the TP is more or less negatively correlated with all other risk premium measures. Unlike the VP_VIX, the VP_MOVE is positively correlated with the bond market risk premium estimates, suggesting that volatility and the level of bond returns might be positively correlated, on average. One notable pattern is that the

<table>
<thead>
<tr>
<th>Measure</th>
<th>Description</th>
<th>Source</th>
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<tr>
<td>MRP</td>
<td>The component of credit and treasury yields that tracks GDP growth. Constructed as the predicted values of a regression of GDP on various corporate bond and treasury spreads.</td>
<td>Adrian, Moench, and Shin, 2010</td>
</tr>
<tr>
<td>EBP</td>
<td>The component of the spread between corporate bonds and treasuries that is not explained by firms’ default risk.</td>
<td>Gilchrist and Zakrajsek, 2012</td>
</tr>
<tr>
<td>ERP</td>
<td>The expected return of stocks in excess of risk-free rate.</td>
<td>Duarte and Rosa, 2014</td>
</tr>
<tr>
<td>TP</td>
<td>The compensation demanded by investors for the uncertain return on holding a long-term bond.</td>
<td>Kim and Wright, 2005</td>
</tr>
<tr>
<td>VP_VIX</td>
<td>Difference between the squared Chicago Board Options Exchange Volatility Index (VIX) and expected realized variance of S&amp;P 500 yields.</td>
<td>Drechsler and Yaron, 2011, and authors’ calculations</td>
</tr>
<tr>
<td>VP_MOVE</td>
<td>Difference between the squared Merrill Option Volatility Estimate index (MOVE) and expected realized variance of Treasury yields.</td>
<td>Authors’ calculations</td>
</tr>
</tbody>
</table>
EBP is significantly correlated with two variance risk premiums which are more highly correlated with financial market turmoils than other risk premium measures.

**Predictability of macroeconomic activity and risk premiums**

The main criteria to judge whether monitoring a particular risk premium measure is worthwhile is whether or not the premium is predictable and provides information about the future economy beyond that provided by conventional macroeconomic indicators. As monetary policy typically influences the real economy with a lag, the current measure of the risk premium must provide information about the future risk premium. Without future information, any monetary policy response to the current estimate of a risk premium will be behind the curve in terms of effects on the real economy. Furthermore, fluctuations in the risk premium need to provide information about the future economy not revealed in the usual macro variables.

The estimated serial correlation coefficient provides a simple measure of a variable’s predictability. Table 3 shows that all the risk premium estimates have moderate to high values of serial correlation with most of coefficients above 0.5. Specifically, risk premium estimates from stock and bond markets are highly persistent with serial correlation coefficients above 0.8 while risk premium estimates from derivatives markets are only moderately persistent. Thus, the risk premium measures pass the first criterion of predictability.

Researchers have found that information from a risk premium measure about the future economy depends on the current state of the economy. While an increase in the risk premium can be a

\[
\begin{array}{ccccccc}
\text{MRP} & \text{EBP} & \text{ERP} & \text{TP} & \text{VP\_VIX} & \text{VP\_MOVE} \\
\hline
\text{MRP} & 1.000 & & & & & \\
\text{EBP} & 0.692 & 1.000 & & & & \\
\text{ERP} & 0.442 & 0.148 & 1.000 & & & \\
\text{TP} & -0.217 & -0.030 & -0.670 & 1.000 & & \\
\text{VP\_VIX} & 0.088 & 0.205 & 0.043 & -0.098 & 1.000 & \\
\text{VP\_MOVE} & 0.440 & 0.570 & -0.009 & 0.206 & -0.032 & 1.000 \\
\end{array}
\]

Table 2
Correlation Matrix of Risk Premiums
relatively good indicator of an economic downturn, a decrease in the risk premium may be a poor indicator of economic growth (Stein 2014). This asymmetry suggests that monetary policy may need to be less accommodative when responding to an exceptionally low risk premium than the pure macroeconomic outlook implies. However, a less accommodative policy would do little damage to the near-term macroeconomic outlook because the exceptionally low risk premium does not typically generate a huge boom in aggregate demand. The unusually low risk premium may sow seeds for future financial instability and subsequent macroeconomic instability as investors underestimate the riskiness of assets to reach for yield.

To evaluate the macroeconomic implications of changes in risk premiums, a statistical model relating real GDP growth one year ahead to the various measures of risk premiums is estimated. Lagged real GDP growth terms are also included in the regression to judge whether the financial indicators provide any additional predictive power beyond that from past GDP growth. Positive changes in risk premiums are included in the regression separately from negative changes to capture the apparent asymmetry in the relationship. The results are presented in Table 4. When only one risk premium measure is used as an explanatory variable in addition to three lags of real GDP growth, the model with the EBP has the highest explanatory power in terms of the adjusted R² statistic. The effect of changes in the EBP on real GDP growth is asymmetric. For example, a 1-standard-deviation increase in the EBP (0.6 percentage point) decreases one-year-ahead real GDP growth by a statistically significant 1.74 percent (2.904×0.6) on average. But a decrease in the EBP by the same magnitude increases one-year-ahead real GDP growth by only 0.64 percent (1.065×0.6)—
Table 4
Regression of One-Year-Ahead Real GDP Growth onto Change in Risk Premiums

<table>
<thead>
<tr>
<th>Explanatory variables</th>
<th>Forward real GDP</th>
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<tbody>
<tr>
<td>Increase in the EBP</td>
<td>-2.904*** (0.607)</td>
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<tr>
<td></td>
<td>-1.065 (0.680)</td>
</tr>
<tr>
<td>Decrease in the EBP</td>
<td>-1.324** (0.523)</td>
</tr>
<tr>
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<td>-1.015 (0.748)</td>
</tr>
<tr>
<td>Increase in the MRP</td>
<td>0.012 (0.014)</td>
</tr>
<tr>
<td></td>
<td>(0.019)</td>
</tr>
<tr>
<td>Decrease in the MRP</td>
<td>1.048 (0.960)</td>
</tr>
<tr>
<td></td>
<td>-0.264 (0.840)</td>
</tr>
<tr>
<td>Increase in the VP_VIX</td>
<td>0.012 (0.001)</td>
</tr>
<tr>
<td></td>
<td>-0.001 (0.002)</td>
</tr>
<tr>
<td>Increase in the TP</td>
<td>1.048 (0.960)</td>
</tr>
<tr>
<td></td>
<td>-0.264 (0.840)</td>
</tr>
<tr>
<td>Decrease in the TP</td>
<td>-0.002** (0.001)</td>
</tr>
<tr>
<td></td>
<td>-0.001 (0.002)</td>
</tr>
<tr>
<td>Increase in the ERP</td>
<td>1.751*** (0.265)</td>
</tr>
<tr>
<td></td>
<td>1.662*** (0.327)</td>
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<tr>
<td></td>
<td>1.626*** (0.263)</td>
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<tr>
<td></td>
<td>1.659*** (0.255)</td>
</tr>
<tr>
<td></td>
<td>1.871*** (0.276)</td>
</tr>
<tr>
<td></td>
<td>2.020*** (0.270)</td>
</tr>
<tr>
<td>First lag of real GDP</td>
<td>0.101* (0.051)</td>
</tr>
<tr>
<td></td>
<td>0.113** (0.053)</td>
</tr>
<tr>
<td></td>
<td>0.143** (0.057)</td>
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<tr>
<td></td>
<td>0.130** (0.056)</td>
</tr>
<tr>
<td></td>
<td>0.102 (0.060)</td>
</tr>
<tr>
<td></td>
<td>0.114** (0.063)</td>
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<tr>
<td>Second lag of real GDP</td>
<td>0.067 (0.057)</td>
</tr>
<tr>
<td></td>
<td>0.042 (0.057)</td>
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<tr>
<td></td>
<td>-0.017 (0.060)</td>
</tr>
<tr>
<td></td>
<td>-0.021 (0.057)</td>
</tr>
<tr>
<td></td>
<td>-0.017 (0.057)</td>
</tr>
<tr>
<td>Third lag of real GDP</td>
<td>0.029 (0.052)</td>
</tr>
<tr>
<td></td>
<td>0.048 (0.058)</td>
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<tr>
<td></td>
<td>0.033 (0.056)</td>
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<tr>
<td></td>
<td>0.032 (0.055)</td>
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<tr>
<td></td>
<td>0.001 (0.058)</td>
</tr>
<tr>
<td></td>
<td>0.028 (0.055)</td>
</tr>
<tr>
<td>Constant</td>
<td>1.751*** (0.265)</td>
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<td>1.659*** (0.255)</td>
</tr>
<tr>
<td></td>
<td>1.871*** (0.276)</td>
</tr>
<tr>
<td></td>
<td>2.020*** (0.270)</td>
</tr>
<tr>
<td>Observations</td>
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<td>89</td>
</tr>
<tr>
<td>Adjusted R²</td>
<td>0.291</td>
</tr>
<tr>
<td></td>
<td>0.164</td>
</tr>
<tr>
<td></td>
<td>0.038</td>
</tr>
<tr>
<td></td>
<td>0.036</td>
</tr>
<tr>
<td></td>
<td>0.093</td>
</tr>
<tr>
<td></td>
<td>0.141</td>
</tr>
</tbody>
</table>

*** Significant at the 1 percent level.
** Significant at the 5 percent level.
* Significant at the 10 percent level.
Note: Robust standard errors are in parentheses.

not statistically significant. While several risk premium measures have statistically significant coefficients, once the EBP is included, other risk premium measures offer little additional information. In this sense, the
EBP seems to be a sufficient statistic to monitor if the goal is to assess the near-term outlook for the macroeconomy.

This does not imply, however, that monitoring risk premium estimates other than the EBP is useless. Although these measures do not provide additional information on future economic activity once the EBP is included, they might be useful in predicting a spike in the EBP that could lead to a bad macroeconomic outcome. To investigate this possibility, the change in the EBP is regressed onto lagged risk premium estimates. The regression results in Table 5 suggest that positive changes in the EBP are more likely to happen when the level of the ERP, the TP, and the VP_VIX is negative. While we do not observe a negative equity risk premium during the sample period, the TP and the VP_VIX occasionally became negative. Together, the regression results in Tables 4 and 5 show that the ERP, the TP, and the VP_VIX have little information about future real GDP by themselves but provide additional information in predicting changes in the EBP. Therefore, ignoring fluctuations in these risk premium estimates solely based on

| Table 5
<p>| Regression of Changes in the EBP on Lagged Risk Premiums |</p>
<table>
<thead>
<tr>
<th>Explanatory variables</th>
<th>(1)</th>
<th>(2)</th>
<th>(3)</th>
<th>(4)</th>
<th>(5)</th>
<th>(6)</th>
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<td>Lag EBP</td>
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<td>-0.0936</td>
<td>-0.0824</td>
<td>-0.0343</td>
<td>-0.0586</td>
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<td>Lag VP_VIX</td>
<td>-0.008**</td>
<td>-0.008**</td>
<td>-0.009**</td>
<td>-0.009**</td>
<td>-0.009**</td>
<td></td>
</tr>
<tr>
<td>Lag ERP</td>
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<td>-0.0834**</td>
<td>-0.069*</td>
<td>-0.070*</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lag TP</td>
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<td>-0.075</td>
<td>-0.084*</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Lag MRP</td>
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<td>-0.074</td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lag VP_MOVE</td>
<td>0.000</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Constant</td>
<td>-0.008</td>
<td>0.089*</td>
<td>0.202***</td>
<td>0.392**</td>
<td>0.385**</td>
<td>0.377**</td>
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<td>Adjusted R²</td>
<td>0.065</td>
<td>0.184</td>
<td>0.202</td>
<td>0.215</td>
<td>0.214</td>
<td>0.209</td>
</tr>
</tbody>
</table>

*** Significant at the 1 percent level.
** Significant at the 5 percent level.
* Significant at the 10 percent level.
Note: Robust standard errors are in parentheses.
the regression of real GDP growth can be misleading, especially if the
goal is to detect the probability of a large spike in the EBP that could
signal a severe recession.

**Monetary policy and risk premiums**

A remaining question for monetary policy makers is whether
changes in the policy interest rate affect the magnitude of risk premi-
ums. To answer this question, this section estimates a statistical model
of the effect of a surprise change in the monetary policy stance on risk
premiums. The model is a vector autoregression (VAR) including an
indicator for the real economy, the real policy rate, the variance risk pre-
mium, and the forecast uncertainty of equity returns similar to Bekaert,
Hoerova, and Lo Duca.\(^8\)

The estimated response of the VP_VIX to a positive shock to the
real federal funds rate suggests that tightening monetary policy above
and beyond the level associated with business conditions and inflation
leads to an increase in the VP_VIX in the subsequent period (Chart
5). The analysis focuses on the variance risk premium for several rea-
sons. First, while an increase in the EBP predicts a decline in future
real GDP growth, the past EBP is not a good predictor for the current
EBP. Second, the VP_VIX becomes negative occasionally during the
sample period and predicts the EBP in a statistically and economically
significant way. The TP also shows these features, but the quantitative
magnitude in terms of predicting future changes in the EBP is smaller
than the VP_VIX. Combining the response of the VP_VIX to a posi-
tive monetary policy shock with previous findings that a lower variance
risk premium predicts an increase in the EBP that leads to a decline in
real GDP growth, the analysis suggests monetary policy could mitigate
a sudden spike in the future corporate bond risk premium that could
tigger macroeconomic instability.

To gauge the potential value of responding to risk premiums, a
counterfactual exercise is performed using the regression results. Using
only mean estimates from the regression analysis and assuming the level
of the VP_VIX (-2.06) as of the second quarter of 2014 is unchanged
for two years, the predicted negative impact of the negative variance
risk premium on real GDP growth from 2016:Q2 to 2017:Q1 is about
0.38 percentage point.\(^9\) Significant monetary policy tightening would
be required to completely offset this effect.
Raising the variance risk premium from -2.06 to 0 for two years would require a surprise monetary policy tightening of about 0.7 percentage point in each of three consecutive quarters. Given the dampening effect of such tightening on spending and thus real GDP growth, the macroeconomic benefit of promoting financial stability is relatively small. A one-percentage-point positive shock to the real funds rate is estimated to decrease real GDP growth by 0.3-0.4 percentage point for about one-and-a-half years (Kiley). Translated into the scale of this article’s exercise, the required monetary policy tightening is expected to reduce one-year-ahead real GDP growth by 0.95-1.3 percentage points with a mean reduction of 1.1 percentage points. Thus, preventing a future decline in economic activity may come at a large output cost today.

However, if policymakers are concerned about the tail risks associated with low risk premiums, the perceived value of a policy response may be greater. Using the upper band of the 95 percent confidence intervals of the estimates in the statistical model to express policymakers’ concern for tail risks, the same counterfactual exercise implies a 1.19-percentage-point decline in real GDP growth from 2016:Q2 to 2017:Q1. The cost of offsetting this risk remains the same as in the
previous exercise. While the magnitude is not necessarily alarming, it is worthwhile to keep in mind that evaluating the tail risk by assuming a normal distribution of regression coefficients likely underestimates the negative effect of the low variance risk premium on future real GDP growth. Therefore, if policymakers are concerned about tail risks, a prolonged period of a negative variance risk premium could be a factor in monetary policy decisions.

III. Conclusion

The severe macroeconomic effects of the 2007-08 financial crisis challenged the pre-crisis consensus that monetary policy should focus on stabilizing inflation and real output rather than financial stability. While a targeted regulatory approach might be effective in addressing particular vulnerabilities within regulated institutions, it may be less effective when vulnerabilities shift to an unregulated sector.

This article examines whether monetary policy could more effectively respond to financial stability concerns such as fluctuations in bond market risk premiums. The empirical analysis shows that positive changes in the excess bond premium have substantially negative effects on future real GDP growth. In addition, changes in this risk premium are better predicted by monitoring the level of other estimated risk premiums, not just its own level. Together, the results suggest monitoring the level of a broad range of estimated risk premiums may be worthwhile. While current levels of risk premium estimates do not suggest an immediate change in monetary policy, a non-negligible tail risk could emerge if the VP_VIX drops further and stays negative for a prolonged period.
Appendix

Construction of Risk Premium Measures

This article considers six risk premium measures constructed from data on aggregate market returns on equity, Treasury bonds, corporate bonds, equity derivatives, and Treasury bond derivatives. Monthly data are available from January 1990 to December 2012, except for the macro risk premium, which is available from July 1990 to December 2012. All monthly observations are converted to quarterly data using the three-month average.

The equity risk premium (ERP) is from Duarte and Rosa, who construct a measure of the one-month-ahead expected excess return of equity over the risk-free rate by extracting the first principal component of 29 different measures of the ERP.

Three different risk premium measures are used to describe bond market risk premiums. The macro risk premium (MRP) is from Adrian, Moench, and Shin, who construct a weighted average of term spreads between long-term Treasury bond yields and short-term Treasury bond yields and corporate bond yield spreads over Treasury bond yields to track the current quarter real GDP growth. The term premium (TP) is from Kim and Wright, who estimate a no-arbitrage three-factor affine term structure model using U.S. Treasury bond yields data and decompose the ten-year Treasury yield into expected short-term interest rates and the TP. The excess bond premium (EBP) is from Gilchrist and Zakrajšek, who compute the portion of corporate bond yield spreads over Treasury yields that cannot be explained by the expected default probability.

Two variance risk premium measures are obtained from derivative markets on equity and Treasury bonds. Following Drechsler and Yaron, the variance risk premium for the equity market (VP_VIX) is computed as the difference between the squared Chicago Board Options Exchange Volatility Index (VIX), which measures the implied volatility of S&P 500 index options, and the fitted variance of S&P 500 index return by a statistical model with one autoregressive term and one moving average term. Carr and Wu show that we can replicate the payoff from the variance swap rate in which the contracted payoff depends on the difference between the pre-fixed variance swap rate and the realized return variance that is computed ex post by using out-of-money
option prices. To prevent arbitrage opportunities in the swap contract, the variance swap rate should be equal to the risk-neutral expected value of the realized variance. Otherwise, by taking a long or a short position, an investor can take a positive profit with zero net investment. The risk-neutral expected value of the realized variance tends to be bigger than the expected value of the realized variance by a statistical model, implying that investors dislike fluctuations in return variance and are willing to pay a premium to fix variance ex ante by taking a long position in the swap contract. The variance risk premium for the bond market (VP_MOVE) is similarly computed but uses the squared Merrill Lynch Option Volatility Estimate (MOVE) that computes a weighted average of implied volatilities of Treasury bond yields from various Treasury bond option prices instead of the VIX.
Endnotes

1 Technically speaking, this assumption means that financial markets are complete. In other words, there exists a full set of state-contingent securities that pays off only when a particular state is realized in the future. When these securities are traded in frictionless financial markets, no-arbitrage conditions guarantee that risk-sharing is efficient in the sense that more risk-tolerant people bear more risks.

2 Financial frictions will generate a less desirable outcome than an economy without such frictions. But conditional on the existence of frictions, the resource allocation is optimal and cannot be improved by available policy tools in the economy unless one introduces additional constraints on the resource allocation due to the zero lower bound on nominal interest rates or a fixed exchange rate (Farhi and Werning). The consideration of such additional constraints along with external borrowing constraints has been largely absent in predominant models before the crisis.

3 Nonetheless, this view does not rule out short-term interventions to protect financial stability during liquidity crises (Bernanke and Gertler).

4 This article’s corporate bond risk premium data is from the Riksbank. A simple regression of Swedish risk premiums for corporate bonds on the growth rate of real GDP reveals a significant negative relationship, with high risk premiums relative to the pre-recession period. However, the risk premiums experienced essentially no change between late 2009 and mid-2010 when the first rate increases occurred.

5 Of course, if investors anticipate the systematic response of monetary policy to low risk premiums, the historical relationship may be weakened.

6 Chabot challenges the view that the low level of bond risk premium presages a future spike in the risk premium by looking at the TP, corporate bond spread, and EBP. Large increases in these three measures of bond risk premiums are found to be independent of the recent level or changes in risk premiums or the federal funds rate. The relatively high persistence of the three risk premium measures is consistent with that finding but the analysis does not consider other risk premium estimates as possible predictors.

7 A lower $R^2$ implies a lower overall magnitude of residual errors. To compare models with different numbers of regressors, an adjusted $R^2$ is preferable because it increases only when an additional regressor improves the model fit more than by chance.

8 The model this article uses to forecast return volatility is different from theirs in two ways. The percentage change in the industrial production index from a year ago is used as an indicator of real activity. The policy rate is measured as the effective federal funds rate deflated by the percentage change in the headline CPI from a year ago.

9 The calculation combines the estimated effect of the level of the variance risk premium on the change in the EBP with the estimated effect of the change in the EBP on future real GDP growth. For simplicity, the second-order effect of
the variance risk premium on the future EBP through the lagged EBP is ignored. Quantitatively, that magnitude turns out to be small.

10This number can be calculated from the cumulative response of the variance risk premium to a 1-standard-deviation positive monetary policy shock.

11If investors take a long position in the swap, a positive payoff occurs only when the realized variance is bigger than the swap rate. By having a higher swap rate than the statistical expectation of the return variance, the investors are willing to pay a premium in order to have an ex ante fixed return variance. If the investors do not care about fluctuations in the return variance, they would set the variance swap rate equal to the statistical expectation of the return variance.
References


Bank Consolidation and Merger Activity Following the Crisis

By Michal Kowalik, Troy Davig, Charles S. Morris, and Kristen Regehr

The number of U.S. banks has trended lower over the past 30 years, dropping from about 14,500 in the mid-1980s to 5,600 today. The number of banks declined for many reasons, such as failures during periods of crisis, consolidation spurred by the relaxation of state branching and national interstate banking restrictions, and voluntary mergers between unaffiliated banks. Since the end of the 2007-09 recession, voluntary mergers have been the primary reason for the decline.

Banks merge for a number of business-related reasons. Mergers allow banks to achieve economies of scale, enhance revenues and cut costs through operational efficiencies, and diversify by expanding business lines or geographic reach. Bank mergers can result in more efficient banks and a sounder banking system and thus benefit the economy, as long as banking markets remain competitive and communities’ access to banking services and credit is not diminished.

This article analyzes the financial characteristics of banks with assets of $1 billion or less that were acquired by an unaffiliated bank in a voluntary merger from 2011 to 2014. The analysis finds these mergers are consistent with the goals of greater economies of scale and improved

Michal Kowalik is a financial economist at the Federal Reserve Bank of Boston. Troy Davig is senior vice president and director of research, Charles S. Morris is a vice president and economist, and Kristen Regehr is an assistant economist at the Federal Reserve Bank of Kansas City. This article is on the bank’s website at www.KansasCityFed.org.
efficiency. Acquired banks are generally smaller, less profitable, less ef-
ficient, and in weaker condition than their non-acquired peers. Section
I reviews the reasons for bank mergers. Section II describes the data.
Section III provides a qualitative assessment of acquired-bank charac-
teristics. Section IV analyzes the mergers to determine the relative im-
portance and significance of an acquired bank’s characteristics.

I. Reasons for Bank Mergers

Bank mergers drove the long-term downward trend in the number
of banks since 1985. Even in the crisis periods of the late 1980s, early
1990s, and 2007-09, the number of mergers exceeded the number of
failures every year.\(^1\) Chart 1 shows the number of community banks,
defined as banks with assets of $1 billion or less, along with mergers
and failures from 2007-14. Community banks are the focus because
mergers involving larger banks, particularly banks with assets of more
than $10 billion, are rare. For example, about 90 percent of the 1,500
mergers since 2007 involved a bank with less than $1 billion in assets.\(^2\)

As Chart 1 shows, the number of community banks fell by al-
most 1,700, or 25 percent, from 2009-11. Although the crisis started
in 2007, the effects of the crisis and recession did not work their way
through the banking system for a couple of years. As a result, mergers
fell and failures rose significantly in 2009, though failures never ex-
ceeded mergers. Since 2011, the decline in the number of community
banks has been mostly due to voluntary mergers between banks.

Business-related reasons to merge reflect perceived opportunities to
increase the total value of two or more separate banks by consolidating
them into one entity (DeYoung and others).\(^3\) Owners of banks that are
less profitable, less efficient, and in weaker condition (in the sense they
are more susceptible to future financial problems) may seek to exit the
industry by selling their businesses, while profitable and efficient banks
may look for opportunities to expand (Hannan and Piloff; Jagtiani;
Wheelock and Wilson).\(^4\)

In addition to quickly expanding its own business, a bank can fur-
ther increase its business and revenue over time by acquiring another
bank and using its resources to expand loans and other business lines.
These resources may have been underused due to ineffective manage-
ment or insufficient capital. For example, acquiring a bank with excess
deposits provides the acquirer with a stable source of funds for expanding lending. Cyree finds that acquirers are willing to pay a larger premium over book value for a bank with a higher ratio of core deposits to assets, supporting the idea that banks with high deposit shares are attractive targets. Acquiring a bank in the same market or with similar products may allow the acquirer to capitalize on some particular expertise and thereby increase its business with modest expense. Acquiring a bank may also provide the acquirer with a broader client base to which they can cross-sell additional products and banking services. An acquisition can also boost the merged entity’s revenue by increasing market share in a given location or business line. Finally, acquiring a bank can boost revenue growth if the acquired bank is in a market with strong economic activity.

In addition to potentially increasing revenue, acquiring a bank can also generate substantial efficiency gains, especially if the acquired bank is inefficient or has ineffective management. For example, an acquisition can allow banks to spread their costs over a larger asset base, reduce staff, and eliminate branches. Mergers can be especially beneficial to banks with similar business or geographical profiles as fewer

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Chart 1
Change in the Number of Community Banks since 2008

![Chart](chart.png)

Note: Community banks are defined as banks with assets of $1 billion or less. Source: Federal Reserve change-in-control data.
resources are needed to serve their combined business purpose (Cornett and others). 6

Mergers can also reduce a bank’s risk by diversifying its asset portfolio, funding sources, and fee generating activities. Acquiring a bank that operates in different markets or business lines will often increase diversification. To reduce risk, however, the acquiring bank must have a strong understanding of the new market’s characteristics and risks, along with expertise in new business lines. Otherwise, the risk of the combined institution could increase. 7

II. Bank Merger Data

The analysis focuses on voluntary mergers between unaffiliated banks that occurred between January 1, 2011, and December 31, 2014, in which the acquired banks had assets of $1 billion or less. Acquired banks are grouped according to the year, or cohort, in which a merger took place, since economic conditions and motives for mergers may change as a business cycle matures. Characteristics of the different cohorts can then be analyzed over time.

From 2011 through 2014, the number of voluntary mergers increased each year. Mergers increased from 73 in 2011 to 162 in 2014. Table 1 divides the total number of banks into those that were acquired in each year and those that were not. The increase in mergers can be explained, in part, by an improvement in overall economic and banking conditions reflecting the transition from the recovery following the financial crisis to a relatively healthy expansion. Improved economic conditions make potential targets more attractive due to their healthier portfolios and the stronger markets in which they operate. Furthermore, improved economic conditions strengthen potential acquirers, giving them greater ability to acquire new banks.

In addition to the number of mergers, the data include comprehensive measures on bank balance sheets and performance collected from Call Reports, change-in-control data, and confidential supervisory ratings (see the Appendix for a data description). Call Reports provide balance sheet and performance information on banks. Federal Reserve change-in-control data provide information for identifying mergers and determining whether they are voluntary and between unaffiliated banks. Confidential ratings data provide information about the safety and soundness of banks that is not available in Call Reports or other public data.
III. Characteristics of Acquired Banks

Although banks are acquired for different reasons, they often share similar characteristics relative to banks that are not acquired. Comparing acquired community banks with their non-acquired peers reveals important differences in profitability, size, and condition. In general, acquired banks are often smaller, less profitable, less efficient, and in weaker condition than their non-acquired peers.

Differences in size, profitability, and efficiency

Chart 2 compares the median total assets of acquired and non-acquired banks from 2011-14. In general, the median acquired bank is about 15 percent smaller than its peers during the sample period. Acquired banks are also less profitable. Low profitability reflects lower returns from loans and other business lines and higher expenses. Panel A of Chart 3 shows the median return on average assets (ROA), the broadest measure of profitability, for non-acquired banks and each cohort of acquired banks. For each cohort, the chart shows the median ROA from 2008, the first full year of the crisis, through the year prior to the merger. For example, the data for the 2011 cohort show the median ROA for those banks from 2008-10. Panel A shows that acquired banks in every cohort were less profitable than the median non-acquired bank. In addition, Panel A shows that banks acquired further past the end of the crisis tended to be more profitable in the year before they were acquired (the end point of each of the cohort lines), likely due to the improving economy.

A bank’s ROA can be divided into three components measuring the bank’s revenue strength and cost structure. These three components are

<table>
<thead>
<tr>
<th>Year</th>
<th>Acquired banks</th>
<th>Non-acquired banks</th>
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<tr>
<td>2011</td>
<td>73</td>
<td>5,881</td>
<td>5,954</td>
</tr>
<tr>
<td>2012</td>
<td>116</td>
<td>5,598</td>
<td>5,714</td>
</tr>
<tr>
<td>2013</td>
<td>134</td>
<td>5,368</td>
<td>5,502</td>
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<tr>
<td>2014</td>
<td>162</td>
<td>5,117</td>
<td>5,279</td>
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</tbody>
</table>

Note: See Appendix for a data description.
Source: Federal Reserve change-in-control data.
net interest income, which measures the profitability of making loans and investing in securities relative to the cost of deposits and other liabilities; non-interest income, which measures fees earned on non-lending services and activities; and non-interest expenses, which reflect the costs of running a bank other than interest paid on liabilities, such as the costs of personnel and maintaining buildings.

Acquired banks are generally less profitable due to lower levels of both net interest income and non-interest income, as well as relatively high operating costs. Panel B of Chart 3 shows the net interest income of acquired banks was mixed across cohorts relative to non-acquired banks through 2009. Since the end of the recession, however, all cohorts of acquired banks had net interest income below the median of non-acquired banks. In terms of non-interest income, Panel C shows acquired banks consistently underperformed across all cohorts. Furthermore, acquired banks consistently had higher non-interest expenses than their peers. Panel D of Chart 3 shows that expenses—including the costs of personnel, maintaining buildings, and data processing—were relatively high as a share of average assets.
Chart 3
Profitability Measures

Panel A: Median return on assets

Panel B: Median net interest income

Panel C: Median non-interest income

Panel D: Median non-interest expense

Panel E: Median efficiency ratio

Notes: Medians are as of year-end. See Appendix for a data description.
Source: Reports of Condition and Income.

A final common performance measure is a bank’s efficiency ratio, defined as non-interest expenses divided by the sum of net interest income and non-interest income. The efficiency ratio increases as costs rise and income declines. Panel E shows that the median acquired bank operated less efficiently than the median non-acquired bank across all cohorts over the sample period. This is not surprising given the differences in income and expenses between acquired and non-acquired banks shown in Panels B-D of the chart.

Differences in condition

In addition to being less profitable and less efficient, acquired community banks also tended to be in weaker condition than non-acquired
banks over the sample period. Acquired banks had relatively less capital, more problem assets, and lower regulatory ratings. Their weaker condition is consistent with their lower profitability and efficiency, since factors such as problem loans reduce interest income and lead to higher costs as banks work them out.

A bank’s condition can be measured in many ways, but capital tends to be the first measure analysts examine. In many cases, losses resulting from the crisis left banks with less capital available to cover unexpected losses, making it more difficult for these banks to make new loans. Panel A of Chart 4 shows that at the time of their acquisition, acquired banks were generally less well-capitalized than non-acquired banks, based on the ratio of tangible common equity to tangible assets. The pattern is less pronounced or absent for banks acquired in 2012 and 2013, consistent with a gradual healing of the industry: the first banks to fail or be acquired were in the worst condition, and the remaining banks generally increased their capital ratios after the recession.

Two other common measures of a bank’s condition are the quality of its asset portfolio, as measured by the share of noncurrent loans to net loans (Chart 4, Panel B), and the share of other real estate owned (OREO) to total assets (Chart 4, Panel C). Noncurrent loans are loans more than 90 days overdue or not accruing interest. The share of noncurrent loans thus provides a good measure of a loan portfolio’s risk of default. High levels of OREO reflect past lending that ended in the borrower defaulting and the bank taking possession of the real estate used to collateralize the loan. As Panels B and C of Chart 4 show, both of these metrics increased for all banks during and after the crisis. The rise in these measures for acquired banks relative to non-acquired banks was substantial, suggesting that acquired banks invested in relatively riskier loans prior to the crisis.

A final measure of a bank’s condition is the confidential supervisory risk rating (CAMELS) that the state and federal supervisory agencies use to summarize a bank’s condition after an examination. The CAMELS rating is an aggregate measure on a scale of 1 (best) to 5 (worst), based on capital adequacy (C), asset quality (A), management quality (M), earnings (E), liquidity (L), and sensitivity to market risk (S). Chart 4, Panel D shows the mean ratings for acquired banks have been substantially worse than the industry average since the crisis, with the gap for 2014 mergers even wider than in 2008.\textsuperscript{8}
**Chart 4**

**Condition Measures**

**Panel A: Median tangible common equity**

- **Notes:** Medians/means are as of year-end. In Panel A, tangible common equity is total equity less perpetual preferred stock, goodwill, and other intangible assets. Tangible assets are total assets less goodwill and other intangible assets. In Panel B, noncurrent loans is the sum of loans 90 or more days past due and nonaccrual loans. See Appendix for a data description.

Source: Reports of Condition and Income.

**Differences in balance sheet composition**

Differences in a bank’s profitability and expenses reflect differences in the composition of its balance sheet, such as the share of loans, cash, and deposits held as a percentage of its total balance sheet. Panel A of Chart 5 shows acquired banks tended to have loan shares modestly higher than non-acquired banks until 2012. The 2013 cohort, which had significantly lower loan shares, is an exception to this trend. Panel B shows acquired banks had higher cash shares than non-acquired banks, and that the gap increased over time. On the liability side, Panel C shows acquired banks tended to have modestly higher deposit shares than non-acquired banks, particularly in the year prior to their...
These results suggest that acquiring banks may have targeted banks that would provide quick increases in loans and access to cash and deposits to support future loan growth. Cyree finds that acquirers are willing to pay a larger premium over book value for a bank with higher deposits to assets, supporting the idea that banks with high deposit shares are attractive targets. These motives are perhaps unsurprising given the lack of lending opportunities and loan demand during much of the recovery from the financial crisis.
IV. The Relative Importance of the Characteristics of Acquired Banks

Although acquired community banks share many characteristics, the statistical or economic significance of these characteristics in determining which banks are acquired can differ. To rank the importance of the characteristics of banks most likely to be acquired, two analytical methods are used: classification trees and probit regression.

Classification trees, as the name suggests, classify data in successive steps according to various criteria, resulting in smaller groups as the analysis progresses. The objective is to create separate groups with similar characteristics, in this case, groups of banks that are likely to be acquired or not.

Splitting banks into groups requires identifying an appropriate variable on which to split, as well as the value used to separate the sample. The ideal variable and split value would result in two samples, or branches of the tree: one containing all acquired banks and the other containing all non-acquired banks. In practice, however, such a clean split is unlikely.

As an example, Figure 1 shows a classification tree based on banks that were acquired in 2014. The sample used to construct the tree comprises 675 banks, 123 of which were acquired. The tree shows that banks with an ROA below 61 basis points were more likely to be acquired. About 31 percent of banks with an ROA below this threshold were acquired, compared to about 11 percent of banks with an ROA above the threshold. It is perhaps not surprising that ROA is the first of the 24 variables to split the sample between acquired and non-acquired banks, given that Chart 3, Panel A showed ROA tends to distinguish acquired banks from other banks.\(^\text{10}\)

The tree also shows that among the subset of banks with a higher ROA, those that are relatively inefficient are more likely to be acquired. Among the 426 banks with an ROA greater than 61 basis points, only seven were relatively inefficient with efficiency ratios above 90. It is not surprising that so few banks with relatively high profits would be relatively inefficient. However, four of these seven banks were acquired.

The example in Figure 1 is based on an actual subset of bank mergers occurring in 2014. In general, the vast majority of banks are not acquired. For example, only 3 percent of all the banks in the data set...
in 2014 were acquired. With such a low number of acquisitions, the classification tree analysis produces subsamples that primarily contain non-acquired banks simply because they dominate the data set. As a result, the criteria used to evaluate the subsets finds they are not sufficiently different, and the classification tree algorithm does not create additional branches of the tree.

Random sampling can address this issue by better balancing the number of observations between acquired and non-acquired banks. In this procedure, the sample includes all acquired banks and a random sample of non-acquired banks to create a 5:1 ratio of non-acquired to acquired banks. Although this ratio is much higher than what is observed in the data, it allows the classification algorithm to more sharply compare the characteristics of the acquired banks with those that were not acquired.

One issue with sampling the data is that the results may depend on the particular random subset of data selected. To mitigate this potential bias, 1,000 different subsamples are constructed for each cohort. The classification tree analysis is then run on each subsample, generating

Figure 1
Classification Tree for Bank Mergers in 2014
1,000 different trees. For each year of the sample, ROA and efficiency are identified as the most important variables in distinguishing acquired from non-acquired banks, suggesting that relatively unprofitable and inefficient banks are the most likely to be acquired. The average cutoff values for ROA are 10, 51, 49, and 46 basis points for banks acquired in 2011, 2012, 2013, and 2014, respectively. The corresponding cutoffs for efficiency ratios are 90, 95, 86, and 85. As an example of how these results are interpreted, in 2014, banks with ROA less than 46 basis points were more likely to be acquired, while banks with ROA equal to or greater than 46 basis points were more likely to be acquired if their efficiency ratio was equal to or greater than 85.

To understand the statistical and economic significance of the most important variables identified by the classification tree analysis, ROA and the efficiency ratio are used as independent variables in a probit regression. The dependent variable indicates whether a bank is acquired. Table 2 shows the results for each cohort using observations for all community banks. The coefficient on ROA is significant at the 5-percent level for every year in the sample. The negative coefficient indicates that as ROA increases, the probability of being acquired declines. The coefficient on the efficiency ratio is positive as expected in every year except 2014, but it is not significant in explaining whether a bank is acquired in any year. The insignificance of the efficiency ratio may reflect that it is important for only a small number of acquisitions when simultaneously accounting for the effect of ROA, which was shown to be the dominant variable in the classification tree analysis.

To get a sense of the importance ROA has for a bank’s probability of being acquired, Chart 6 shows how the estimated probabilities vary by cohort. For banks with a high level of losses—for example, an ROA of -500 basis points—the probability of being acquired in 2014 was 0.48, substantially higher than the 0.07 probability in 2012 for a bank with the same ROA. As ROA increases and turns positive, however, the probability of being acquired falls to near zero regardless of the year.

The probability of a bank with a negative ROA being acquired is generally economically significant. For example, the estimated probabilities of being acquired in 2014 for banks with ROAs less than 100 basis points are significantly greater than the 0.03 probability of being acquired calculated from the raw data sample.
Table 2
Probit Regression of Acquired Banks

<table>
<thead>
<tr>
<th>Year</th>
<th>ROA</th>
<th>Efficiency</th>
<th>Number of observations</th>
</tr>
</thead>
<tbody>
<tr>
<td>2011</td>
<td>-0.14**</td>
<td>0.0004</td>
<td>5,954</td>
</tr>
<tr>
<td></td>
<td>(0.026)</td>
<td>(0.001)</td>
<td></td>
</tr>
<tr>
<td>2012</td>
<td>-0.12**</td>
<td>0.0006</td>
<td>5,714</td>
</tr>
<tr>
<td></td>
<td>(0.035)</td>
<td>(0.001)</td>
<td></td>
</tr>
<tr>
<td>2013</td>
<td>-0.23**</td>
<td>0.0003</td>
<td>5,502</td>
</tr>
<tr>
<td></td>
<td>(0.040)</td>
<td>(0.009)</td>
<td></td>
</tr>
<tr>
<td>2014</td>
<td>-0.32**</td>
<td>-0.0003</td>
<td>5,279</td>
</tr>
<tr>
<td></td>
<td>(0.047)</td>
<td>(0.001)</td>
<td></td>
</tr>
</tbody>
</table>

** Significant at the 5-percent level.
Notes: Dependent variable is whether a bank is acquired. Standard errors in parentheses.
Source: Reports of Condition and Income.

Chart 6
Probability of Being Acquired Due to Changes in ROA by Cohort

Notes: Probabilities derived from the probit regression results in Table 2. In calculating the probabilities, the coefficient on efficiency is set to zero because it is insignificant.
These results suggest that for a given ROA, the probability of being acquired increases as the effects of the financial crisis and recession recede. Improving economic and banking conditions have generally made banks stronger and more optimistic about the future of the economy. As a result, banks are looking for opportunities to grow and possibly expand into new markets and activities, which may explain why the number of mergers has increased.

V. Conclusion

The number of banks has declined sharply over the past 30 years, due in part to voluntary mergers between unaffiliated banks. In fact, voluntary mergers have been the primary factor in the decline since the end of the 2007-09 recession. This article analyzes the mergers of community banks over the past four years and finds they are consistent with the goals of achieving greater economies of scale and improving efficiencies. Acquired banks tend to be smaller and have a lower return on assets, lower net interest income, and higher non-interest expenses than non-acquired banks. Acquired banks may be less profitable because they tend to have lower loan and higher cash and deposit shares. In addition, the condition of acquired banks tends to be worse than their industry peers in terms of capital, supervisory examination ratings, and problem loans and assets. Among the characteristics that differentiate acquired banks, statistical analysis suggests profitability and efficiency are the most important factors.

The results suggest that mergers on average result in more efficient banks and a sounder banking system, which should lead to greater access to credit at lower cost and thus be beneficial for local communities. However, the benefits of mergers can be offset if mergers make local banking markets less competitive and reduce the communities’ access to banking services and credit. Although federal banking regulatory agencies monitor mergers and do not approve those that are expected to result in uncompetitive banking markets, more research is needed to determine the net effect of bank mergers on local communities.
Appendix

Data Description

The article focuses on unaffiliated bank mergers that occurred between 2011 and 2014 involving acquisitions of community banks, defined as banks with assets of $1 billion or less. The data consist of 25 variables from Call Reports, the Federal Reserve System’s database of changes in bank control, and confidential supervisory examination ratings. To eliminate outliers, banks with ROA greater than the 99.5 percentile or less than the 0.5 percentile are excluded from the analysis.

For mergers that involve bank holding companies (BHCs), unaffiliated bank mergers are defined as acquisitions that occur between banks not part of the same bank holding company (BHC). When BHCs merge, however, the banks are often not simultaneously merged. BHCs may delay bank mergers, for example, to determine the best way to consolidate operations and information technology systems or make personnel changes. For such mergers, the merger of the subsidiary banks is considered unaffiliated if it occurs within one year of the BHC merger. The one-year cutoff was chosen to ensure that banks merged in such a manner are not improperly classified as consolidations of banks part of the same BHC. The distinction between unaffiliated mergers and consolidations is important because the reasons driving these two events very likely differ. Including consolidations with unaffiliated mergers in the analysis could bias the results.
Endnotes

1Other factors affect the change in the number of banks from year to year, the most important of which is newly chartered banks (referred to as de novo banks). Other than the crisis periods of the late 1980s, early 1990s, and 2007-09, the decline in the number of banks is almost entirely due to mergers of affiliated or unaffiliated banks, partially offset by de novo banks. For example, from 1995 to 2007, about 5,200 mergers were partially offset by about 2,000 de novos and only 47 bank failures.

2These numbers include mergers of affiliated and unaffiliated banks because both types of mergers reduce the number of banks. However, mergers of affiliated banks have declined sharply in recent years because most geographic restrictions were eliminated by the mid-1990s. As a result, the vast majority of mergers are between unaffiliated banks.

3DeYoung and others provide an extensive review of the merger and acquisition literature. In addition to business motives for mergers, private motives can also play an important role in a banker’s decision to sell. For example, community banks are often family-owned and may lack successors or be located in declining rural markets that can become “overbanked.” Alternatively, some owners start banks with the goal of quickly selling them to a larger institution, rather than operating them independently on a long-term basis. Although this latter example may sound like a business motive, it is primarily driven by the owner’s private motive to cash out as quickly as possible.

4Hannan and Piloff show that banks are more likely to be acquired as their profitability declines and their inefficiency rises. Jagtiani shows acquirers tended to be more efficient and better managed than the targets. Wheelock and Wilson also find that increased inefficiency or decreased profitability lead to a greater probability of being acquired.

5For relatively small community banks, specializing in a business activity or location may allow them to diversify the idiosyncratic risk in their loan portfolios by reducing exposure to individual loans.

6Cornett and others show significant increases in earnings in acquiring banks following a merger, particularly when mergers result in focusing activities or geographical reach, as opposed to diversifying.

7During the crisis, many community banks failed because they had expanded lending into out-of-territory areas where they had little understanding of the markets and associated risks. Since the crisis, one of the risks that has become more prevalent is strategic risk, which includes the risk of banks expanding into new business lines without sufficient expertise.

8A CAMELS rating of 3 means a bank’s condition is less than satisfactory. The mean is used instead of the median because the discrete nature of the rating system leads to all of the medians being 2, which is not surprising since a 2 rating is near the middle of the range and not less than satisfactory.
While Cyree’s analysis uses core deposits, the trend for core deposits and total deposits is similar for our sample over the period analyzed.

The full data set described in the Appendix has 25 variables. However, the data set used to conduct the classification tree analysis excludes the CAMELS rating and thus has only 24 variables. The CAMELS rating was excluded because, as a supervisory measure of a bank’s overall condition, it reflects many of a bank’s underlying characteristics, such as its balance sheet and condition variables. As a result, if the classification tree were to split on the CAMELS rating, especially at the first level, it would mask the underlying differences between acquired and non-acquired banks.

Probit regression is a regression technique used when the dependent variable is a discrete “yes or no” variable, such as whether a bank is acquired or not, as opposed to a continuous variable.

In Chart 6, the coefficient on efficiency is set to zero because it was insignificant. Alternatively, setting efficiency to the sample average for each cohort and using the estimated coefficients does not materially change the results.
References


What Could Lower Prices Mean for U.S. Oil Production?

By Nida Çakır Melek

Oil prices have declined sharply since the summer of 2014, raising questions about whether the boom in oil and gas production can continue. Since 2005, U.S. oil and gas production has increased more than 50 percent. The share of oil and gas in private fixed investment increased from 2.9 percent in 2005 to 5.8 percent in 2013. With oil prices at about half their summer 2014 level, will the investment continue to be profitable and boost production?

The dramatic increase in production post-2005 became possible when high and rising energy prices allowed two complementary but expensive technologies—multistage hydraulic fracturing and horizontal drilling—to be applied on a large scale for the first time. Energy producers were able to access previously untapped reservoirs using the newly profitable technologies, first in shale gas fields such as the Barnett field of east Texas, and then in tight oil fields such as the Bakken in North Dakota. Since 2011, over 95 percent of the growth in U.S. oil and gas production has come from these unconventional sources. To continue this growth, however, energy prices must remain high enough to justify the costs of extraction. Shale fields require significant drilling activity and thus significant ongoing capital investment to increase, much less

Nida Çakır Melek is an economist at the Federal Reserve Bank of Kansas City. Elena Ojeda, a research associate at the Oklahoma City Branch of the bank, helped prepare the article. This article is on the bank’s website at www.KansasCityFed.org.
maintain, production levels. Moreover, the cost of an unconventional well could be as high as five times the cost of a conventional well.

The recent sharp decline in oil prices and drop in oil rig counts have called into question whether oil production will continue to increase in 2015. This article estimates that, despite highly productive new wells and an increase in the number of wells drilled per rig, U.S. oil production could decline from 0.7 to 8 percent in 2015, due in part to the significant decline in rig counts and depletion in existing wells. While the 0.7 to 8 percent range appears wide, it reflects uncertainty regarding productivity gains in the sector over a one-year period as well as how much further rig counts could decline. For production to increase in 2015, rig efficiency and initial well production would need to increase markedly or the decline in rig counts would need to halt.

Section I reviews the key technologies driving the recent boom and describes tight oil and shale gas field characteristics. Section II investigates the trends in energy prices and production in the U.S. oil and gas sector since 1990. Section III examines the implications of the recent oil price decline for drilling activity and U.S. oil production.

I. Tight Oil and Shale Gas

The recent growth in U.S. oil and natural gas production reflects a move toward shale gas and tight oil extraction. Shale gas is natural gas trapped deep within shale formations, while tight oil is oil produced from low-permeability source rocks deep within the earth. Horizontal drilling and hydraulic fracturing have made these fields accessible (see Box for a description of these technologies). In 2000, shale gas provided only 1 percent of U.S. natural gas production; in 2010, it provided over 20 percent.

Although companies have only recently developed horizontal drilling and hydraulic fracturing on a large scale, the technologies have existed for over 50 years. When U.S. oil and gas production started to decline in the 1970s, producers searched for other sources of domestic production. A combination of private and government funding contributed to improvements in the late 1970s. Output nearly stabilized in the 1990s as a result of both management and technological advancements in the oil and gas sector (Bohi).
Box
Overview of Key Technologies

The key technologies that contributed to the oil and gas boom are horizontal drilling, hydraulic fracturing, and pad drilling.

**Horizontal wells** typically start vertically and then curve to horizontal at depth to follow a particular reservoir (Hughes 2013a). The first horizontal oil well was drilled in 1929, but the commercial application was not developed until the 1980s. The development of supportive technologies—including three-dimensional seismology, measurement-while-drilling (MWD), and steerable drilling motors—played an important role in the process. Three-dimensional (3D) seismology information, obtained by sensors sent into the earth, is used to determine where to locate a well, how many wells to drill, and how to drill the well for maximum production (Wang and Krupnick). An MWD package, or downhole instrument package, transmits sensor readings of the drill bit location to the surface. Additional sensors in the drill string also provide real time information on the downhole environment and physical characteristics. Using the data from the MWD package, the direction of the hole can then be controlled with a steerable motor.

**Hydraulic fracturing (“fracking”)** is the process of inducing fractures in reservoir rocks through the injection of fluids, chemicals, and solids under very high pressure. A mixture of sand and other granular materials creates or holds open fractures in the rock to allow the hydrocarbons to flow freely to the well. The first experiments with hydraulic fracturing took place in 1947 and marginal developments followed. Mitchell Energy began large-scale testing of the technology in 1978 with the Department of Energy’s support (Wang and Krupnick). The knowledge developed during that test was then transferred to other unconventional areas. As with horizontal drilling, 3D seismology supported hydraulic fracturing by giving developers a better understanding of the geology of the reservoir and how best to stimulate it.

**Pad drilling** is another technique that has been used intensively along with hydraulic fracturing and horizontal drilling since
Experiments with horizontal drilling date back several decades, but the development of complementary technologies—such as 3D seismic surveying methods—made horizontal drilling more practical. In 1991, the first horizontal well was drilled in the Barnett Shale field. In 1997, hydraulic fracturing was successfully applied to shale formations. Together, these technologies have changed the energy sector significantly: the most productive tight oil and shale gas fields accounted for more than 95 percent of growth in oil and gas production from 2011 to 2013, due largely to extensive use of hydraulic fracturing and horizontal drilling (U.S. EIA 2014b).

Production in tight oil and shale gas fields depends on several factors, such as initial well production, production decline rates, and extraction costs. These factors have led to considerable and continued drilling activity and investment in oil and gas extraction in recent years, without which U.S. production would have fallen quickly.

Initial production

Oil and natural gas production in shale formations depends heavily on the initial production (IP) of unconventional wells—that is, their production rate when first drilled. For a few high-quality wells, IP can be significant, but for the majority of wells, IP is considerably lower. For example, 2 percent of gas wells in the Haynesville field of east Texas and west Louisiana have an IP over 7,300 million cubic feet per year. However, as shown in Table 1, the field’s average IP is much lower at around 2,993 million cubic feet per year. In the Eagle Ford tight oil field of south Texas, about 10 percent of oil wells have an IP of more than 365 thousand barrels per year, but the average IP is around 160 thousand barrels per year (Hughes 2013a). Nevertheless, these lower
Table 1
Average Well Production by Field

<table>
<thead>
<tr>
<th>Tight oil field</th>
<th>Average well production (1,000 bbl)</th>
<th>Average initial well production (1,000 bbl)</th>
<th>Shale gas field</th>
<th>Average well production (million cubic feet)</th>
<th>Average initial well production (million cubic feet)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bakken</td>
<td>45.3</td>
<td>146.0</td>
<td>Haynesville</td>
<td>910.0</td>
<td>2,993.4</td>
</tr>
<tr>
<td>Eagle Ford</td>
<td>61.3</td>
<td>159.5</td>
<td>Marcellus</td>
<td>470.9</td>
<td>710.7</td>
</tr>
<tr>
<td>Permian</td>
<td>7.1</td>
<td>30.4</td>
<td>Woodford</td>
<td>226.3</td>
<td>836.6</td>
</tr>
<tr>
<td>Niobrara</td>
<td>1.7</td>
<td>9.2</td>
<td>Granite Wash</td>
<td>112.4</td>
<td>759.2</td>
</tr>
</tbody>
</table>

Source: Hughes (2013a).

average IP rates are still significantly higher than average well production, a measure which includes all operating wells both new and old. Average well production is only 61 thousand barrels per year in Eagle Ford.

Production decline rates

Unconventional wells have steeper production decline rates than conventional wells. In conventional oil fields, annual production decline rates typically range from 5 to 10 percent (Hook and others). A conventional well can go through a longer period of steady, flat production between its peak and decline. In unconventional wells, however, production falls rapidly in the first three years and then enters a sustained period of low production. As a result, new and high-producing wells have to be drilled constantly to maintain steady production across unconventional fields.

In shale gas and tight oil formations, production typically declines sharply in the first year (Table 2). In the next couple of years, production continues to fall fairly rapidly. For example, production in an average gas well in the Marcellus shale gas field of Pennsylvania and western Virginia declines around 47 percent in its first year. In three years, the overall decline averages around 80 percent. Similarly, in the Haynesville shale gas field of eastern Texas and western Louisiana, production declines 68 percent in the first year and nearly 90 percent over the first three years. The average three-year decline rate across the top five shale gas fields is over 80 percent.

In the Bakken, one of the top tight oil fields in North Dakota and Montana, production in an average well declines 69 percent in its first
year and more than 85 percent in its first three years. In the Eagle Ford tight oil field of south Texas, production in an average well declines 60 percent in its first year and more than 90 percent over its first three years. Chart 1 shows the well decline curves for oil production in the Bakken/Three Forks and Eagle Ford. Although initial production is high in these fields, the steep decline rates mean that drilling, and thus investment in the oil and gas sector, must remain at high levels to increase production.

Extraction costs

A third factor in oil and natural gas production is the high cost of drilling in tight oil and shale gas fields. An unconventional well can cost from $5 million to $9 million. In 2012, the average cost of a new well across the top 10 tight oil fields was about $8.3 million (Table 3). In 2013, a well in the Eagle Ford cost about $6 million (Xu). Similarly, wells in the Permian and Bakken fields cost, on average, $5.5 million and $8 million, respectively. In contrast, a conventional vertical well can cost from $1 million to $3 million (Barker).

Due to the high cost of unconventional wells, energy companies had little incentive to broadly employ sophisticated, expensive, and capital-intensive drilling techniques when prices were low. However, rising energy prices in the 2000s made these technologies profitable for commercial oil and gas production. As a result, the share of horizontal rigs in total rigs has increased from 9 percent in 2002 to 81 percent in 2014 (Chart 2).

Table 2

First Year Well Decline Rates

<table>
<thead>
<tr>
<th>Tight oil field</th>
<th>Decline rates (percent)</th>
<th>Shale gas field</th>
<th>Decline rates (percent)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bakken</td>
<td>69</td>
<td>Haynesville</td>
<td>68</td>
</tr>
<tr>
<td>Eagle Ford</td>
<td>60</td>
<td>Marcellus</td>
<td>47</td>
</tr>
<tr>
<td>Permian</td>
<td>66</td>
<td>Woodford</td>
<td>58</td>
</tr>
<tr>
<td>Niobrara</td>
<td>79</td>
<td>Granite Wash</td>
<td>78</td>
</tr>
</tbody>
</table>

Source: Hughes (2013a).
Chart 1
Bakken/Three Forks and Eagle Ford Oil Well Decline Curves

![Chart showing Bakken/Three Forks and Eagle Ford Oil Well Decline Curves. The chart displays crude oil production for each field over a span of months. The x-axis represents the number of months, ranging from 1 to 36, and the y-axis represents crude oil production in barrels per day, ranging from 0 to 600. The chart includes two lines, one for Eagle Ford and another for Bakken/Three Forks, illustrating the decline in production over time.]

Source: Hughes (2013b).

Table 3
Approximate Well Costs

<table>
<thead>
<tr>
<th>Tight oil field</th>
<th>Average approximate well cost (million $)</th>
<th>Shale gas field</th>
<th>Average approximate well cost (million $)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total</td>
<td>8.3</td>
<td>Total</td>
<td>5.9</td>
</tr>
<tr>
<td>Top 5</td>
<td>8.7</td>
<td>Top 5</td>
<td>5.75</td>
</tr>
<tr>
<td>Bottom 5</td>
<td>4.9</td>
<td>Bottom 5</td>
<td>7.17</td>
</tr>
</tbody>
</table>

Notes: Bakken, Eagle Ford, Bone Spring, Niobrara, Granite Wash, Permian, Barnett, Austin Chalk, Spraberry, and Monterey-Tremblor are the oil fields considered. Bakken, Eagle Ford, Bone Spring, Austin Chalk, and Granite Wash are the top five according to their average IP, and the rest are the bottom five. The first row presents average values across 10 fields. All statistics presented are weighted average values where the weights are shares of these fields in total tight oil production. Haynesville, Marcellus, Barnett, Fayetteville, Eagle Ford, Woodford, Granite Wash, Bakken, and Niobrara are the gas fields considered. Haynesville, Marcellus, Barnett, Fayetteville, and Eagle Ford are the top five according to their average IP, and the rest are the bottom four. The first row presents average values across nine fields. All statistics presented are weighted average values where the weights are shares of these fields in total shale gas production.

Sources: Hughes (2013a) and author’s calculations.
II. Trends in Energy Prices and Production since 1990

Past trends in the energy sector may help explain the path of future production growth. The 1990s to the early 2000s was a period marked by low prices, slowly declining oil and gas production, and a generally stable number of producing wells. As a result, well productivity—that is, output per producing well—declined slightly in the 1990s, from 6.7 thousand barrels of oil equivalent per well in 1990 to 6.5 thousand barrels of oil equivalent per well in 1999 (Chart 3). Low energy prices in the 1990s meant firms had little incentive to invest and to drill new wells, and the capital stock in the oil and gas sector declined slightly in the early 1990s and stayed flat the rest of the decade (Chart 4).

Oil and gas prices rose from early 2000 to the beginning of the Great Recession. With rising prices, previously unprofitable technologies—in particular, hydraulic fracturing and horizontal drilling—became more economical. Not only were previously unprofitable wells developed, but the number of exploratory wells also increased. Chart 4 shows both the number of oil and gas wells drilled and the capital stock in the sector increased significantly in the 2000s, with the number of gas wells nearly tripling from the 1990s to the beginning of the Great Recession in 2008. Although increased drilling eventually led to a significant increase in output, initially the number of wells grew faster.
Chart 3
U.S. Oil and Gas Sector Indicators

Barrels of oil equivalent per well, in thousands

Note: Gray bars denote NBER-defined recessions.
Sources: EIA, Baker Hughes, and author’s calculations.

Chart 4
Energy Prices, Capital Stock, and Wells Drilled

Total number of oil and gas wells drilled (L) — Price index for oil and gas extraction (R) — Capital stock (R)

Note: Gray bars denote NBER-defined recessions.
Sources: EIA, BLS, BEA, Baker Hughes, and author’s calculations.
As a result, U.S. oil and gas productivity (output per producing well) fell, dropping from 6.3 thousand barrels of oil equivalent per well in 2000 to as low as 5.4 thousand barrels of oil equivalent per well in 2008 (Chart 3).

Not surprisingly, the Great Recession caused a break in the energy sector. In particular, prices—and therefore oil and natural gas drilling activity—collapsed in 2008 before rebounding in 2009. The number of natural gas wells drilled decreased by 44 percent from 2008 to 2009 and kept declining due to low prices. Natural gas production, however, continued to increase.\(^9\)

After their fall, oil prices began increasing again in 2009. As a result, oil exploration and development rebounded strongly, with the number of oil wells drilled doubling from 1990s levels. The increase in the number of oil wells represented a significant increase in investment in the oil and gas sector. The share of oil and gas in total U.S. capital investment jumped from just 1.9 percent in the 1990s to 5.8 percent in 2013.\(^10\)

The resulting increase in the capital stock led to an increase in production and well productivity. In 2013, well productivity was almost 6.5 thousand barrels of oil equivalent per well, up more than 20 percent from its 2008 low. In 2014, oil and gas production reached 7.7 billion barrels of oil equivalent per well, 43 percent higher than its 2008 level.

III. Implications of the Recent Oil Price Decline for U.S. Oil Production

This section narrows the article’s focus from developments in the oil and gas industry to the effects of lower oil prices on oil production. The analysis projects 2015 oil production based on reasonable assumptions about rig counts, the number of new wells drilled, and rig and well efficiency.

The sharp decline in oil prices since the summer of 2014 has led to a subsequent decline in oil rig counts—that is, the number of drilling rigs actively exploring for or developing oil (Chart 5).\(^11\) Oil prices declined around 55 percent from their peak in June 2014 to the end of March 2015. The decline in oil prices reflects a combination of changes in demand and supply factors including lower-than-expected oil demand from China, Japan, and Europe; continued faster-than-expected...
U.S. production; and Libyan output returning to the market. In addition, Saudi Arabia, the biggest oil producer within the Organization of the Petroleum Exporting Countries (OPEC), publicly announced its intention to maintain production in the face of falling prices. OPEC subsequently decided on Thanksgiving Day 2014 not to cut production.

Oil rig counts in the United States began to decline in October, and fell sharply after Thanksgiving. In particular, weekly oil rig counts declined more than 49 percent from their peak in October 2014 to the end of March 2015, and could decline further if projected prices are not high enough to make continued drilling profitable.

To determine the effect of the recent oil price decline on oil production in 2015, the analysis considers two hypothetical cases: oil rig counts declining by 50 percent from 2014 to 2015 and oil rig counts declining by 60 percent over the same period. Under these assumptions, oil rig counts would fall from 1,527 in 2014 to 763 and 611 in 2015, respectively. Falling rig counts, however, do not necessarily imply falling production. The relationship between changes in rig count and changes in oil production is not simple because rigs drill wells, but wells pump the oil. For example, even though rig counts have declined over the past four months, U.S. oil production has continued to increase.
To estimate oil production in 2015, the analysis first estimates the effect of a decline in rig counts on the number of wells drilled. Then, it estimates the effect of a decline in the number of wells drilled on oil production. Under reasonable assumptions, the analysis suggests oil production could decline in 2015 from 0.7 to 8 percent. However, oil production could increase by around 5 percent in 2015 if efficiency increases significantly and rig counts decline by slightly less than 50 percent.

The effect of a decline in rig counts on the number of wells drilled

The effect of a decline in rig counts on the number of oil wells likely to be drilled in 2015 depends on both rig counts and rig efficiency—that is, the number of wells that can be drilled by a rig. For example, if the number of rigs falls but each rig can drill more wells, the number of wells could increase or decrease. An average rig can drill more wells today than in the past due to pad drilling, and most shale wells today are drilled from pads (see Box). Since one rig drills many wells from the same surface location without demobilizing or remobilizing, drilling has become more efficient. Moreover, the most inefficient rigs are expected to be removed first when prices fall, contributing to a potential disconnect between rig counts and production.12

In 2014, the average rig could drill around 22 wells, an efficiency increase of 11 percent from 2011 (or about 3.5 percent per year).13 Individual fields saw sharp efficiency gains. For example, the average drilling rig efficiency rose around 50 percent in the Bakken field from 2011 to 2013, or about 22 percent per year (U.S. EIA 2014c). Rig efficiency in Eagle Ford rose 38 percent from 2012 to 2014, or about 18 percent per year.14

Given the wide range of estimates of the improvement in rig efficiency and uncertainty about whether these rates of improvement can persist, this article considers two alternative production scenarios slightly higher than recent gains but lower than gains in the most productive fields: rig efficiency rising by 5 percent and by 10 percent in 2015. In other words, rig efficiency, which was 22 wells per rig in 2014, is assumed to increase to 23 (in the first scenario) and 24 (in the second scenario) in oil fields in 2015.

The analysis in this section focuses on oil production, and therefore considers the number of oil wells drilled. The EIA provides estimates
for the total number of wells drilled, but does not distinguish between oil and gas wells. To estimate the number of oil wells drilled using the EIA’s total number of oil and gas wells drilled estimates, the ratio of oil wells to oil and gas wells is set at 82 percent. About 11 percent of total wells are assumed to be dry holes, and are thus excluded. Given these estimates, the 41 thousand oil and gas wells drilled in 2014 translate into an estimated 29.6 thousand oil wells drilled in 2014.

Table 4 shows estimates of the number of oil wells drilled under each efficiency scenario and for both hypothetical rig count declines. Panel A shows that under the first scenario, a 50 percent decline in oil rigs implies a 47 percent decline in the number of oil wells drilled in 2015, from 29.6 thousand to 15.6 thousand. Under the second scenario, a 50 percent decline in oil rigs implies a 45 percent decline in the number of oil wells drilled, from 29.6 thousand to about 16.4 thousand. With a 60 percent decline in rig counts, the decline in oil wells drilled is significantly larger. Panel B shows that under the first scenario, a 60 percent decline in oil rigs implies a 58 percent decline in the number of oil wells drilled, from 29.6 thousand to about 12.5 thousand. Under the second scenario, a 60 percent decline in oil rigs

<table>
<thead>
<tr>
<th>Improvement in rig efficiency</th>
<th>Number of oil wells drilled</th>
<th>Improvement in rig efficiency + IP</th>
<th>Oil production (million barrels)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5%</td>
<td>15,605 (-47%)</td>
<td>5% (rig)</td>
<td>3,147 (-0.7 %)</td>
</tr>
<tr>
<td>10%</td>
<td>16,348 (-45%)</td>
<td>10% (rig)</td>
<td>3,322 (+4.9 %)</td>
</tr>
</tbody>
</table>

Panel A: 50 percent decline in oil rig counts

<table>
<thead>
<tr>
<th>Improvement in rig efficiency</th>
<th>Number of oil wells drilled</th>
<th>Improvement in rig efficiency + IP</th>
<th>Oil production (million barrels)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>5%</td>
<td>12,484 (-58%)</td>
<td>5% (rig)</td>
<td>2,909 (-8 %)</td>
</tr>
<tr>
<td>10%</td>
<td>13,078 (-56%)</td>
<td>10% (rig)</td>
<td>3,049 (-3.8 %)</td>
</tr>
</tbody>
</table>

Panel B: 60 percent decline in oil rig counts

Sources: Hughes (2013a), EIA, Baker Hughes, and author’s calculations.
implies a 56 percent decline in oil wells drilled, from 29.6 thousand to 13.1 thousand.

The effect of a decline in the number of wells drilled on 2015 oil production

The effect of a decline in the number of wells drilled on oil production can be obtained using estimates of production coming from existing wells (old production) and from newly drilled wells (new production). These estimates depend on annual overall field decline rates, the average IP of a well in U.S. tight oil fields, 2014 annual U.S. crude oil production, the number of oil wells drilled, and U.S. well count data by basin.18

Production from existing wells declines due to resource depletion in existing wells. A field’s average production decline rate provides an estimate of how much production would be lost from 2014 to 2015. The average annual field decline rate across the top 10 fields is about 38 percent.19 With 3,168 million barrels of oil produced in 2014, a 38 percent decline rate means 2015 production from existing wells would be around 1,960 million barrels (3,168 times (1-0.38)).

Production from wells drilled in 2015 depends on a well’s average IP. The IP of a well varies significantly across and within regions. Statistics provided by Hughes (2013a) are used to estimate the average IP of a well in U.S. tight oil production. Since rigs in less productive areas would be removed first, drilling is assumed to continue in the most productive areas. Using the average IP of a well in the most productive U.S. fields—the Bakken, Eagle Ford, Permian, and Niobara—an overall average IP estimate for U.S. oil production of 72.6 thousand barrels per year is obtained.20 This estimate is assumed to increase in 2015, due in part to continued efforts by oil companies to enhance well stimulation, and the analysis considers well productivity gains of 5 percent or 15 percent over a one-year period.21 Assuming a 50 percent decline in oil rigs, a 5 percent rise in rig efficiency and a 5 percent rise in IP, new oil production in 2015 is estimated to be 1,190 million barrels (that is, approximately 15.6 thousand oil wells times 76.3 thousand barrels per year). If rig efficiency increases 10 percent and IP rises 15 percent, then new oil production in 2015 will be higher, around 1,365 million barrels. However, if oil rig counts decline 60 percent, then new production will be much less: 952 million barrels and 1,092 million barrels, respectively.
Table 4 combines production from existing wells and new wells to present 2015 production estimates. Panel A shows production estimates assuming a 50 percent decline in oil rig counts. Under this assumption, if rig efficiency increases by 5 percent and well productivity rises by 5 percent, then production will decline by around 0.7 percent, from 3,168 million barrels in 2014 to 3,147 million barrels in 2015. If rig efficiency increases by 10 percent and IP increases by 15 percent, however, production will increase by around 5 percent, from 3,168 million barrels to 3,322 million barrels. That is, even with a 50 percent decline in rig counts, improvements in efficiency could increase production in 2015. A near 7 percent increase in IP, along with a 5 percent increase in rig efficiency, could be enough to keep production steady. However, if rig counts decline 60 percent, then even improvements in rig and well efficiency of 10 and 15 percent, respectively, would not be enough to increase production (Panel B). Under this assumption, production could decline as much as 8 percent. In order to keep production steady from 2014 to 2015, IP would need to rise more than 27 percent to around 92.6 thousand barrel per year, even with a 10 percent rise in rig efficiency.

IV. Conclusion

Developments in shale gas and tight oil formations created a boom in the U.S. oil and gas extraction sector over the past decade which significantly expanded drilling activity and the capital stock. High initial productivity but fast production decline rates have required increasing investment and drilling over time in shale fields. However, the recent sharp decline in oil prices has put the drilling activity necessary to continue shale production at risk. Using two hypothetical cases, this article finds U.S. oil production in 2015 could decline from 0.7 to 8 percent from 2014 levels despite production taking place in the most productive fields with efficiency gains. For production to stay the same or increase, efficiency would need to increase markedly or the decline in rig counts would need to halt.
Endnotes

1These technologies were primarily developed to find new oil and gas sources to deal with the energy crises facing the United States in the 1970s, including the 1973 oil embargo and the decline in domestic gas production.

2The private sector, some argue, had little financial incentive to invest in research and development programs, thus spurring government involvement. The Department of Energy spent $137 million (in 1999 dollars) on the Eastern Gas Shales Program from 1978 to 1992 (Wang and Krupnick). Private companies then took that expertise and further developed it for their use.

3Bohi suggests major companies responded to the decline in oil prices after 1986 by changing their management structure, moving from hierarchical to team decision-making.

4Highly productive shale gas and tight oil fields are not widespread, and production can vary considerably within fields. “Sweet spots”—the most productive portions of shale gas and tight oil fields—are relatively scarce. Current production mostly occurs in sweet spots, and output per well in these regions has recently shown signs of improvement. As these spots are exhausted, however, production must move to less-productive areas—requiring significant capital investment and additional wells to offset high decline rates—unless new productive fields are found or well productivity increases significantly (Hughes 2013a).

5The Three Forks shale formation, like the Bakken, is also within the Williston Basin in North Dakota and Montana.

6Data on approximate well cost in each field is obtained from Hughes (2013a). Average cost is then calculated as the weighted average cost across 10 fields where the weights represent the share of each field in tight oil production.

7Factors such as available locations to drill, locations of wells, fracturing stages, and others also determine production.

8For example, from 2003 to 2008, amid rising oil and gas prices, the number of exploratory oil wells increased more than 150 percent.

9Natural gas production increased due to production coming from previously drilled wells, efficiency gains, and associated gas produced from oil wells.

10Share is calculated as private fixed investment in current U.S. dollars.

11To be counted as active, a rig must be on location and be drilling. Active rig counts data published weekly by Baker Hughes are the timeliest data on the status of the U.S. oil industry. For this article, the weekly rig data are converted into monthly and annual rig count numbers by calculating arithmetic averages of the rigs reported.

12In addition, a time delay between the start of the drilling of a well and that well’s initial production contributes to the disconnect. The delay between drilling a new well and bringing it into full production can vary from one or two months up to six months. The analysis in this article focuses on annual changes mainly
due to data restrictions on well information. As a result, it assumes that new wells drilled in 2015 will contribute to production during that same year.

13 The EIA provides data on the number of oil and gas wells drilled each year through 2011 and the EIA’s Annual Energy Outlook provides estimates on the total number of oil and gas wells drilled from 2012 to 2014. The average rig efficiency is then obtained by dividing total wells drilled by total rig counts.

14 Rig efficiency for Eagle Ford is calculated as land well count per land rig count by basin (Baker Hughes).

An estimate for the number of oil wells drilled is obtained using the monthly seasonally adjusted ratio of oil rig counts to total oil and gas rig counts (Baker Hughes and Haver Analytics). The ratio of oil rig counts in total rig counts has increased significantly since 2011. In 2012, the ratio was 71 percent, and in 2014, it was 82 percent. For this article’s 2015 calculations, the 82 percent ratio is assumed to hold.

16 From 2000 to 2011, on average about 11 percent of total oil and gas wells drilled in the United States were dry holes (EIA).

17 In 2014, oil rigs numbered 1,527. A 50 percent decline in rig counts would lead to 763 rigs in 2015. Since 2014 rig efficiency was 22 wells per rig and the first scenario assumes a 5 percent increase in rig efficiency, the number of oil wells drilled in 2015 would be approximately 763 times 22 times 1.05 times 0.89 (excluding dry wells) equals around 16 thousand.

18 Baker Hughes provides quarterly data on U.S. land well count by basin since 2012. The number of wells drilled and oil production are obtained from the EIA. Hughes (2013a) presents 2011 and 2012 estimates of productivity and decline rates for 21 tight oil fields in the United States. Among these fields, the top 10 constitute 99 percent of tight oil production and therefore serve as a proxy for the U.S. oil producing regions. Note that in terms of well metrics, the EIA publicly releases data only on the number of wells drilled in the nation, reported as the sum of their county-level estimates from detailed data on fields at the county/reservoir level. As a result, this analysis uses Hughes’ (2013a) estimates for other well metrics.

19 Hughes (2013a) estimates decline rates using production data from all wells drilled prior to 2011 for each of the fields considered. These decline rates across 10 fields are used to calculate the overall field decline rate. The production decline rate for tight oil wells is 38.23 percent on average for the United States, calculated as the weighted average of the 10 top tight oil fields’ overall annual decline rates before 2011. Field decline rates in unconventional fields tend to increase over time. As a result, the estimates of this article may be quite conservative.

20 Share of land well count by basin in total U.S. land well count is used to weigh IP levels across the four fields, which are then averaged to obtain the U.S. average. In other words, well-count weighted average IP across these four fields is used as a proxy for U.S. IP of a well.

21 The EIA’s periodic study on drilling productivity across top U.S. tight oil fields shows that efficiency, measured as new well production per rig, has
continued to rise in recent years. In the Bakken, efficiency increased on average 30 percent from 2011 to 2014; in the Permian, efficiency increased 22 percent per year over the same period. This efficiency measure, new well production per rig by field, incorporates both rig efficiency and well productivity. Hence, assuming a range of 5 to 15 percent well productivity gains and 5 to 10 percent rig efficiency gains would be reasonable given the EIA’s recent drilling productivity data for the most productive fields.
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Research Working Papers

A list of research working papers published by the Federal Reserve Bank of Kansas City over the past five years appears annually in the First Quarter Economic Review. To print copies of working papers dating from 1998 and abstracts from 1995, visit the bank's website at www.KansasCityFed.org. To order earlier working papers, please send your name and address, along with the number of any paper you wish to receive, to: Public Affairs, Federal Reserve Bank of Kansas City, 1 Memorial Drive, Kansas City, Missouri 64198.

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