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Over the past few decades, the U.S. economy seems to have become less responsive to changes in monetary policy. Unusually slow recoveries followed recessions in 1990-91, 2001, and 2007-09 despite sizeable monetary accommodation from the Federal Reserve. Employment, in particular, appears to have become less sensitive to changes in long-term interest rates.

Shifts in interest sensitivity could stem from a variety of factors. Jonathan L. Willis and Guangye Cao investigate potential sources of the economy's shifting interest sensitivity by examining how total employment responds to changes in monetary policy. The results suggest the economy's interest sensitivity has declined due not to changes in the conduct of monetary policy, but to structural changes within industries and financial markets.

Millennials, Baby Boomers, and Rebounding Multifamily Home Construction
By Jordan Rappaport

Construction of both single-family and multifamily homes collapsed with the onset of the housing crisis in 2006. Since then, single-family construction has moved up only modestly. Multifamily construction, however, has rebounded strongly, surpassing its pre-crisis level. Business-cycle factors are partly responsible—the crisis and slow recovery have constrained wages, driving more households to live in apartments, which are typically less expensive than single-family homes. But demographic factors such as marriage rates and improving health have proved equally important.

Jordan Rappaport breaks down changes in the number of occupied multifamily units to determine which age groups have contributed most to the rebound in multifamily home construction. He finds that young adults have primarily driven the recent rebound, reversing their swing toward single-family homes in the early 2000s. In the long-run, however, baby boomers will likely drive construction as they age into their senior years and downsize from single-family homes.
The Response of Employment to Changes in Oil and Gas Exploration and Drilling

By Jason P. Brown

Oil prices declined significantly during the summer of 2014, leading to a subsequent decline in energy exploration and drilling. By the end of April 2015, rig counts were down 49 percent. In the past, these declines have disproportionately affected the economies of oil- and gas-producing states, decreasing statewide employment and inducing “regional recessions.” But advances in extraction technologies may have partially mitigated these effects, and some evidence suggests oil- and gas-producing states rely less on the energy sector now than in previous decades.

Jason P. Brown examines the relationship between energy exploration and drilling and employment in oil- and gas-producing states by estimating the response of total employment to changes in rig counts caused by changes in oil prices. His results suggest that the recent declines in oil prices and rig counts have had a modest effect on employment, spurring total employment reductions from 0.1 to 4 percent across oil and gas states. However, if the oil and gas sector continues to become more capital intensive, employment may be less responsive to future price declines.
Has the U.S. Economy Become Less Interest Rate Sensitive?

By Jonathan L. Willis and Guangye Cao

Over the past three decades, the U.S. economy seems to have become less responsive to monetary policy. Slow recoveries followed recessions in 1990-91, 2001, and 2007-09, a contrast to the much more rapid recoveries that followed pre-1990 recessions. These slow recoveries occurred despite sizeable monetary accommodation from the Federal Reserve, primarily through reductions in short-term interest rates.

This article investigates shifts in the economy’s interest sensitivity by examining how total employment responds to changes in monetary policy. The Federal Open Market Committee (FOMC) has emphasized the important link between monetary policy and employment. For example, in September 2012, the FOMC announced its intention to provide additional monetary policy accommodation on an open-ended basis that would continue as long as “the outlook for the labor market does not improve substantially.” While this implies a direct transmission channel between monetary policy and employment, the empirical analysis in this article suggests aggregate employment has become less responsive to monetary policy in recent decades.

The responsiveness of employment to monetary policy could have diminished for three reasons. First, the shift could be a result of changing behavior of monetary policy makers. Numerous researchers have

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characterized monetary policy in the past three decades as following an active (systematic) approach compared with the passive approach of the 1960s and 1970s (Clarida, Gali, and Gertler). Second, the shift could be due to innovations in financial markets and changes in governmental regulation of the banking industry. Monetary policy works by influencing market interest rates. Studies have suggested that developments in financial markets have weakened the relationship between interest rates and firm and consumer activities (Dynan, Elmerndorf, and Sichel). Third, the shift could be due to changes within and across industries. For example, changes in the relative sizes of industries may affect the overall interest sensitivity of the economy as interest-sensitive sectors, such as durable goods manufacturing and construction, have contracted, and less interest-sensitive sectors, such as the private service-providing sector, have expanded. Supply-side structural shifts occurring within individual industries over the past several decades, including changes in technology and capital intensity, may also affect interest sensitivity. And on the demand side, each industry’s customers may now respond differently to changes in monetary policy.

This article finds that the key contributors to declining interest sensitivity are structural shifts within industries and a weaker transmission mechanism between short-term interest rates and the economy. In particular, two segments of the transmission channel appear to have operated with a longer lag since the mid-1980s: the transmission from shorter-term to longer-term rates and the transmission from longer-term rates to employment. Overall, the findings suggest the decline in the economy’s interest sensitivity is not due to changes in the conduct of monetary policy but rather to structural changes in industries and financial markets.

Section I describes the interest rate channel of monetary transmission and the vector autoregression (VAR) model used to evaluate interest sensitivity. Section II assesses whether the declining interest sensitivity is specific to certain industries or more widespread. Section III uses the VAR and a structural model to examine the three possible sources of declining interest sensitivity.
I. The Declining Interest Rate Sensitivity of Employment

Monetary policy can affect the economy through several channels. The most frequently mentioned channel, or transmission mechanism, is the interest rate channel. In this channel, an increase in monetary accommodation such as a cut in the target federal funds rate leads to a decline in real interest rates if prices are slow to adjust. Lower interest rates increase spending in interest-sensitive sectors. Next, the increase in interest-sensitive spending increases aggregate demand and ultimately output. Finally, to produce more output, firms increase employment.

While the interest rate channel is easy to describe, its recent effectiveness is hard to confirm. Monetary policy accommodation following the three most recent recessions did not produce the robust economic recoveries of the 1970s and 1980s. Furthermore, when the FOMC tightened monetary policy in 2004, the interest rate transmission channel appeared broken. In a speech in February 2005, the Federal Reserve’s then-Chairman Alan Greenspan called the decline in long-term interest rates in the face of steady increases in the federal funds rate a “conundrum.”

Evidence suggests the interest sensitivity of the U.S. economy has declined over the past 50 years. The challenge, however, is disentangling the interest rate channel of monetary policy from other factors affecting economic activity, such as changes in technology and the behavior of consumers and businesses. This section introduces a statistical model relating the federal funds rate to employment to identify shifts in the interest rate channel of monetary policy.

A statistical model of the interest rate channel of monetary policy

The statistical model consists of four economic variables. The first two—the federal funds rate and total nonfarm payroll employment—are included to capture the transmission of monetary policy to employment. The third variable is the Chicago Fed National Activity Index (CFNAI), which is included to capture movements in the economy associated with the business cycle. The fourth variable is the price index for personal consumption expenditures excluding food and energy, which captures movements in inflation. By including a nominal interest
rate and a price index, the model implicitly incorporates a real interest rate, a key element of the interest rate channel.

The framework for the analysis is a VAR with a sample period of January 1960 to December 2007. Data from the post-2007 period are excluded because the federal funds rate has been constrained at the zero lower bound during this period. Following Christiano, Eichenbaum, and Evans, the VAR includes 12 lags of each variable. The estimates are computed using ordinary least squares, and 90 percent confidence intervals are computed using Bayesian methods (Sims and Zha). A detailed description of the model is provided in Appendix A.

The interest rate channel of monetary policy is identified through an assumption on the timing by which the four variables interact with one another. Independent changes, or shocks, to the federal funds rate are assumed to have no effect on the other three variables in the first month in which they occur—instead, they affect the other variables with a lag. This assumption follows Milton Friedman’s famous dictum that monetary policy operates on the economy with “long and variable lags.”

Evidence of changes in the interest rate channel of monetary policy

The statistical model shows the response of employment to a specific change in the federal funds rate over time. While the timing assumption precludes an employment response in the first month, the employment response in subsequent months captures the dynamic interactions among the model’s four variables stemming from the initial shift in interest rates. All other possible shocks to the model are eliminated to focus solely on the interest rate channel of monetary policy.

To determine whether the interest rate channel of policy has diminished over time, the analysis is split into two subsamples. The first subsample is the pre-1985 period (from January 1960 to December 1984), and the second subsample is the post-1984 period (from January 1985 to December 2007). The selection of these subsamples is similar to Boivin and Giannoni, who found the behavior of monetary policy makers changed in the early to mid-1980s.

The estimated responses of employment to changes in the federal funds rate indicate aggregate employment has become less interest-sensitive in recent decades (Chart 1). In the pre-1985 period, an unexpected 25 basis point cut in the federal funds rate led to a steady increase in employment, with a cumulative increase of approximately 0.2
percent after two years. Based on the current size of nonfarm payrolls, this response would have added 255,000 jobs over a two-year period. In the post-1984 period, an identical cut in the federal funds rate had a statistically insignificant effect on employment. The estimates suggest the interest sensitivity of the economy decreased markedly from the pre-1985 to the post-1984 period.\(^5\)

The estimated responses of employment, however, are sensitive to the choice of sample period. To illustrate this sensitivity, the VAR analysis is run repeatedly across 20-year segments of the data beginning with a start period of January 1960 and concluding with a start period of December 1987. Chart 2 shows the cumulative responses of employment at 12 months and 24 months following an unexpected 25 basis point cut in the federal funds rate. The 24-month response of employment is strong when the 20-year sample period starts before 1962. Both the 12- and 24-month responses weaken as the start date moves through the early 1970s. Once the start date moves past 1982, the 24-month response falls to a level near zero while the 12-month response becomes negative. When the start date reaches 1985, both employment responses increase briefly before subsequently declining.
II. Shifts in the Interest Rate Sensitivity of Employment across U.S. Industries

Shifts in the interest sensitivity of employment could be due to a variety of factors. Changing behavior of policymakers, households, and firms could explain the observed shift. Similarly, structural changes resulting from new technologies, increased globalization, and financial regulations could alter the economy’s responsiveness to monetary policy actions.

The analysis considers employment responses at the industry level to evaluate whether changes in overall interest sensitivity are due to shifts in a few industries or widespread. Some industries, such as durable goods manufacturing and construction, are more interest sensitive than others, such as health-care services and education. Accounting for differences in interest sensitivity across industries—and uncovering possible shifts in interest sensitivity over time for these industries—can provide useful insights into the overall change in the interest rate channel of monetary policy.
A statistical model of the industry-specific interest rate channel of monetary policy

To capture the industry-specific interest channel of monetary policy, the statistical model is expanded to include one additional variable: employment in an individual industry. The aggregate employment variable is adjusted to exclude employment in the given industry, and therefore represents employment in all other industries. The other three variables remain the same. In this expanded structure, the model estimates the relationship between the federal funds rate and employment in an individual industry. The timing assumption that monetary policy affects employment with a one-month lag remains the same.

The analysis incorporates a comprehensive set of industry-level employment variables. The initial stage of analysis examines four broad industry categories in the private sector. The first two categories encompass industries traditionally considered the most interest sensitive: durable goods manufacturing and construction. The third category encompasses nondurable goods manufacturing, and the fourth category represents employment in the private service-providing industries. The second stage of the analysis examines interest sensitivity within 18 different industries that make up the entire economy.

Changes in the interest rate channel of monetary policy across industries

Estimates of employment’s interest sensitivity in the pre-1985 period closely match the traditional story of the interest rate channel of monetary policy. The largest employment response to an unexpected 25 basis point cut in the federal funds rate occurred in the durable goods manufacturing and construction categories (Chart 3, Panel A). Twenty-four months after the cut, the cumulative employment increase was 0.25 percent for construction and durable goods manufacturing, a greater response than that of aggregate employment.

The two other categories, nondurable goods manufacturing and private service-providing industries, exhibited less interest sensitivity than the overall economy in the pre-1985 period. The employment responses of these two categories were similar: a gradual increase in employment cumulating in an increase of 0.12 percent two years after the cut in the federal funds rate (Chart 3, Panel B). In broad terms, these estimates match the typical view of the interest rate channel that
**Chart 3**

**Response of Industry-Specific Employment to a Cut in the Federal Funds Rate, Pre-1985**

**Panel A**

<table>
<thead>
<tr>
<th>Months</th>
<th>Percent change in employment</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>-0.2</td>
</tr>
<tr>
<td>5</td>
<td>0</td>
</tr>
<tr>
<td>10</td>
<td>0.2</td>
</tr>
<tr>
<td>15</td>
<td>0.4</td>
</tr>
<tr>
<td>20</td>
<td>0.4</td>
</tr>
</tbody>
</table>

**Panel B**

<table>
<thead>
<tr>
<th>Months</th>
<th>Percent change in employment</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>-0.2</td>
</tr>
<tr>
<td>5</td>
<td>0</td>
</tr>
<tr>
<td>10</td>
<td>0.2</td>
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<tr>
<td>15</td>
<td>0.4</td>
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<tr>
<td>20</td>
<td>0.4</td>
</tr>
</tbody>
</table>

Note: The panels display the estimated responses of employment for specified industries to an unexpected 25 basis point cut in the federal funds rate. The responses are estimated using monthly data from January 1960 to December 1984. Dotted lines represent 90 percent Bayesian confidence intervals.

Source: Authors’ calculations.
durable goods manufacturing and construction are the most interest-sensitive sectors and nondurable goods manufacturing and private service-providing industries are less interest sensitive, with the overall economy somewhere in between.

In the post-1984 period, interest sensitivity declined across all categories (Chart 4). Durable goods manufacturing experienced the largest downward shift in employment response, but the responses of nondurable goods manufacturing and private service-providing industries also decreased notably. In the nondurable goods manufacturing category, the cumulative employment response two years after the cut in the federal funds rate was a net decline of about 0.19 percent, as opposed to a 0.12 percent positive response in the pre-1985 period. In the construction category, the employment response in the post-1984 period was delayed much longer than in the pre-1985 period. The employment responses in all categories were statistically insignificant in the post-1984 period.

A similar decrease in the interest sensitivity of employment is found across a broad range of industries (Table 1). Industries with the greatest interest sensitivity in the pre-1985 period, such as construction and durable goods manufacturing, experienced the largest decreases in responsiveness over time. But many industries in the service sector, such as retail trade and trade, transportation, and utilities, experienced similar declines. The industry with the largest overall decline in interest sensitivity was information services, with a net decline of 0.5 percentage point 18 months after an unexpected 25 basis point cut in the federal funds rate in the post-1984 period compared with the pre-1985 period. The only industries with a modest increase in interest sensitivity were education and health, other services, and government, but the estimated employment responses for these industries were insignificant in the post-1984 period.

In summary, nearly all measures of employment’s interest sensitivity at the aggregate and industry level declined in the post-1984 period. This evidence, however, does not identify the source of the change in the interest rate channel.
Chart 4
Response of Industry-Specific Employment to a Cut in the Federal Funds Rate, Post-1984

Panel A
Percent change in employment

-0.6 0 0.6

0 5 10 15 20 Months

Construction
Durable goods manufacturing

Panel B
Percent change in employment

-0.6 0 0.6

0 5 10 15 20 Months

Nondurable goods manufacturing
Private services

Notes: The panels display the estimated responses of employment for specified industries to an unexpected 25 basis point cut in the federal funds rate. The responses are estimated using monthly data from January 1985 to December 2007. Dotted lines represent 90 percent Bayesian confidence intervals.
Source: Authors’ calculations.
Table 1
Response of Industry-Specific Employment to a Cut in the Federal Funds Rate

<table>
<thead>
<tr>
<th>Industry</th>
<th>Pre-1985 (percent)</th>
<th>Post-1984 (percent)</th>
<th>Change (percentage point)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total nonfarm</td>
<td>0.15*</td>
<td>-0.01</td>
<td>-0.16</td>
</tr>
<tr>
<td>Goods producing</td>
<td>0.15*</td>
<td>-0.13*</td>
<td>-0.28</td>
</tr>
<tr>
<td>Mining and logging</td>
<td>-0.07</td>
<td>-0.11</td>
<td>-0.04</td>
</tr>
<tr>
<td>Construction</td>
<td>0.25*</td>
<td>0.00</td>
<td>-0.25</td>
</tr>
<tr>
<td>Manufacturing</td>
<td>0.19*</td>
<td>-0.19*</td>
<td>-0.38</td>
</tr>
<tr>
<td>Durable goods</td>
<td>0.25*</td>
<td>-0.21</td>
<td>-0.46</td>
</tr>
<tr>
<td>Nondurable goods</td>
<td>0.12*</td>
<td>-0.22*</td>
<td>-0.34</td>
</tr>
<tr>
<td>Private service-providing</td>
<td>0.09*</td>
<td>-0.03</td>
<td>-0.12</td>
</tr>
<tr>
<td>Trade, transportation, and utilities</td>
<td>0.13*</td>
<td>-0.03*</td>
<td>-0.16</td>
</tr>
<tr>
<td>Retail trade</td>
<td>0.15*</td>
<td>0.00</td>
<td>-0.16</td>
</tr>
<tr>
<td>Information services</td>
<td>0.05</td>
<td>-0.44</td>
<td>-0.50</td>
</tr>
<tr>
<td>Financial activities</td>
<td>0.09*</td>
<td>0.08*</td>
<td>-0.01</td>
</tr>
<tr>
<td>Professional and business services</td>
<td>0.06*</td>
<td>0.03</td>
<td>-0.03</td>
</tr>
<tr>
<td>Education and health services</td>
<td>0.04*</td>
<td>0.08*</td>
<td>0.04</td>
</tr>
<tr>
<td>Leisure and hospitality</td>
<td>0.13*</td>
<td>0.09*</td>
<td>-0.04</td>
</tr>
<tr>
<td>Other services</td>
<td>0.04*</td>
<td>0.07*</td>
<td>0.03</td>
</tr>
<tr>
<td>Government</td>
<td>0.04</td>
<td>0.06</td>
<td>0.01</td>
</tr>
</tbody>
</table>

*Significant at the 95 percent confidence level.

Notes: The table displays the estimated cumulative percentage change in employment 18 months after a 25 basis point cut in the federal funds rate. The pre-1985 response is estimated using monthly data from January 1960 to December 1984. The post-1984 response is estimated using monthly data from January 1985 to December 2007. Source: Authors’ calculations.
III. Decomposing the Decline in Employment’s Interest Rate Sensitivity

The decline in the interest rate sensitivity of employment may be a result of changes at different points in the interest rate channel of the monetary transmission mechanism (Figure 1). First, the response of monetary policy to current economic conditions such as inflation and employment may have changed over time. Second, changes in the financial sector may have altered the transmission of monetary policy changes to broader market interest rates and ultimately to the overall economy. And third, structural changes across the economy may have changed the way industries and the aggregate economy interact. These relationships are studied to analyze interactions between the federal funds rate and the 10-year Treasury yield, industry employment, and aggregate employment.

The contribution of monetary policy shifts to changes in interest sensitivity

While the Federal Reserve conducts monetary policy to “promote effectively the goals of maximum employment, stable prices, and moderate long-term interest rates,” its methods have evolved, most notably in the late 1970s and early 1980s. On October 6, 1979, then-Chairman Paul Volcker led a change in the Fed’s approach to begin targeting monetary aggregates—that is, the Fed began targeting the quantity of reserves rather than interest rates. By controlling the banking system’s reserves, the Fed limited the supply of money to curb inflation. Although the Fed reverted to targeting the federal funds rate in 1982, the early 1980s marked the beginning of a new era in which monetary policy became more responsive to inflation.

Did the change in the conduct of monetary policy contribute to the estimated decline in the interest sensitivity of employment? To address this question, a counterfactual exercise is performed with an alternative model designed to capture the key features of the monetary transmission mechanism. An alternative model is needed because the VAR model used in the prior sections is not designed to analyze changes in the conduct of monetary policy over time.
The alternative model consists of three equations specified at a quarterly frequency (Giordani). The first equation is the IS curve, characterizing the investment-savings relationship in which higher real interest rates dampen economic activity. The second equation is the Phillips curve, capturing the positive short-run relationship between inflation and employment. And the third equation is a monetary policy rule, characterizing the response of monetary policy to inflation and employment.\footnote{The variable $emp^g_t$ denotes the employment gap, measured as the difference between actual employment and the Congressional Budget Office’s potential employment. The gap is expressed as a percentage of the overall labor force, where a negative employment gap indicates slack labor market conditions and a positive employment gap indicates tight labor market conditions. For the remaining variables, $\pi_t$ represents core PCE inflation, and $i_t$ represents the federal funds rate. The three shocks in this model are a shock to aggregate demand, $\varepsilon^{AD}_t$, a cost-push shock to inflation, $\varepsilon^{CP}_t$, and a monetary policy shock, $\varepsilon^{MP}_t$. The latter shock represents an unexpected change in the federal funds rate.}

IS curve: $emp^g_t = \beta \cdot emp^g_{t-1} - \beta_r (i_{t-1} - \pi_{t-1}) + \varepsilon^{AD}_t$

Phillips curve: $\pi_t = \alpha \cdot emp^g_{t-1} + \varepsilon^{CP}_t$

Policy rule: $i_t = \gamma \cdot \pi_t + \gamma \cdot emp^g_t + \varepsilon^{MP}_t$

The model is estimated to examine whether a change in the conduct of monetary policy contributed to the declining interest sensitivity of employment. The data are separated into pre-1985 and post-1984 periods, and the parameters for each period are estimated using a generalized method of moments procedure. To test whether monetary policy
is the cause of decreased interest sensitivity in the later period, the estimated monetary policy rule parameters ($\gamma_\pi, \gamma_y$) of the pre-1985 period (1960:Q1 to 1984:Q4) are replaced with those from the post-1984 period (1985:Q1 to 2007:Q4). The reaction of the employment gap to an unexpected 25 basis point decrease in the federal funds rate is then examined. A full description of the model and estimates is provided in Appendix B.

The analysis suggests that a more proactive monetary policy in the post-1984 period did not contribute to the drop in interest sensitivity. Panel A of Chart 5 displays the actual pre-1985 response of the employment gap to the monetary policy shock and the counterfactual response produced using the alternative monetary policy estimated from the post-1984 period. The responses are qualitatively similar. The employment gap increases in the quarter following the shock and widens to approximately 1.2 basis points before gradually dissipating over the next three years. Panel B shows the results of the corresponding experiment in the post-1984 period—that is, imposing monetary policy’s reaction from the early period onto the later period. The actual employment gap response post-1984 closely matches the counterfactual response, and both responses are much smaller than in the pre-1985 period.

Two caveats should be attached to these results. First, this structural model of the economy incorporates only backward-looking agents and is relatively simple compared with models with a greater focus on expectations through forward-looking agents. Second, the literature is divided on the contribution of monetary policy shifts to observed declines in interest sensitivity. For example, Boivin, Kiley, and Mishkin find that changes in the conduct of monetary policy almost entirely account for the estimated declines in interest sensitivity. However, Primiceri finds that changes in the conduct of monetary policy “did not play an important role” in shifts in interest responsiveness over time.

The role of long-term interest rates in the interest rate transmission channel of monetary policy

While changes in the conduct of monetary policy do not appear to account for the observed change in interest sensitivity, changes in financial markets, as well as changes in lending and borrowing patterns of households and individuals, may alter the response of the economy to a given change in monetary policy.
Chart 5
Actual and Counterfactual Response of the Employment Gap to a Cut in the Federal Funds Rate

Panel A: Pre-1985

Panel B: Post-1984

Notes: The panels display the estimated responses of the employment gap to an unexpected 25 basis point cut in the federal funds rate. The pre-1985 response is estimated using quarterly data from 1960:Q1 to 1984:Q4. The post-1984 response is estimated using quarterly data from 1985:Q1 to 2007:Q4. The solid line represents estimates from the baseline model and the dashed line represents estimates from a counterfactual exercise where monetary policy parameters from the other period are substituted.

Source: Authors’ calculations.
Two possible shifts in the interest rate channel of monetary policy are examined. First, the transmission of monetary policy shocks from short-term interest rates (measured by the federal funds rate) to long-term interest rates (measured by the 10-year Treasury yield) may have changed. Second, the effect of a change in long-term interest rates on the economy, as measured by aggregate employment, may have changed.

The first exercise focuses on the transmission of monetary policy to long-term interest rates. In this transmission channel, the central bank’s changes in short-term rates are transmitted through financial markets to broader market conditions, including long-term interest rates. This relationship, however, has not necessarily remained stable over time. For example, when the Federal Reserve began raising interest rates in 2004, long-term interest rates did not move up as expected.

In line with the 2004 experience, the estimated transmission mechanism from unexpected changes in monetary policy to longer-term interest rates has shifted somewhat from the pre-1985 period to the post-1984 period. To examine policy’s effect on broader interest rates, the VAR model from Section II incorporates the 10-year nominal Treasury yield as an additional variable and is estimated separately for the pre-1985 and post-1984 periods. In response to an unexpected decline in the federal funds rate of 25 basis points in the pre-1985 period, the 10-year yield declines gradually over the first 15 months before the response begins to dissipate (Chart 6). In the post-1984 period, the 10-year yield initially rises in response to an unexpected decline in the federal funds rate. After 15 months, the response of the 10-year yield turns negative. The yield then moves down quickly over the next 5 months and drops below the response from the pre-1985 period after 19 months.

In comparison, the negative response of the 10-year yield to an unexpected decline in the federal funds rate is significant much earlier in the pre-1985 period than in the post-1984 period. This suggests that the transmission of monetary policy from short-term to longer-term interest rates occurs with a longer lag in the post-1984 period. This evidence is also in line with comments made by then-Chairman Greenspan in 2004 regarding the “conundrum” of longer-term yields not initially moving in the same direction as short-term rates.

The second exercise focuses on the transmission channel from long-term interest rates to aggregate employment. Long-term interest rates
are influenced by many factors, and this exercise investigates whether interest rate movements arising from factors other than monetary policy generated different aggregate employment responses across periods.

The estimated response of aggregate employment to unexpected movements in long-term interest rates is more protracted in the post-1984 period. The VAR model measures this relationship by estimating the response of aggregate employment to an unexpected 25 basis point decline in the 10-year Treasury yield. In this framework, the unexpected shifts in long-term interest rates are independent from monetary policy shocks, which are transmitted through the federal funds rate. In the pre-1985 period, total nonfarm employment steadily increases in response to an unexpected shock to long-term interest rates, with a peak cumulative increase of 0.18 percent 18 months after the initial shocks (Chart 7). In the post-1984 period, employment responds with a longer lag. The response becomes significant after 15 months with a peak response of 0.14 percent after 27 months. These results suggest that aggregate employment continues to respond to unexpected changes in long-term interest rates unrelated to monetary policy, but with a longer lag.
Structural shifts within industries could have also contributed to the estimated decline in interest sensitivity. Shifts in industry size, such as decreasing employment in the interest-sensitive durable goods manufacturing industry and increasing employment in the less-interest-sensitive private service-providing sector, could alter the response of aggregate employment to changes in interest rates. Changes within industries and by their customers could also alter the way particular industries interact with the broader economy and contribute to overall changes in aggregate employment.

One potential explanation for employment’s declining interest sensitivity relates to shifts in the size of various industries. From 1960 to 2007, the share of total employment in the most interest-sensitive industry, durable goods manufacturing, declined from 17 percent to 6 percent. In contrast, the share of total employment in private service-providing industries, which were much less interest sensitive in the pre-1985 period, increased from 49 percent to 68 percent (Table 2, Columns 1 and 2). These shifts in industry size may contribute to changes in overall interest sensitivity.
Table 2
Response of Aggregate Employment to an Increase in Industry Employment

<table>
<thead>
<tr>
<th>Industry</th>
<th>Employment share</th>
<th>Contemporaneous response</th>
<th>Response after 12 months</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1960 (percent change)</td>
<td>2007 (percent change)</td>
<td>Pre-1985 (percent change)</td>
</tr>
<tr>
<td>Goods producing</td>
<td>35.9</td>
<td>15.9</td>
<td>0.11*</td>
</tr>
<tr>
<td>Mining and logging</td>
<td>1.4</td>
<td>0.5</td>
<td>0.01*</td>
</tr>
<tr>
<td>Construction</td>
<td>5.6</td>
<td>5.4</td>
<td>0.03*</td>
</tr>
<tr>
<td>Manufacturing</td>
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<td>9.9</td>
<td>0.15*</td>
</tr>
<tr>
<td>Durable goods</td>
<td>17.1</td>
<td>6.3</td>
<td>0.10*</td>
</tr>
<tr>
<td>Nondurable goods</td>
<td>11.8</td>
<td>3.6</td>
<td>0.28*</td>
</tr>
<tr>
<td>Private service-providing</td>
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<td>67.9</td>
<td>0.65*</td>
</tr>
<tr>
<td>Trade, transportation, and utilities</td>
<td>20.5</td>
<td>19.3</td>
<td>0.51*</td>
</tr>
<tr>
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<td>10.2</td>
<td>11.3</td>
<td>0.26*</td>
</tr>
<tr>
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<td>3.2</td>
<td>2.2</td>
<td>0.02*</td>
</tr>
<tr>
<td>Financial activities</td>
<td>4.6</td>
<td>6.0</td>
<td>0.51*</td>
</tr>
<tr>
<td>Professional and business services</td>
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<td>13.0</td>
<td>0.72*</td>
</tr>
<tr>
<td>Education and health services</td>
<td>5.3</td>
<td>13.6</td>
<td>0.38*</td>
</tr>
<tr>
<td>Leisure and hospitality</td>
<td>6.3</td>
<td>9.8</td>
<td>0.38*</td>
</tr>
<tr>
<td>Other services</td>
<td>2.1</td>
<td>4.0</td>
<td>0.43*</td>
</tr>
<tr>
<td>Government</td>
<td>15.3</td>
<td>16.2</td>
<td>-0.10*</td>
</tr>
</tbody>
</table>

*Significant at the 95 percent confidence level.

Notes: Columns 3 and 4 display the estimated contemporaneous response of aggregate employment to a 1 percent increase in industry employment. Columns 6 and 7 display the response 12 months after the increase. The pre-1985 response is estimated using monthly data from January 1960 to December 1984. The post-1984 response is estimated using monthly data from January 1985 to December 2007.

Source: Authors’ calculations.
To examine spillover effects of individual industries on aggregate employment, the VAR model provides two measures of the effect of a change in employment in a particular industry on total employment. The first estimated relationship measures the direct, contemporaneous channel between industry employment and overall employment, filtering out the effects of monetary policy, aggregate prices, and business cycle fluctuations. In particular, the results show the estimated effect of a 1 percent increase in employment in a given industry on employment in all other industries in the initial month of the shift (Table 2, Columns 3-5). Based on these estimates, the immediate effect of an increase in industry employment on employment in all other industries has declined for expanding industries. For example, the effect of a 1 percent increase in employment in the private service-providing sector on all other industries declined from 0.65 percent in the pre-1985 period to 0.41 percent in the post-1984 period, a 0.24 percentage point drop in sensitivity.

Over a longer time horizon, however, the cumulative effect of shifts in industry employment on employment in all other industries suggests a more ambiguous relationship between the two. To measure the effect over a longer horizon, the VAR framework is used to estimate the cumulative change in employment in all other industries during the 12 months following a 1 percent increase in industry employment (Table 2, Columns 6-8). According to these estimates, the 12-month effect on employment in all other industries increased in the post-1984 period for most industries. However, expanding industries, mostly those in the service sector, witnessed the largest increase in their cumulative effect on total employment. The exceptions are education and health services, leisure and hospitality, and government: despite growing as a share of total employment, these industries had a smaller estimated effect on employment in all other industries in the post-1984 period.

Overall, these results suggest a notable shift over time in how employment changes in specific industries spill over into other industries. Compositional shifts in industry size seem to account for changes in only some industries, suggesting other factors may have altered the way industries interact. For example, the advanced use of integrated supply-chain management and lean manufacturing could account for changes in some industries. By reducing the need for inventories, which require
financing in many industries, these innovations may have contributed to an overall reduction in interest sensitivity. A second factor contributing to spillovers across industries may be technological. New technologies have encouraged outsourcing employment to other industries and shifts in occupations within industries associated with a decline in middle-skill jobs and increases in high- and low-skill jobs. Finally, in response to advancing technologies, some industries may have shifted their mix of capital and labor through capital deepening and increases in intangible capital (Corrado, Hulten, and Sichel). Such shifts could alter employment responses within and across industries over time.

IV. Conclusion

Although monetary policy is an important tool for promoting price and economic stability, its efficacy can change over time. This article investigates the interest rate channel of monetary policy and, more specifically, the response of employment to changes in the federal funds rate. Analytical results suggest the interest sensitivity of employment has declined in recent decades for nearly all industries and for the overall economy.

The article tests three possible explanations for the observed change in interest sensitivity. First, changes in the conduct of monetary policy do not appear to be responsible for the shift in interest sensitivity. Second, linkages between the short end and the long end of the yield curve along with linkages between financial markets and the overall economy have become protracted. Third, structural shifts have altered how employment changes at the industry level feed back to the aggregate economy.

Overall, the findings suggest that the decline in the interest sensitivity of the economy is not due to changes in the conduct of monetary policy, but rather to structural changes in industries and financial markets. Future research should investigate whether and how monetary policy should adapt in response to these changes.
Appendix A
Vector Autoregression (VAR) Model

A vector autoregression (VAR) model is used to estimate the response of employment to an unexpected monetary policy shock. The baseline VAR includes the following four variables: natural log of total nonfarm employment, the Chicago Fed National Activity Index (CFNAI), natural log of the price index for personal consumption expenditures excluding food and energy (core PCE), and the federal funds rate.

\[
Y_t = \begin{pmatrix}
\ln(\text{employment}_t) \\
\text{CFNAI}_t \\
\ln(\text{core PCE}_t) \\
\text{FFR}_t
\end{pmatrix}
\]

The data are analyzed at a monthly frequency, and the sample period is January 1960 to December 2007. Following Christiano, Eichenbaum, and Evans, 12 lags are used. The VAR is specified as:

\[
Y_t = \alpha + B_1 Y_{t-1} + B_2 Y_{t-2} + \ldots + B_{12} Y_{t-12} + u_t.
\]

The order of the variables in \( Y_t \) reflects the identifying assumptions, in which each variable can only contemporaneously influence those ordered below itself. The federal funds rate is ordered last based on the assumption that monetary policy affects all other variables with a lag. The impulse responses are constructed using a Cholesky decomposition of the variance-covariance matrix of the residuals from OLS estimation.

Given that two of the variables, employment and the price index, are nonstationary, it is important to note that the OLS estimates are consistent, although test statistics may not be (Sims and others). Killian pointed out that in small samples, impulse response estimates may be biased and skewed, and confidence intervals may be inaccurate. Using the method described in Sims and Zha, 90 percent confidence intervals using Bayesian methods are computed to overcome the small sample problem. The prior assumes that coefficients are normally distributed and that the covariance matrix follows the Wishart distribution. For the posterior, coefficients follow normal distribution conditional on the covariance matrix being Wishart.
Charts A-1 and A-2 display the impulse responses of all four variables to an unexpected 25 basis point cut in the federal funds rate, respectively, in the pre-1985 and post-1984 periods. With the exception of core PCE, the variables respond more quickly to a monetary shock in the pre-1985 period than in the post-1984 period. The employment response is insignificant in the post-1984 period. For the expanded VAR, in which the 10-year Treasury yield and a commodity price index are added, the responses of employment, CFNAI, and the federal funds rate to a monetary policy shock are qualitatively similar. The inclusion of a commodity price index mitigates the negative, but insignificant, response of core prices to a monetary policy shock in the post-1984 period.
Chart A-1
Response to a Cut in the Federal Funds Rate, Pre-1985

Notes: The chart displays the estimated responses to an unexpected 25 basis point cut in the federal funds rate. The pre-1985 response is estimated using monthly data from January 1960 to December 1984. Dotted lines represent 90 percent Bayesian confidence intervals.
Source: Authors’ calculations.
Notes: The chart displays the estimated responses to an unexpected 25 basis point cut in the federal funds rate. The post-1984 response is estimated using monthly data from January 1985 to December 2007. Dotted lines represent 90 percent Bayesian confidence intervals. Source: Authors’ calculations.
Appendix B
Structural Model

A structural model by Svensson as described by Giordani is used to capture shifts in the conduct of monetary policy. The model consists of an IS equation, a Phillips curve, and a monetary policy rule obtained from the monetary authority’s optimization problem. These equations describe the relationship between the employment gap ($emp_{t}$), inflation ($\pi_{t}$), and the federal funds rate ($i_{t}$). The employment gap is measured as the difference between actual employment and the Congressional Budget Office’s potential employment. The gap is then expressed as a percentage of the total labor force. Inflation is measured by the quarterly percentage change (annualized) in the core PCE price index.

IS curve: $emp_{t} = \beta_{y} emp_{t-1} - \beta_{r} (i_{t-1} - \pi_{t-1}) + \varepsilon_{i,AD}^{t}$

Phillips curve: $\pi_{t} = \pi_{t-1} + \alpha emp_{t-1} + \varepsilon_{t,CP}^{t}$

Monetary policy rule: $i_{t} = \gamma_{x,\pi} + \gamma_{y} emp_{t} + \varepsilon_{t,MP}^{t}$

All shocks are assumed to be independently and identically distributed (i.i.d). They represent aggregate demand (AD) shock, cost-push (CP) shock, and monetary policy (MP) shock. The VAR(1) representation of the model is:

$$\begin{bmatrix}
emp_{t} \\
\pi_{t} \\
i_{t}
\end{bmatrix} = \begin{bmatrix} \beta_{y} & \beta_{r} & -\beta_{r} \\
\alpha & 1 & 0 \\
\gamma_{x,\alpha} & \gamma_{x,\beta} & \gamma_{y,\beta} & -\beta_{y,\beta}
\end{bmatrix} \begin{bmatrix}
emp_{t-1} \\
\pi_{t-1} \\
i_{t-1}
\end{bmatrix} + \begin{bmatrix} 1 & 0 & 0 & 0 \\
0 & 1 & 0 & 0 \\
\gamma_{x,\gamma} & \gamma_{x,\varepsilon} & 1
\end{bmatrix} \begin{bmatrix}
\varepsilon_{i,AD}^{t} \\
\varepsilon_{i,CP}^{t} \\
\varepsilon_{i,MP}^{t}
\end{bmatrix}.$$

The parameters are estimated using generalized method of moments (GMM). Lagged values of employment, inflation, and the federal funds rate are used as instruments along with a constant. An identity matrix is used as the weighting matrix in the estimation.

Separating the data into pre-1985 (1960:Q1-1984:Q4) and post-1984 (1985:Q1-2007:Q4) periods, the GMM estimates and standard errors, in parentheses, are shown in Table B-1.

This stylized model does not fit the data particularly well. Few parameters are statistically significant. However, $\gamma_{x,\pi}$ is precisely estimated in both periods, indicating a significant shift in the responsiveness of monetary policy to inflation in the post-1984 period.
The estimates in Table B-1 are used to construct the responses of the employment gap to an unexpected 25 basis point cut in the federal funds rate in Chart 5. For the pre-1985 period, the employment gap response is constructed using the pre-1985 estimates. For counterfactual responses the monetary policy rule coefficients from the post-1984 period are used in place of the pre-1985 coefficients. Similarly, for the post-1984 period, the employment gap response is constructed using the post-1984 estimates. For counterfactual responses in the post-1984 period, the monetary policy rule coefficients from the pre-1985 period are used in place of the post-1984 coefficients.

Table B-1

Coefficient Estimates of Structural Model

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<thead>
<tr>
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<th>Pre-1985</th>
<th>Post-1984</th>
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<td>$\beta_y$</td>
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<td>0.893</td>
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<td>(0.259)</td>
<td>(0.660)</td>
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<tr>
<td>$\beta_r$</td>
<td>0.046</td>
<td>0.004</td>
</tr>
<tr>
<td></td>
<td>(0.047)</td>
<td>(0.089)</td>
</tr>
<tr>
<td>$\alpha$</td>
<td>0.105</td>
<td>0.083</td>
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<tr>
<td></td>
<td>(0.209)</td>
<td>(0.403)</td>
</tr>
<tr>
<td>$\gamma_y$</td>
<td>-0.191</td>
<td>1.004</td>
</tr>
<tr>
<td></td>
<td>(0.299)</td>
<td>(0.823)</td>
</tr>
<tr>
<td>$\gamma_\pi$</td>
<td>1.554</td>
<td>2.312</td>
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<td>(0.032)</td>
<td>(0.123)</td>
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Appendix C
Replication of Christiano, Eichenbaum, and Evans

Many studies of monetary shocks focus on the responsiveness of real GDP to an unexpected change in the federal funds rate. To investigate whether the findings of a declining interest sensitivity of employment also apply to real GDP, this appendix replicates the VAR analysis of Christiano, Eichenbaum, and Evans for their sample period and also for the article’s pre-1985 and post-1984 periods.

Following Christiano, Eichenbaum, and Evans, a VAR is specified with the following variables at a quarterly frequency: real GDP, the real GDP deflator, a commodity price index, the federal funds rate, total reserves, and the money stock (M1).

$$Y_t = \begin{bmatrix} \ln(\text{real GDP}_t) \\ \ln(\text{real GDP deflator}_t) \\ \ln(\text{commodity price index}_t) \\ \text{FFR}_t \\ \ln(\text{total reserves}_t) \\ \ln(M1_t) \end{bmatrix}$$

The data sources for several variables differ from the original analysis of Christiano, Eichenbaum, and Evans due to data availability limitations. The commodity price index is the commodity spot index from the Commodity Research Board. Total reserves of depository institutions and M1 are from the Federal Reserve Board. All six variables were collected from Haver Analytics.

The impulse responses are constructed from VAR estimates with four lags (quarterly) and a Cholesky decomposition of the residuals using the ordering of the variables listed above. To replicate the analysis of Christiano, Eichenbaum, and Evans, the impulse response of real GDP to a one standard deviation (70 basis points) increase in the federal funds rate is generated. Christiano, Eichenbaum, and Evans estimate the response of real GDP to a monetary shock using data from 1965:Q3 to 1995:Q2. The response shown in Chart C-1 for this sample period matches up very closely with Figure 2 in Christiano, Eichenbaum, and Evans.
The shift in the responsiveness of real GDP to monetary shocks across the pre-1985 and post-1984 periods is qualitatively similar to the estimated shift in responsiveness of employment. The response of real GDP in the pre-1985 period (1960:Q1-1984:Q4) to an unexpected 70 basis point increase in the federal funds rate is larger and more persistent than the response estimated by Christiano, Eichenbaum, and Evans. And the response of real GDP in the post-1984 period (1985:Q1-2007:Q4) is smaller and less persistent than the response estimated by Christiano, Eichenbaum, and Evans.
Endnotes

1 Other transmission channels are beyond the scope of this article but include the exchange rate channel, the credit channel, and other asset price effects (Mishkin).

2 See Hakkio and Kahn for an analysis of monetary policy during periods when the federal funds rate is constrained by the zero lower bound.

3 Christiano, Eichenbaum, and Evans examine the effect of monetary policy shocks on real GDP using data from 1965 to 1995. To examine whether real GDP has become less interest sensitive, their results are replicated using currently available data (see Appendix C). The results indicate that the responsiveness of real GDP to a monetary shock has diminished in the post-1984 period.

4 While the data sample begins in January 1959, the VAR analysis starts in January 1960 due to the use of 12 lags.

5 Boivin, Kiley, and Mishkin also find the responsiveness of employment has diminished in the post-1984 period using a factor-augmented VAR model. But contrary to this article’s results, the diminished response of employment remains significant in the post-1984 period.

6 This is an adaptive expectations model in which agents are backward-looking. See Milani for a discussion of additional models using rational expectations and learning behavior.

7 A commodity price index is also included to control for the price puzzle commonly found in these types of models. See Sims for additional description of the price puzzle. Adding a commodity price index does not quantitatively change any of the results described in Sections I and II. The source for the commodity price index is the commodity spot index from the Commodity Research Board.

8 In this VAR specification, the 10-year Treasury yield is ordered immediately before the federal funds rate, which is ordered last. The impulse response to a Treasury yield shock is then constructed using a Cholesky decomposition of the variance-covariance matrix of the residuals from an ordinary least squares (OLS) estimation.
References


Construction of both single-family and multifamily homes collapsed with the onset of the housing crisis in 2006. Since then, single-family construction has moved up only modestly, but multifamily construction has rebounded strongly. A number of factors account for this difference. Prior to the crisis, single-family housing was significantly overbuilt, leaving excess stock. The large declines in income and employment associated with the severe recession and slow recovery drove households to move to less expensive housing units, which are typically multifamily units. The housing crisis itself—characterized by plunging house prices and waves of foreclosures—left many households wary of homeownership. This wariness has primarily dampened demand for single-family homes, which have accounted for 95 percent of owned housing units since 1990.

Many analysts have speculated about the demographic composition driving the multifamily rebound. A number of anecdotes suggest millennials may be the main driver, due in part to a strong preference for living in urban cores where multifamily housing dominates. Other anecdotes suggest baby boomers downsizing from single-family homes may be the main driver.

A careful parsing of census data shows both explanations are partly correct. Adults in their 20s and early 30s, the current age range of

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millennials, swung back toward living in multifamily units after the housing crisis, reversing their swing away from multifamily units during the housing boom. But adults in their 50s and 60s, the current age range of baby boomers, accounted for most of the increase in the actual number of occupied multifamily units both before and after the housing crisis. Looking forward, millennials will continue to help drive multifamily construction over the next few years. Over the longer term, however, baby boomers will be the main driver of multifamily construction as they age through their senior years.

Section I describes the diverging paths of single-family and multifamily construction since the housing crisis and the demographic composition driving the multifamily rebound. Section II analyzes the forces underpinning changes in demand for multifamily units by adults in their 20s, 30s, and 40s. Section III does the same for adults 50 and older.

I. The Multifamily Construction Rebound and Multifamily Occupancy

Following the onset of the housing crisis in early 2006, single-family (SF) and multifamily (MF) construction plunged (Chart 1). By late 2009, starts of each unit type had decreased by nearly three-quarters. While single-family construction has moved up only tepidly since then, multifamily construction has rebounded strongly. By the end of 2014, multifamily construction starts had surpassed their pre-crisis level.

The recent rebound in multifamily construction was driven primarily by young adults (ages 20-34), who sharply increased the number of multifamily units they occupied following a sharp decrease during the housing boom. Chart 2 breaks out recent changes in multifamily occupancy—the number of occupied multifamily units—into four age groups: young adults (ages 20-34), intermediate-age adults (35-49), older adults (50-69), and seniors (70+). The number of multifamily units headed by young adults decreased by one-half million from 2000 to 2007, freeing up multifamily units that other age groups could occupy. From 2007 to 2013, this pattern reversed: the number of multifamily units headed by young adults increased by one-half million. This increase required other age groups to free up existing units and builders to construct new ones. The implied one-million unit flip from young adults freeing up units to claiming new ones accounted for much of
Chart 1

House Starts

Notes: Starts data is through April 2015. Gray bars denote NBER-defined recessions. Sources: Census Bureau and Haver Analytics.

Chart 2

Change in Occupied Multifamily Units by Age

Sources: Census Bureau, Ruggles, and author’s calculations.
the rebound in multifamily construction. The Box describes the close relationship between construction and changes in occupancy.

In contrast, intermediate-age adults (ages 35-49) have recently exerted modest downward pressure on multifamily construction as they flipped from claiming more units from 2000 to 2007 to freeing up units from 2007 to 2013.

Older adults (ages 50-69) accounted for most of the increase in multifamily occupancy from 2000 to 2007 and from 2007 to 2013, and nearly all of the net increase over the two periods combined. Even so, older adults contributed relatively little to the construction rebound. Their increase in occupancy from 2007 to 2013 was only slightly larger than their increase from 2000 to 2007; as a result, only a moderate increase in multifamily construction was needed during the later period to meet older adults’ demand.

Seniors (ages 70 and older) contributed to the multifamily rebound in the same way as young adults. From 2000 to 2007, seniors freed up 250-thousand multifamily units. From 2007 to 2013, they claimed an additional 250-thousand units. The implied one-half million swing in senior occupancy significantly spurred multifamily construction from 2007 to 2013.

II. Changing Multifamily Occupancy by Young and Intermediate-Age Adults

The number of occupied multifamily units can be decomposed as the product of three components: population, headship, and the share of households living in multifamily units.

\[
\text{Occupied MF units} = \text{Population} \times \text{Headship} \times \text{MF share},
\]

where \( \text{Headship} = \frac{\text{Occupied units}}{\text{Population}} \) and \( \text{MF share} = \frac{\text{Occupied MF units}}{\text{Occupied units}} \).

The headship rate is the ratio of occupied units to the total population—that is, the inverse of the average number of persons per household. For example, a two-person household is equivalent to a one-half headship rate. Higher headship rates imply more units are required to house the entire population. This same decomposition can be done separately for multifamily households headed by individuals in different age groups.
Do the Same Age Groups Drive Growth in Multifamily Occupancy and Multifamily Home Construction?

The age group driving changes in multifamily occupancy need not be the same age group driving multifamily home construction. For example, households might remain in the same house or apartment permanently. If so, young adults would occupy most newly constructed units and thus be the main drivers of both single-family and multifamily construction. In practice, however, people of all ages move frequently between different multifamily units as well as from single-family to multifamily units. For example, approximately half of all baby-boom households who lived in a multifamily unit in 2013 had moved into it during the previous four years (author’s calculation based on Ruggles).

Due to shifting taste preferences, age groups can drive new multifamily construction out of proportion to changes in their multifamily occupancy. For example, senior baby boomers may prefer larger multifamily units than did seniors of the previous generation. This would spur construction of larger multifamily units even if the total number of multifamily units occupied by seniors remained unchanged.

An age group’s location preferences may also change over time. For example, senior baby boomers may prefer to remain nearer to where they lived during their working-age years than did seniors of the previous generation. This would dampen construction of multifamily units in warm-weather locations and spur construction elsewhere, even if the national number of senior multifamily units remained unchanged. Similarly, millennial young adults may have a stronger preference for central urban locations than did young adults in Generation X. This would spur construction of urban multifamily units, even if the total number of young-adult households living in multifamily units remained unchanged.

An age group can also drive construction even if it does not occupy the newly constructed units. For example, seniors typically have greater financial resources than do young adults. If both age groups prefer to live in central urban locations, the upward pressure on central urban rents may displace young adults to newly constructed multifamily units elsewhere. In this case, seniors moving into existing units would arguably drive the new construction.
Growth in the total number of occupied multifamily units is simply the sum of the growth in each component:

\[
\frac{\Delta \text{Occupied MF units}}{\text{Occupied MF units}} \approx \frac{\Delta \text{Population}}{\text{Population}} + \frac{\Delta \text{Headship}}{\text{Headship}} + \frac{\Delta \text{MF share}}{\text{MF share}}.
\]

The symbol \( \Delta \) denotes the numerical change of population and the percentage point change of headship and the multifamily share. For example, a 2 percentage point change in the headship rate from 10 percent to 12 percent equals a 20 percent growth in headship: \((12 - 10)/10\). The growth of each component reflects its contribution to changes in the number of occupied multifamily units and helps to identify the underlying forces driving the rebound in multifamily construction.

**Decomposing changes in multifamily occupancy by young and intermediate-age adults**

From 1990 to 2013, the varying growth rates of population, headship, and the multifamily share each contributed to the varying growth rate of young adults’ multifamily occupancy (Chart 3). During the 1990s, the number of multifamily units occupied by young-adult households was essentially unchanged.\(^3\) The share of young-adult households living in multifamily units grew modestly, offsetting a modest contraction in the age group’s population. From 2000 to 2007, young adults’ multifamily occupancy contracted, as modest growth in their population was more than offset by modest contractions in their headship and multifamily share. From 2007 to 2013, young adults’ multifamily occupancy rebounded. Moderate growth in population and their multifamily share more than offset a large contraction in their headship.

Intermediate-age adults’ multifamily occupancy grew significantly during the 1990s—due entirely to strong population growth—and then remained essentially unchanged through 2013 (Chart 4). From 2000 to 2007, intermediate-age headship, population, and multifamily share were each flat. From 2007 to 2013, contractions in population and headship offset moderate growth of the multifamily share.

**Underlying causes**

Changes in young and intermediate-age adults’ population, headship, and multifamily share were driven by a variety of underlying factors.
Chart 3

Growth Decomposition: Ages 20-34

Sources: Census Bureau, Ruggles, and author’s calculations.

Chart 4

Growth Decomposition: Ages 35-49

Sources: Census Bureau, Ruggles, and author’s calculations.
Population growth. Demographic factors such as birth rates and aging drove population growth for young adults. The number of young adults contracted moderately during the 1990s, as baby boomers moved out of this age range and the smaller, post-baby-boom generation (Generation X) began moving into it. In 2000, the young-adult population began to grow, reflecting a pickup in birth rates 20 years earlier.

Similar factors accounted for growth in the intermediate-age population. Population growth for intermediate-age adults was exceptionally strong during the 1990s, as the trailing edge of baby boomers moved into this age range. The intermediate-age population contracted moderately from 2007 to 2013, as baby boomers moved out of this age range.

Headship. Headship, the ratio of households to population, contracted for both young and intermediate-age adults from 1990 to 2013. The contraction was especially sharp from 2007 to 2013, reflecting the recession and slow recovery.

For the most part, declining headship corresponded with the increasing share of adults living with their parents. For example, the share of young adults in their early 30s living with their parents rose by more than 1.5 percentage points from 2000 to 2007 and by more than 4 percentage points from 2007 to 2013 (Chart 5). From 1980 to 2013, the share of young adults living with their parents more than doubled. Similarly, the share of intermediate-age adults living with their parents doubled from 1980 to 2013.

Both business cycle and long-term forces drove these increases. The sharp rise in unemployment during the 2007-09 recession and subsequent slow recovery kept young adults from moving out of their parents’ homes and forced many intermediate-age adults to move back into them (Paciorek). Over the longer term, sluggish income growth has also been driving more adults to live with their parents. The share of U.S. workers in low-skilled occupations has been increasing since the 1980s while real hourly wages in these occupations have steadily decreased (Tüzemen and Willis; Autor and Dorn; Autor, Katz, and Kearney). In addition, those with less education have increasingly dropped out of the labor force since the 1970s (Autor). The associated decreases in income have compelled working-age adults to pare their expenses; living with their parents helps accomplish this goal. Consistent with
this explanation, the increase in the share of young adults living with their parents has been considerably smaller for college graduates than for high school graduates who did not attend college.\textsuperscript{5}

While rising student debt also contributed to the increase in adults living with their parents (Bleemer, Brown, Lee, and van der Klaauw), it is unlikely to be the main long-term cause. The rise in student debt accelerated in the mid-1990s, many years after the share of adults living with their parents began trending upward (Akers and Chingos). In addition, the negative effects of debt for students who graduate college appear to be relatively short-lived (Mezza, Sommer, and Sherlund).\textsuperscript{6} For those who fail to graduate, however, student debt is likely to be a stronger, longer-lasting impediment to living on their own.

\textit{The multifamily share.} Both short-term and long-term forces drove changes in the share of households living in multifamily units. During the 2000-07 housing boom, relaxed access to mortgage credit and expectations of rapid house price appreciation fueled demand for homeownership. This depressed the multifamily share, as nearly all owner-occupied units are single-family units.\textsuperscript{7} Then, during the sharp recession and slow recovery, young and intermediate-age adults swung back toward living in multifamily units. Doing so is typically less expensive than living in single-family units and thus becomes more
attractive when unemployment rises and income growth slows. Furthermore, many households moved to multifamily units after losing their single-family homes to foreclosure.

In addition to these shorter-term swings, the share of young and intermediate-age adult households living in multifamily units has been trending up since 1980. For young adults, the share gradually increased from 40 percent in 1980 to 44 percent in 2000. After temporarily decreasing during the housing boom, the young-adult share climbed to 46 percent in 2013.

Underlying this upward trend is the increasingly later age at which adults first marry or have children. The share of adults in their 20s through 50s who have ever been married has moved steadily down over time (Chart 6). For those ages 30 to 34, for example, the share decreased by 26 percentage points from 1980 to 2013. Over this same period, the share of women ages 30 to 34 living with one or more of their own children fell by 16 percentage points (author’s calculations based on Ruggles).

As is intuitive, individuals living on their own or with a housemate are significantly more likely to live in multifamily units than are married couples (Chart 7). Similarly, married couples without children are significantly more likely to live in multifamily units than are married
Chart 7

Multifamily Share in 2013 by Household Type

Sources: Census Bureau, Ruggles, and author’s calculations.

couples with children. For example, 61 percent of individuals ages 30 to 34 who lived alone occupied a multifamily unit in 2013 compared with 35 percent of those who were married without children and 18 percent of those who were married with children.

III. Changing Multifamily Occupancy by Older Adults and Seniors

The factors driving the multifamily occupancy of older adults and seniors differ significantly from each other and from those driving the occupancy of young and intermediate-age adults. Population growth primarily drove occupancy among older adults, while declines in headship and the multifamily share dampened occupancy among seniors.

Older adults

The number of multifamily units occupied by older adults surged from 1990 to 2013 (Chart 8). The increase was driven almost exclusively by strong population growth as the baby boom generation—individuals born from 1946 to 1964—entered and moved through this age range (see Appendix for an illustration of the age distribution).
The increase in population was modestly offset by a decrease in older adults’ multifamily share during the 1990s, largely accounted for by households in their upper 60s. More recent changes in older adults’ headship and multifamily share were partly driven by the same forces affecting intermediate-age adults. From 2000 to 2013, a small but increasing share of individuals in their 50s lived with their parents, thereby putting downward pressure on headship. From 2007 to 2013, the collapse in housing prices and severe recession put upward pressure on the multifamily share.

**Seniors**

The number of multifamily units occupied by seniors, individuals ages 70 and older, has fluctuated since 1990. The decomposition in Chart 9 shows that senior population growth in each of the three periods was at least partly offset by declines in seniors’ headship and multifamily share. These declines were mostly caused by seniors’ increasing longevity and health.  

Increased longevity increased seniors’ population and thus the total number of housing units they occupied. However, increased longevity also put downward pressure on seniors’ headship by allowing couples to live together longer before one partner’s death. As a result, the share of...
seniors living with a married or unmarried partner has trended significantly upward over time (Chart 10). For example, the share of seniors ages 70 to 74 living with a partner increased from one-third in 1980 to one-half in 2013. Correspondingly, the average number of persons per senior household rose and senior headship fell.\textsuperscript{10}
As is the case for young adults, the multifamily share of senior households is considerably lower for married couples than for seniors who live on their own. The increase in the share of seniors living with a partner thus put downward pressure on seniors’ multifamily share. Correspondingly, the age at which seniors began downsizing into multifamily units (indicated by a rise in the multifamily share) gradually rose from 50 in 1980 to 75 in 2013 (Chart 11).

Seniors’ improving health, a factor separate from longer life expectancy, may also have contributed to their decreasing multifamily share. Improved health eases maintenance and other demands of single-family homeownership. Furthermore, improved health may increase seniors’ desire to host visiting friends and family, which typically requires the larger space of a single-family home.

IV. Summary and Conclusions

Young adults have primarily driven the recent rebound in multifamily construction, swinging back toward living in multifamily units after a swing toward single-family units in the early 2000s. In the near term, young adults will continue to help drive multifamily construction as the expanding economy allows more of them to form their own households.

Over the longer term, however, seniors will drive strong multifamily construction. The baby-boom generation will begin turning
70 in 2016, thereby ushering in two decades of rapid growth in the senior population. This population growth is likely to far outweigh any further increase in forces pushing down seniors’ headship and multifamily share. As a result, the multifamily occupancy of seniors will grow rapidly for two decades.

Moreover, as baby boomers age through their 70s and 80s, their multifamily share will increase sharply. While older adults and seniors are downsizing to multifamily units at increasingly older ages, downsizing—once it begins—increases more rapidly with age than in previous decades. In consequence, multifamily home construction is likely to continue to grow at a healthy rate through the end of the decade and thereafter remain well above its level prior to the housing crisis (Rappaport).

Due to the shifting age profile of demand, from young adults to seniors, developers risk overbuilding multifamily units that appeal only to the former group. For example, seniors typically have greater financial resources than do young adults and so may prefer larger apartments with more amenities. But the tastes of baby boomers have consistently differed from those of preceding generations, and what type of multifamily units will appeal to them is not yet clear. Will aging baby boomers prefer to live in the suburbs or the city? Will they prefer to remain in their present locations or move to a place with better weather or lower housing prices? Even if developers correctly anticipate these and other considerations, multifamily units that match the tastes of aging baby boomers will likely prove to be in short supply over the coming decades.
Appendix

**Chart A-1**

**Adult Population by Age**

![Chart A-1](image)

**Notes:** The markers indicate age range of baby boom in each of the displayed years. The gray vertical dashed line shows the projected 1990-2000 increase in population 50 to 54 attributable to leading edge of baby boom. The black vertical dashed line shows the 2000-15 increase in population 65 to 69 attributable to leading edge of baby boom.

Sources: Census Bureau, Haver Analytics, and author’s calculations.

**Chart A-2**

**Sex Ratio of Population**

![Chart A-2](image)

**Note:** See endnote 8 for a discussion of the sex ratio and seniors’ increasing longevity.

Sources: Census Bureau, Ruggles, and author’s calculations.
Endnotes

1 Changes in an age group’s multifamily occupancy partly reflect household heads aging out of one age group and into another while remaining in the same multifamily unit. To understand the changing age composition of multifamily occupancy, it is helpful to think of exits from the younger age group as freeing up multifamily units and entries into the older age group as claiming them.

2 The Census Bureau defines a household as an occupied housing unit. The overwhelming majority of households live in single-family or multifamily units, but some households live in other structures, primarily mobile homes and trailers. The share of households living in these other structures fluctuated between 6 percent and 7 percent from 2000 to 2013.

3 The age of couples is measured as the age of the person identified as the head of household.

4 Adults are considered to be living with their parents if one of the parents is listed as the head of household on the Census Bureau questionnaire. In contrast, a parent is considered to be living with an adult child if the child is listed as the head of household. In theory, an increase in the share of young adults living with their parents need not decrease headship. For example, headship would be unchanged if one of multiple housemates moved out to live with his or her parents and no replacement housemate moved in. But for the most part, this has not been the case. For example, both the share of young adults living with three or more housemates and the average household size among young adults not living with their parents have steadily increased over time.

5 For example, the share of adults ages 30 to 34 living with their parents was 2 percentage points higher for high school graduates with no college than it was for college graduates in 1980. This difference more than doubled to 5 percentage points in 2000 and then doubled again to 10 percentage points in 2013 (author’s calculations based on Ruggles).

6 Mezza, Sommer, and Sherlund document that homeownership is negatively correlated with student debt for college graduates in their 20s but not for those in their early 30s.

7 The multifamily share of owner-occupied units remained close to 5 percent from 1990 to 2013.

8 Based on 2014 actuarial estimates, the remaining life expectancy of a 65-year-old increased from 16.1 years in 1990 to 19.2 years in 2013 for males and from 19.5 to 21.5 years for females. The downward trends of seniors’ headship and multifamily share depend on increases in longevity for both males and females and on the larger relative increase of males’ longevity. To get a more intuitive sense of magnitude, Chart A-2 in the Appendix shows the effect of the larger increase in the longevity of males (3.1 years) relative to the increase in the longevity of females (2.5 years). Males outnumber females at birth and so the sex ratio, the number of males per 100 females, begins above 100. Male mortality exceeds
female mortality, causing the sex ratio to decline as a cohort ages. In 1990, the sex ratio began falling off rapidly at about age 60. In 2013, this rapid falloff did not start until about age 75. Correspondingly, the sex ratio for the population ages 75 to 79 increased from 61.5 in 1990 to 78.8 in 2013.

9 Only a small portion of the increase in senior-occupied multifamily units from 2007 to 2013 can be accounted for by an increase in assisted-living units. In 2009, only 3 percent of the population ages 75 to 84 lived in assisted-living units; only 8 percent of the population 85 and older did (Federal Interagency Forum on Aging Related Statistics). Increases in the number of seniors in long-term care are classified as increases in the population living in group quarters rather than in multifamily units.

10 Chart 10 also illustrates that the share of people in their 20s through 50s living with a spouse or unmarried partner has trended steadily down over time. This largely reflects young adults delaying getting married.
References


The Response of Employment to Changes in Oil and Gas Exploration and Drilling

By Jason P. Brown

During early summer of 2014, oil prices exceeded $100 per barrel, and many industry analysts expected prices to remain at that level for some time. However, oil prices began to decline in July, and were down more than 50 percent by the beginning of 2015. Although the response was delayed by a few months, exploration and drilling for oil and gas dropped significantly, with rig counts down 49 percent by the end of April 2015. Exploration and drilling may decline further depending on when oil prices settle and for how long.

In energy-producing states, exploration and drilling in the oil and gas sector—and economic activity more broadly—are vulnerable to energy price declines, with smaller and less-diversified states expected to be the most exposed. The net effects of price declines are not obvious. When oil prices fall, consumers likely have more money to spend on other goods and services. However, oil- and gas-producing states have a larger share of employment in the oil and gas sector, and falling oil prices can thus directly decrease employment. For example, when energy prices collapsed in 2008-09, employment in energy-producing states fell, partially reversing the strong performance of those states through the early stages of the Great Recession. In subsequent years of the recovery, growth in the global oil supply—mostly from U.S. production—coupled with

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declining global demand for oil, led to the price of oil falling by over 50 percent in the second half of 2014, with potential negative effects on oil- and gas-producing states.

Despite the growth of the oil and gas sector over the past decade, energy-producing states appear to now rely less on the sector than in the early and mid-1980s, but more than in the late 1990s. Given the technological changes the sector has experienced, it is unclear how the recent decline in crude oil prices will affect energy-producing states. Prior research has shown that employment in oil- and gas-producing states is more responsive to changes in exploration and drilling, measured by rig counts, than to oil prices directly. As a result, changes in oil prices could affect total employment in producing states through changes in rig counts.

This article estimates the response of total employment in oil- and gas-producing states to changes in rig activity caused by changes in oil prices. Results indicate that removing an active rig eliminates 28 jobs in the first month, 82 jobs after six months, and 171 jobs in the long run. Given the decline in rigs from September 2014 to April 2015, total employment is expected to fall as much as 4 percent in some energy-producing states but as little as 0.1 percent in others.

Section I highlights past boom and bust cycles in the oil and gas sector. Section II discusses the various phases of oil and gas development and the changing nature of the employment footprint associated with each phase. Section III introduces a model to estimate how total employment responds to changes in rig counts.

I. Boom and Bust Cycles of Oil Prices, Exploration, and Drilling

Over the last five years, the oil and gas sector underwent a boom, with rigs more than doubling, and then a bust, with rigs falling over 50 percent in the last six months. Such boom and bust cycles are not uncommon in energy-producing states. Steep oil price declines have occurred several times in the last 30 years. Each of these declines induced a large decline in exploration and drilling as measured by rig counts. Yet each cycle had unique circumstances due to changes in supply and
demand factors. Over the same time period, the share of economic output and labor compensation from oil and gas declined in most energy-producing states, potentially making them less vulnerable to the current drop in rig counts.

A rapid decline in crude oil prices and subsequent decline in rigs is not a rare event. Crude oil prices dropped sharply six times from 1981 to 2009 (Chart 1). Wilkerson summarized these episodes to contextualize the most recent decline and found differences in the speed of the price decline, the path of prices prior to the decline, the duration of low oil prices, and the state of the U.S. economy at the time of the decline (Table 1).

The 1985-86 period appears to be most similar to the present situation. Real oil prices fell by more than 50 percent, rigs declined by 60 percent, and the United States was not in a recession—all similar to the second half of 2014 and beginning of 2015. The role of the Organization of the Petroleum Exporting Countries (OPEC) was also similar to today. From 1981 to 1985, Saudi Arabia, the largest OPEC member, reduced its production by 75 percent in the wake of falling oil prices (Hamilton). When the price of oil continued to decline in 1986, Saudi Arabia abandoned this strategy and began increasing production. With the increase in supply, the price of oil declined further to $20 per barrel, spurring a further decline in rigs. Similarly, in November 2014, OPEC announced it would not cut production despite the price of oil declining in each of the prior four months. In the past, OPEC would often cut production to boost prices. However, in the face of growing supply from U.S. producers, OPEC was unwilling to cut production, perhaps to protect their market share of global oil sales. Their unwillingness to cut production was an additional shock to oil prices, and West Texas Intermediate (WTI) futures prices declined nearly 20 percent in both December 2014 and January 2015. Futures prices averaged about $49 per barrel through March 2015, with a significant reduction in rig activity.

Throughout these boom and bust cycles, the effect on oil- and gas-producing states has differed from the effect on the national economy. Oil- and gas-producing states are typically the first to experience the effects of boom and bust cycles in energy activity and may, as a result, face different outcomes compared with the nation as a whole.
Chart 1

Real Price of Oil and Rig Counts, 1974 to 2014

Note: Blue bars denote periods of oil price declines of 30 percent or higher.
Sources: Energy Information Administration and Baker Hughes.

Table 1

Past Episodes of Declining Real Oil Prices

<table>
<thead>
<tr>
<th>Period</th>
<th>Months of price decline</th>
<th>Real oil price change (percent)</th>
<th>Prior six months price change (percent)</th>
<th>Rig counts change (percent)</th>
<th>Prior six months rig counts change (percent)</th>
<th>U.S. recession</th>
<th>Months before price recovered by half</th>
</tr>
</thead>
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<td>-31</td>
<td>38</td>
<td>-48</td>
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<td>-1</td>
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<td>7</td>
<td>-54</td>
<td>6</td>
<td>-49</td>
<td>5</td>
<td>No</td>
<td>?</td>
</tr>
</tbody>
</table>

Note: Rig counts data for 2014-15 are through April 2015.
Source: Wilkerson.
Hamilton and Owyang found U.S. oil-producing states experienced their own regional recession in the mid-1980s when oil prices declined even while the U.S. economy grew strongly.

Despite the growing importance of the oil and gas sector in recent years, most oil and gas states rely less on the sector now than in prior decades. For example, in 1982, the average share of economic output from oil and gas extraction in energy-producing states was 17 percent. The share was as high as 35 percent in Wyoming and Louisiana compared with just 4 percent for the United States as a whole (Chart 2, Panel A). The relative size of the sector decreased in the late 1990s, as oil and gas shrunk in energy-producing states on average to around 3 percent of total output. By 2012, the average share had increased to 9.5 percent but was still only 2 percent of total U.S. output. A similar trend occurred in the share of total labor compensation from the oil and gas sector: the share declined from 1982 to 1997 and was higher by 2012, though still below its 1980s level (Chart 2, Panel B). One exception to this trend is North Dakota, which saw labor compensation from the sector increase from 1982 to 2012.

Since the relative importance of oil and gas differs among the states, it is not surprising that the effect of changes in oil prices or rigs would also differ. For example, recent work by Murphy, Plante, and Yücel shows that the cost and benefits of the recent oil price decline are unevenly distributed across the 50 states. They estimate a 50 percent decline in crude oil prices could reduce total employment from 0 to 1 percent in Alaska, Louisiana, New Mexico, Texas, and West Virginia. The authors expect larger declines of more than 2 percent in Oklahoma, North Dakota, and Wyoming, but expect employment in the remaining states to increase modestly.¹

II. Employment in Phases of Oil and Gas Extraction

Oil and natural gas extraction involves four main phases: exploration, appraisal, development, and production. The number and type of workers involved in each phase varies. Development in a region often takes place over several years. Workers as well as goods and services may be sourced throughout a state to directly and indirectly support
Chart 2

Oil and Gas Sector Share of GDP and Labor Compensation

Panel A: GDP

Panel B: Labor Compensation

Sources: Bureau of Economic Analysis and author’s calculations.
development, all of which potentially influence total employment as a result of oil and gas activity.

In the first phase (exploration), teams of geologists, geophysicists, and engineers identify, characterize, and examine geologic prospects that hold the most promise of yielding commercial quantities of oil and natural gas. Before drilling can occur, procurement specialists negotiate oil and gas leases with public or private mineral owners (Fitzgerald). These leases give energy companies the legal right to access public and private land and negotiate what mineral owners will be paid if oil and gas is found. Workers then drill exploratory wells to determine whether a reservoir has sufficient oil and gas to make development profitable (Dahl and Duggan).

In the second phase (appraisal), workers drill additional wells in smaller areas of the reservoir to confirm earlier estimates of the amount of oil and gas that can be extracted profitably. The purpose of this phase is to reduce uncertainty about the size of the oil or gas field and its properties (Stoneburner). Petroleum geologists, geophysicists, and reservoir engineers evaluate samples and information collected from the reservoir to determine how much oil or gas might be in the reservoir and how fast oil or gas will move through it. The appraisal phase helps a company decide whether the oil or gas field can be developed. Employment associated with the exploration and appraisal phases mostly occurs within the oil and gas sector and in professional and business services, such as legal services to negotiate the terms of leasing contracts or engineering services to conduct environmental assessment studies.

The third phase (development) takes place after successful appraisal and before full-scale production. The development stage is the most labor intensive. Workers must prepare the drilling site, drill and case the well, perform hydraulic fracturing (“fracking”), and construct the needed pipeline infrastructure (Jacquet). Additional workers are also often needed to build access roads to reach new development areas. Jobs in the development phase include drilling rig operators, excavation crews, truck drivers, heavy equipment operators, fracking equipment operators, and semiskilled general laborers. These workers come not only from the oil and gas sector but also from the manufacturing,
construction, and transportation sectors. Once workers finish drilling wells in one area, crews and rigs typically move on to other areas in the same region to drill more wells. During this phase, areas of development experience the largest influx of oil and gas workers and the highest demand for goods and services from the sector.

In the fourth phase (production), rig operators extract hydrocarbons from oil or gas fields and see the first revenue from selling the oil or gas. Production can last from a few years to several decades depending on the size of the oil or gas field and the cost of running the wells and production facilities. Compared with the development stage, fewer workers are needed during production, and most jobs are within the oil and gas sector (Jacquet).

As most development phases involve jobs in multiple sectors, net employment effects are best measured as the change in total employment in each state. Oil and gas extraction directly increases employment and the income of those working in the industry, particularly during exploration and drilling but also during production. Expenditures on constructing and operating oil and gas wells may also indirectly increase demand for other goods and services such as gravel, water, concrete, vehicles, fuel, hardware, consumables, food services, and housing. As a result, other industries producing or selling these goods and services in an area with large-scale development may also increase employment to meet demand.

III. Employment Response to Changes in Exploration and Drilling

The increase in U.S. oil and gas production over the past decade has renewed interest in the sector’s influence on economic outcomes, especially employment. Prior studies of the employment effects of oil and gas activity principally use simulation or empirical methods that identify differences in outcomes between energy-producing and non-producing areas. Empirical studies mostly rely on variations across regions to identify any changes in total employment from changes in oil and gas employment or changes in oil and gas production (see the Box for more details on these studies). Most of these studies, however, do
not account for the dynamic effects of oil and gas development and changes in the employment response as the sector changes over time. The dynamic portion is potentially important to understand the complete effect on employment in the short- and long-run.

**Measures of oil and gas drilling and exploration**

One of the most timely and frequent measures of oil and gas activity are rig counts. Many firms and industry analysts use rig counts as a measure of exploration and drilling in the oil and gas sector. Baker Hughes, a large supplier of oil- and gas-field services, surveys rig operators in North America and publishes a weekly, state-level count of rigs actively exploring, drilling, or developing oil or natural gas.²

Chart 3 shows rig counts vary significantly from month to month across major oil- and gas-producing states. The level and variation over time are also quite different across states. For example, the level of rig counts is significantly higher in Texas, Oklahoma, and Louisiana; North Dakota and Kansas, however, have experienced larger variations in rig counts. North Dakota has experienced recent sharp increases, but Kansas has experienced a large and long-lasting decline in the number of rigs. Much of the recent variation is explained by activity in states with large shale plays such as the Fayetteville in Arkansas; the Woodford in Oklahoma; the Bakken in North Dakota; the Niobrara in Colorado; and the Barnett, Eagle Ford, and Permian Basin in Texas.

Recent work by Agerton and others shows employment in oil- and gas-producing states is more responsive to changes in rig counts than changes in oil prices. This result is intuitive, as oil and gas companies typically change future investment decisions first when faced with an oil price shock. When oil prices decline, firms often cut their planned capital spending, including exploration and drilling. In 2015, for example, exploration and production companies are expected to cut capital expenditures by 32 percent on average (Oil & Gas Journal). The reduction in exploration and drilling would mean fewer oil and gas workers. Depending on the initial intensity of activity, the size of the development area, and the length of the oil-price drop, employment in other sectors could also decline.
Previous studies have used simulation models, principally input-output models such as the Impact Analysis for Planning (IMPLAN), to project the economic effects of expanding unconventional oil and gas drilling. The input-output approach creates a mathematical representation of an economy by specifying linkages between sectors. When combined with region-specific industry information, the relationships between sectors permit projections of how the expansion or contraction of one industry would affect output in the entire economy. Most importantly, they can provide projections before much industry growth has happened. However, input-output approaches often assume that input prices such as wages are not affected by changes in demand and, therefore, that increased demand in one sector does not crowd out inputs in other sectors (Kilkenny and Partridge). Kinnaman suggests recent studies on the oil and gas sector using input-output models likely overstate spillover effects from oil and gas because of this same assumption.

Thus far, most empirical approaches test for differences in outcomes between oil- and gas-producing areas and non-producing areas. Despite different methods, measures of oil and gas activity (for example, employment or production), areas of study, and time frames, these studies consistently find modest effects from the oil and gas sector on total employment (for example, Weinstein and Partridge; Weber (2012, 2014); Brown (2014); Munasib and Rickman). Compared with the simulation studies, these studies are able to capture potential crowding-out effects from the oil and gas sector. However, one common and potentially limiting feature of these studies is that outcomes are usually measured on an annual frequency and over a limited number of years.
Chart 3

Oil and Gas Rig Counts by State

Source: Baker Hughes.
Modeling the dynamic nature of oil and gas activity

Since several sectors of a state economy may be involved in various phases of oil and gas development, changes in rig activity likely take time to work through the economies of energy-producing states. To capture these potentially dynamic effects, the model assumes changes in total employment in a particular state are a function of past changes in employment and current and past changes in rig counts, and may be correlated with changes in employment in other states. A reduction of one rig in a large state like Texas, with nearly 1,000 active rigs, would be a much smaller shock to the state economy than would a reduction of one rig in North Dakota, a state with less than 200 rigs. To account for this, the model scales rig counts and employment by population. Seasonally adjusted employment data are from the Current Employment Survey produced by the Bureau of Labor Statistics. Monthly data from January 1976 to December 2014 are used for 12 oil and gas states.

The base model estimated is:

$$\Delta emp_{it} = \sum_{m=1}^{12} \alpha_m \Delta emp_{i,t-m} + \sum_{k=0}^{6} \beta_k \Delta rigs_{i,t-k} + \gamma_t + \epsilon_{it},$$

where $\Delta emp_{it}$ is the change in employment per capita in state $i$ at time $t$, $\Delta rigs_{it}$ is the change in rig counts per capita in state $i$ at time $t$, $\gamma$ is a time-fixed effect to control for seasonal factors, and $\epsilon_{it}$ is an error term. Goodness-of-fit measures determined the number of lags (12 for employment and six for rigs) in the model. The immediate employment response from a change in rig counts is estimated by $\beta_0$, which is the number of jobs added per rig in the same month the rig is deployed. The other coefficients, $\beta_1, \beta_2, \ldots, \beta_6$, estimate the employment response in months one to six following a change in rig counts. The main estimate of interest is the long-run multiplier (LRM), the long-run effect of a change in rig counts on employment. The LRM is estimated by:

$$LRM = \frac{\sum_{k=0}^{6} \beta_k}{1 - \sum_{m=1}^{12} \alpha_m}.$$
The estimated employment response from changes in rig counts is significant and grows over time. Chart 4 shows the cumulative response increases over time, with an additional rig adding 28 jobs in the first month, 94 jobs after six months, and 171 jobs in the long run. The full set of model results is reported in the Appendix (Table A-1). A significant employment response occurs in the same month as the change in rig counts and in months one, three, and six following the addition of a new rig.6

The initial change in employment is likely related to the installation of the rig itself and the oil and gas sector more broadly. Over time, however, the employment response likely spills over to other sectors in the economy that directly and indirectly support oil and gas. The cumulative employment response in the first six months is used as a proxy for the short-run employment response, in which most of the change in employment is associated with workers operating and servicing the rig. The long-run response is a combination of those workers and employment that spills over into other sectors. Following this logic, a rough approximation of the employment multiplier for the oil and gas sector would be the ratio of the LRM to the short-run (first six months)
cumulative response. The implicit multiplier is 1.8 (171/94), suggesting 0.8 jobs added outside the oil and gas sector for every job in the sector. This number is similar to some previous estimates, which range from 0.7 to 1.4 additional jobs (Brown (2014); Weber; Munasib and Rickman).

**Employment response from the recent decline in rig counts**

Oil- and gas-producing states may feel the recent decline in rigs differently depending on the timing and pace of the decline in each state. The rig counts began to fall in most states in September 2014. The employment response from the observed decline in rig counts from September 2014 to April 2015 is forecast using the base model results. The first two columns in Table 2 report the observed decline in rig counts in each state over the time period in level and percentage terms. The table also reports the estimated short-run and long-run job losses as well as the long-run job losses as a percentage of total employment in each state in September 2014. The predicted job losses are larger in the long run, as the dynamic effect of the reduction in rig counts works its way through the state economy. The states with the largest decreases in rigs—Texas, North Dakota, and Oklahoma—had the largest predicted reduction in employment: nearly 82,000 fewer jobs in Texas, 17,000 in North Dakota, and 16,000 in Oklahoma.

Although Texas saw the largest level of employment losses, less-diversified states may feel the decline in rig counts more severely. For example, the predicted job reduction in North Dakota and Wyoming represented 3.8 percent and 1.9 percent of total employment, respectively, compared with 1 percent in Oklahoma and 0.7 percent in Texas. These estimates are in line with the predictions of Murphy, Plante, and Yücel, but estimates for other states show a smaller employment reduction than the authors predict. While these results suggest only modest employment effects thus far, they may not capture the full effect, as the recent decline in energy activity is still unfolding.

Rig counts could decline further through the second half of 2015 before leveling off. Thus far, oil and gas rigs combined have declined nearly 50 percent from September 2014 through April 2015 for the United States as a whole, consistent with the 50-percent drop in the
Table 2
Predicted Employment Response from Decline in Rig Counts

<table>
<thead>
<tr>
<th>State</th>
<th>Change in rig counts (Sept. 2014 to April 2015)</th>
<th>Percent change in rig counts (Sept. 2014 to April 2015)</th>
<th>Forecast short-run change in employment</th>
<th>Forecast long-run change in employment</th>
<th>Long-run percent change in employment (versus Sept. 2014)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arkansas</td>
<td>-3</td>
<td>-25.0%</td>
<td>-81</td>
<td>-514</td>
<td>-0.04%</td>
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<tr>
<td>Colorado</td>
<td>-39</td>
<td>-51.3%</td>
<td>-1,114</td>
<td>-6,686</td>
<td>-0.3%</td>
</tr>
<tr>
<td>Kansas</td>
<td>-13</td>
<td>-52.0%</td>
<td>-366</td>
<td>-2,229</td>
<td>-0.2%</td>
</tr>
<tr>
<td>Louisiana</td>
<td>-45</td>
<td>-39.1%</td>
<td>-1,270</td>
<td>-7,714</td>
<td>-0.4%</td>
</tr>
<tr>
<td>Montana</td>
<td>-7</td>
<td>-87.5%</td>
<td>-194</td>
<td>-1,200</td>
<td>-0.3%</td>
</tr>
<tr>
<td>New Mexico</td>
<td>-50</td>
<td>-50.5%</td>
<td>-1,392</td>
<td>-8,571</td>
<td>-1.0%</td>
</tr>
<tr>
<td>North Dakota</td>
<td>-102</td>
<td>-54.5%</td>
<td>-2,924</td>
<td>-17,486</td>
<td>-3.8%</td>
</tr>
<tr>
<td>Oklahoma</td>
<td>-92</td>
<td>-43.0%</td>
<td>-2,603</td>
<td>-15,771</td>
<td>-1.0%</td>
</tr>
<tr>
<td>Texas</td>
<td>-480</td>
<td>-53.2%</td>
<td>-13,762</td>
<td>-82,285</td>
<td>-0.7%</td>
</tr>
<tr>
<td>Utah</td>
<td>-15</td>
<td>-65.2%</td>
<td>-438</td>
<td>-2,571</td>
<td>-0.2%</td>
</tr>
<tr>
<td>West Virginia</td>
<td>-6</td>
<td>-21.4%</td>
<td>-172</td>
<td>-1,029</td>
<td>-0.1%</td>
</tr>
<tr>
<td>Wyoming</td>
<td>-33</td>
<td>-56.9%</td>
<td>-928</td>
<td>-5,657</td>
<td>-1.9%</td>
</tr>
</tbody>
</table>

Note: The change and percent change in rig counts are calculated from September 2014 to April 2015. Sources: Baker Hughes and author’s calculations.

price of oil from its recent peak in June 2014. However, rigs have declined more than 50 percent in some states already, and it is unclear how many more rigs will be taken out of service. Table 3 shows the associated employment response in the long run if the rig counts decline by an additional 10 percent. Under this assumption, total employment in New Mexico, North Dakota, Oklahoma, and Wyoming would decline by over 1 percent, with even larger declines in North Dakota (4.4 percent) and Wyoming (2.3 percent).

Robustness checks

Additional specifications were estimated as robustness checks to the base model. These other models focused on possible non-linearity and variation in the employment response in different decades. Large changes in rig counts may have proportionally larger employment effects than small changes. To test for this, quadratic terms of changes in rig counts were added to the base model. The full results are shown in the Appendix (Table A-2). The quadratic terms were not jointly
statistically significant, suggesting the employment response was not different for large and small changes in rig counts.

Over the past few decades, the oil and gas sector has experienced several technological advances that could alter the employment response over time. Some evidence suggests the sector has recently become more capital intensive and more productive (Melek). As a result, the sector may use less labor than it once did, and rigs may be associated with fewer jobs. To test this hypothesis, the base model is estimated restricting the sample from 1985 to 1989 and, separately, from 2010 to 2014. In the mid- to late 1980s, one new rig added 37 jobs in the same month, 141 jobs after six months, and 242 jobs in the long run (Table A-3). From 2010 to 2014, however, one new rig added only 20 jobs in the initial month, 62 jobs after six months, and 100 jobs in the long run (Table A-4). Combined, these results indicate the employment response to oil and gas activity may be on the decline, with further declines possible if the sector continues to become more capital intensive. However, additional hypothesis testing revealed that the

Table 3
Employment Response from a 10 Percentage Point Larger Rig Decline in Each State

<table>
<thead>
<tr>
<th></th>
<th>Change in rig counts (versus Sept. 2014)</th>
<th>Percent change in rig counts (versus Sept. 2014)</th>
<th>Forecast long-run change in employment</th>
<th>Long-run percent change in employment (versus Sept. 2014)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arkansas</td>
<td>-4</td>
<td>-35.0%</td>
<td>-720</td>
<td>-0.1%</td>
</tr>
<tr>
<td>Colorado</td>
<td>-47</td>
<td>-61.3%</td>
<td>-7,986</td>
<td>-0.3%</td>
</tr>
<tr>
<td>Kansas</td>
<td>-16</td>
<td>-62.0%</td>
<td>-2,657</td>
<td>-0.2%</td>
</tr>
<tr>
<td>Louisiana</td>
<td>-56</td>
<td>-49.1%</td>
<td>-9,680</td>
<td>-0.5%</td>
</tr>
<tr>
<td>Montana</td>
<td>-8</td>
<td>-97.5%</td>
<td>-1,337</td>
<td>-0.3%</td>
</tr>
<tr>
<td>New Mexico</td>
<td>-60</td>
<td>-60.5%</td>
<td>-10,268</td>
<td>-1.2%</td>
</tr>
<tr>
<td>North Dakota</td>
<td>-121</td>
<td>-64.5%</td>
<td>-20,677</td>
<td>-4.4%</td>
</tr>
<tr>
<td>Oklahoma</td>
<td>-113</td>
<td>-53.0%</td>
<td>-19,443</td>
<td>-1.2%</td>
</tr>
<tr>
<td>Texas</td>
<td>-570</td>
<td>-63.2%</td>
<td>-97,724</td>
<td>-0.8%</td>
</tr>
<tr>
<td>Utah</td>
<td>-17</td>
<td>-75.2%</td>
<td>-2,965</td>
<td>-0.2%</td>
</tr>
<tr>
<td>West Virginia</td>
<td>-9</td>
<td>-31.4%</td>
<td>-1,507</td>
<td>-0.2%</td>
</tr>
<tr>
<td>Wyoming</td>
<td>-39</td>
<td>-66.9%</td>
<td>-6,652</td>
<td>-2.3%</td>
</tr>
</tbody>
</table>

Note: The forecast for Montana suggests that all rigs would be taken out of service, which may not be a likely scenario. Sources: Baker Hughes and author’s calculations.
employment response to the change in rig counts and six monthly lags was not jointly statistically different in the 1985-89 period compared with 2010-14. Furthermore, results for the more recent time period were less precise, making the full sample model preferable due to greater precision in the estimates.\footnote{8}

The results suggest a modest employment response to changes in rig counts overall, but a more substantial response in states where the oil and gas sector is a larger share of the economy. The modest response overall is not surprising, since oil and gas is still a relatively small share of overall economic activity. The employment response is dynamic in nature, with significant effects several months after an initial change in rig activity. The cumulative response increases over time as it spreads to other sectors of the economy beyond oil and gas. However, some evidence suggests the employment response has diminished in more recent years, perhaps because the sector has become more capital intensive.

IV. Conclusion

Combining hydraulic fracturing with horizontal drilling has opened petroleum reserves in several parts of the United States. The rapid expansion in production has led the country to become a global leader in hydrocarbon production, with large increases in activity concentrated in a few states. Over the past several decades, oil and gas states have experienced boom and bust cycles in exploration and drilling. In general, these states appear to be less dependent on the oil and gas sector now than in the early to mid-1980s. Nonetheless, the recent sharp decline in the price of oil and drilling activity will likely have a sizeable effect in a few states.

This article finds that within the timeframe and region under consideration, an increase in one rig added 28 jobs in the same month, 94 jobs after six months, and 171 jobs in the long run. The overall employment response from the decline in oil and gas activity in energy states will depend upon how long oil prices remain low, how quickly the oil and gas sector responds to future changes in the price of oil, and how productivity within the sector changes in the near term. Thus far, the expected employment declines are modest, with an estimated decline in
employment from 0.1 to 4 percent across oil and gas states. Further declines are possible in the second half of 2015. However, some evidence suggests the employment response to changes in rig activity has dampened relative to earlier decades. If the oil and gas sector continues to become more capital intensive, total employment in energy-producing states may be less responsive to future changes in oil and gas activity depending upon the relative size of the sector in each state.
# Appendix

**Table A-1**  
Employment Response to Changes in Oil and Gas Rigs, 1976 to 2014

<table>
<thead>
<tr>
<th></th>
<th>Coefficient</th>
<th>Robust standard errors</th>
<th>T-statistic</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\Delta\text{emp}_{t-1}$</td>
<td>-0.016</td>
<td>0.031</td>
<td>-0.520</td>
</tr>
<tr>
<td>$\Delta\text{emp}_{t-2}$</td>
<td>0.102***</td>
<td>0.027</td>
<td>3.780</td>
</tr>
<tr>
<td>$\Delta\text{emp}_{t-3}$</td>
<td>0.156***</td>
<td>0.024</td>
<td>6.560</td>
</tr>
<tr>
<td>$\Delta\text{emp}_{t-4}$</td>
<td>0.075***</td>
<td>0.021</td>
<td>3.570</td>
</tr>
<tr>
<td>$\Delta\text{emp}_{t-5}$</td>
<td>0.037</td>
<td>0.025</td>
<td>1.480</td>
</tr>
<tr>
<td>$\Delta\text{emp}_{t-6}$</td>
<td>0.043**</td>
<td>0.019</td>
<td>2.230</td>
</tr>
<tr>
<td>$\Delta\text{emp}_{t-7}$</td>
<td>0.050***</td>
<td>0.015</td>
<td>3.310</td>
</tr>
<tr>
<td>$\Delta\text{emp}_{t-8}$</td>
<td>0.030*</td>
<td>0.017</td>
<td>1.800</td>
</tr>
<tr>
<td>$\Delta\text{emp}_{t-9}$</td>
<td>0.059**</td>
<td>0.024</td>
<td>2.490</td>
</tr>
<tr>
<td>$\Delta\text{emp}_{t-10}$</td>
<td>0.049***</td>
<td>0.016</td>
<td>3.120</td>
</tr>
<tr>
<td>$\Delta\text{emp}_{t-11}$</td>
<td>-0.009</td>
<td>0.023</td>
<td>-0.390</td>
</tr>
<tr>
<td>$\Delta\text{emp}_{t-12}$</td>
<td>-0.054*</td>
<td>0.027</td>
<td>-2.020</td>
</tr>
<tr>
<td>$\Delta\text{rig}_{t}$</td>
<td>27.826***</td>
<td>5.368</td>
<td>5.180</td>
</tr>
<tr>
<td>$\Delta\text{rig}_{t-1}$</td>
<td>13.842*</td>
<td>6.380</td>
<td>2.170</td>
</tr>
<tr>
<td>$\Delta\text{rig}_{t-2}$</td>
<td>6.321</td>
<td>8.898</td>
<td>0.710</td>
</tr>
<tr>
<td>$\Delta\text{rig}_{t-3}$</td>
<td>14.423*</td>
<td>7.612</td>
<td>1.890</td>
</tr>
<tr>
<td>$\Delta\text{rig}_{t-4}$</td>
<td>7.955</td>
<td>8.708</td>
<td>0.910</td>
</tr>
<tr>
<td>$\Delta\text{rig}_{t-5}$</td>
<td>0.308</td>
<td>7.912</td>
<td>0.040</td>
</tr>
<tr>
<td>$\Delta\text{rig}_{t-6}$</td>
<td>11.083*</td>
<td>5.711</td>
<td>1.940</td>
</tr>
</tbody>
</table>

| LRM             | 171.43    |
| F-statistic     | 13.12***  |
| $R^2$           | 0.129     |
| N=5,460         |           |

* Significant at the 10 percent level.
** Significant at the 5 percent level.
*** Significant at the 1 percent level.

Source: Author’s calculations.
Table A-2
Non-Linear Employment Response to Changes in Oil and Gas Rigs, 1976 to 2014

<table>
<thead>
<tr>
<th>Term</th>
<th>Coefficient</th>
<th>Robust standard errors</th>
<th>T-statistic</th>
</tr>
</thead>
<tbody>
<tr>
<td>( \Delta \text{emp}_{t-1} )</td>
<td>-0.017</td>
<td>0.031</td>
<td>-0.560</td>
</tr>
<tr>
<td>( \Delta \text{emp}_{t-2} )</td>
<td>0.105***</td>
<td>0.028</td>
<td>3.750</td>
</tr>
<tr>
<td>( \Delta \text{emp}_{t-3} )</td>
<td>0.161***</td>
<td>0.024</td>
<td>6.580</td>
</tr>
<tr>
<td>( \Delta \text{emp}_{t-4} )</td>
<td>0.077****</td>
<td>0.023</td>
<td>3.420</td>
</tr>
<tr>
<td>( \Delta \text{emp}_{t-5} )</td>
<td>0.031</td>
<td>0.026</td>
<td>1.190</td>
</tr>
<tr>
<td>( \Delta \text{emp}_{t-6} )</td>
<td>0.041*</td>
<td>0.020</td>
<td>2.070</td>
</tr>
<tr>
<td>( \Delta \text{emp}_{t-7} )</td>
<td>0.049**</td>
<td>0.016</td>
<td>3.070</td>
</tr>
<tr>
<td>( \Delta \text{emp}_{t-8} )</td>
<td>0.029</td>
<td>0.017</td>
<td>1.770</td>
</tr>
<tr>
<td>( \Delta \text{emp}_{t-9} )</td>
<td>0.060**</td>
<td>0.023</td>
<td>2.580</td>
</tr>
<tr>
<td>( \Delta \text{emp}_{t-10} )</td>
<td>0.045**</td>
<td>0.017</td>
<td>2.700</td>
</tr>
<tr>
<td>( \Delta \text{emp}_{t-11} )</td>
<td>-0.011</td>
<td>0.023</td>
<td>-0.460</td>
</tr>
<tr>
<td>( \Delta \text{emp}_{t-12} )</td>
<td>-0.050*</td>
<td>0.025</td>
<td>-2.000</td>
</tr>
<tr>
<td>( \Delta \text{rig}_0 )</td>
<td>28.304***</td>
<td>6.025</td>
<td>4.700</td>
</tr>
<tr>
<td>( \Delta \text{rig}_{t-1} )</td>
<td>16.294**</td>
<td>6.705</td>
<td>2.430</td>
</tr>
<tr>
<td>( \Delta \text{rig}_{t-2} )</td>
<td>2.865</td>
<td>8.029</td>
<td>0.360</td>
</tr>
<tr>
<td>( \Delta \text{rig}_{t-3} )</td>
<td>8.378</td>
<td>6.496</td>
<td>1.290</td>
</tr>
<tr>
<td>( \Delta \text{rig}_{t-4} )</td>
<td>7.819</td>
<td>8.699</td>
<td>0.900</td>
</tr>
<tr>
<td>( \Delta \text{rig}_{t-5} )</td>
<td>1.486</td>
<td>7.574</td>
<td>0.200</td>
</tr>
<tr>
<td>( \Delta \text{rig}_{t-6} )</td>
<td>12.806**</td>
<td>5.695</td>
<td>2.250</td>
</tr>
<tr>
<td>( \Delta \text{rig}_{t-7} )</td>
<td>0.005</td>
<td>0.139</td>
<td>0.040</td>
</tr>
<tr>
<td>( \Delta \text{rig}_{t-8} )</td>
<td>0.364**</td>
<td>0.150</td>
<td>2.420</td>
</tr>
<tr>
<td>( \Delta \text{rig}_{t-9} )</td>
<td>-0.280</td>
<td>0.181</td>
<td>-1.550</td>
</tr>
<tr>
<td>( \Delta \text{rig}_{t-10} )</td>
<td>-0.410*</td>
<td>0.194</td>
<td>-2.120</td>
</tr>
<tr>
<td>( \Delta \text{rig}_{t-11} )</td>
<td>0.022</td>
<td>0.204</td>
<td>0.110</td>
</tr>
<tr>
<td>( \Delta \text{rig}_{t-12} )</td>
<td>0.083</td>
<td>0.321</td>
<td>0.260</td>
</tr>
<tr>
<td>( \Delta \text{rig}_{t-13} )</td>
<td>0.033</td>
<td>0.141</td>
<td>0.230</td>
</tr>
</tbody>
</table>

| F-test | 10.61*** | F-test (quadratic terms) | 0.370 |
| R²     | 0.134    | "                      | "     |

* Significant at the 10 percent level.
** Significant at the 5 percent level.
*** Significant at the 1 percent level.
Source: Author’s calculations.
**Table A-3**

Employment Response from Changes in Oil and Gas Rigs, 1985 to 1989

<table>
<thead>
<tr>
<th>Δ emp&lt;sub&gt;t-1&lt;/sub&gt;</th>
<th>Coefficient</th>
<th>Robust standard errors</th>
<th>T-statistic</th>
</tr>
</thead>
<tbody>
<tr>
<td>-0.076</td>
<td>0.063</td>
<td>-1.190</td>
<td></td>
</tr>
<tr>
<td>Δ emp&lt;sub&gt;t-2&lt;/sub&gt;</td>
<td>0.117**</td>
<td>0.046</td>
<td>2.570</td>
</tr>
<tr>
<td>Δ emp&lt;sub&gt;t-3&lt;/sub&gt;</td>
<td>0.187***</td>
<td>0.032</td>
<td>5.790</td>
</tr>
<tr>
<td>Δ emp&lt;sub&gt;t-4&lt;/sub&gt;</td>
<td>0.067</td>
<td>0.043</td>
<td>1.560</td>
</tr>
<tr>
<td>Δ emp&lt;sub&gt;t-5&lt;/sub&gt;</td>
<td>0.099</td>
<td>0.056</td>
<td>1.770</td>
</tr>
<tr>
<td>Δ emp&lt;sub&gt;t-6&lt;/sub&gt;</td>
<td>-0.034</td>
<td>0.046</td>
<td>-0.740</td>
</tr>
<tr>
<td>Δ emp&lt;sub&gt;t-7&lt;/sub&gt;</td>
<td>0.062</td>
<td>0.040</td>
<td>1.560</td>
</tr>
<tr>
<td>Δ emp&lt;sub&gt;t-8&lt;/sub&gt;</td>
<td>0.082</td>
<td>0.062</td>
<td>1.330</td>
</tr>
<tr>
<td>Δ emp&lt;sub&gt;t-9&lt;/sub&gt;</td>
<td>0.099***</td>
<td>0.043</td>
<td>2.280</td>
</tr>
<tr>
<td>Δ emp&lt;sub&gt;t-10&lt;/sub&gt;</td>
<td>0.029</td>
<td>0.031</td>
<td>0.940</td>
</tr>
<tr>
<td>Δ emp&lt;sub&gt;t-11&lt;/sub&gt;</td>
<td>-0.059</td>
<td>0.040</td>
<td>-1.480</td>
</tr>
<tr>
<td>Δ emp&lt;sub&gt;t-12&lt;/sub&gt;</td>
<td>-0.120**</td>
<td>0.047</td>
<td>-2.590</td>
</tr>
<tr>
<td>Δ rig&lt;sub&gt;t&lt;/sub&gt;</td>
<td>37.108***</td>
<td>8.886</td>
<td>4.180</td>
</tr>
<tr>
<td>Δ rig&lt;sub&gt;t-1&lt;/sub&gt;</td>
<td>41.454***</td>
<td>9.731</td>
<td>4.260</td>
</tr>
<tr>
<td>Δ rig&lt;sub&gt;t-2&lt;/sub&gt;</td>
<td>-7.306</td>
<td>18.754</td>
<td>-0.390</td>
</tr>
<tr>
<td>Δ rig&lt;sub&gt;t-3&lt;/sub&gt;</td>
<td>14.901</td>
<td>11.045</td>
<td>1.350</td>
</tr>
<tr>
<td>Δ rig&lt;sub&gt;t-4&lt;/sub&gt;</td>
<td>18.293</td>
<td>11.144</td>
<td>1.640</td>
</tr>
<tr>
<td>Δ rig&lt;sub&gt;t-5&lt;/sub&gt;</td>
<td>-10.999</td>
<td>23.362</td>
<td>-0.470</td>
</tr>
<tr>
<td>Δ rig&lt;sub&gt;t-6&lt;/sub&gt;</td>
<td>38.665***</td>
<td>6.781</td>
<td>5.700</td>
</tr>
</tbody>
</table>

LRM 242.03
F-statistic 55.69***
R² 0.234
N=720

* Significant at the 10 percent level.
** Significant at the 5 percent level.
*** Significant at the 1 percent level.
Source: Author's calculations.
**Table A-4**

Estimated Employment Response, 2010 to 2014

<table>
<thead>
<tr>
<th>Δ emp_{t-1}</th>
<th>Coefficient</th>
<th>Robust standard errors</th>
<th>T-statistic</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>-0.085**</td>
<td>0.035</td>
<td>-2.410</td>
</tr>
<tr>
<td>Δ emp_{t-2}</td>
<td>0.025</td>
<td>0.033</td>
<td>0.740</td>
</tr>
<tr>
<td>Δ emp_{t-3}</td>
<td>0.116***</td>
<td>0.025</td>
<td>4.660</td>
</tr>
<tr>
<td>Δ emp_{t-4}</td>
<td>0.015</td>
<td>0.065</td>
<td>0.230</td>
</tr>
<tr>
<td>Δ emp_{t-5}</td>
<td>0.050*</td>
<td>0.024</td>
<td>2.070</td>
</tr>
<tr>
<td>Δ emp_{t-6}</td>
<td>0.001</td>
<td>0.038</td>
<td>0.020</td>
</tr>
<tr>
<td>Δ emp_{t-7}</td>
<td>0.075**</td>
<td>0.025</td>
<td>2.990</td>
</tr>
<tr>
<td>Δ emp_{t-8}</td>
<td>-0.047**</td>
<td>0.020</td>
<td>-2.320</td>
</tr>
<tr>
<td>Δ emp_{t-9}</td>
<td>0.132***</td>
<td>0.037</td>
<td>3.520</td>
</tr>
<tr>
<td>Δ emp_{t-10}</td>
<td>0.023</td>
<td>0.017</td>
<td>1.350</td>
</tr>
<tr>
<td>Δ emp_{t-11}</td>
<td>-0.086</td>
<td>0.075</td>
<td>-1.140</td>
</tr>
<tr>
<td>Δ emp_{t-12}</td>
<td>0.063</td>
<td>0.067</td>
<td>0.940</td>
</tr>
<tr>
<td>Δ rig_{t}</td>
<td>20.939*</td>
<td>10.366</td>
<td>2.020</td>
</tr>
<tr>
<td>Δ rig_{t-1}</td>
<td>24.811</td>
<td>20.969</td>
<td>1.180</td>
</tr>
<tr>
<td>Δ rig_{t-2}</td>
<td>-12.253</td>
<td>43.102</td>
<td>-0.280</td>
</tr>
<tr>
<td>Δ rig_{t-3}</td>
<td>46.883*</td>
<td>24.411</td>
<td>1.920</td>
</tr>
<tr>
<td>Δ rig_{t-4}</td>
<td>7.849</td>
<td>37.597</td>
<td>0.210</td>
</tr>
<tr>
<td>Δ rig_{t-5}</td>
<td>5.747</td>
<td>17.089</td>
<td>0.340</td>
</tr>
<tr>
<td>Δ rig_{t-6}</td>
<td>-21.562</td>
<td>16.645</td>
<td>-1.300</td>
</tr>
</tbody>
</table>

| LRM             | 100.79      |
| F-statistic     | 28.39***    |
| R^2             | 0.083       |
| N               | 720         |

* Significant at the 10 percent level.
** Significant at the 5 percent level.
*** Significant at the 1 percent level.

Source: Author’s calculations.
Endnotes

1Murphy, Plante, and Yücel estimate positive employment effects from 0 to 1 percent in eight states, with employment in the remaining states increasing by more than 1 percent.

2Rig counts data are available at http://phx.corporate-ir.net/phoenix.zhtml?c=79687&p=irol-reportsother.

3Monthly population estimates are from the Bureau of Labor Statistics, Local Area Unemployment Statistics.

4The states chosen are major oil and gas producers with a history of development but also recent activity in shale plays. The states are Arkansas, Colorado, Kansas, Louisiana, Montana, New Mexico, North Dakota, Oklahoma, Texas, Utah, West Virginia, and Wyoming.

5The error term, $\epsilon_{it}$, is adjusted for autocorrelation and heteroscedasticity using Driscoll-Kraay standard errors. Driscoll-Kraay standard errors are a Newey-West estimator applied to cross-sectional averages of the model’s moments. The number of lags was chosen from the model with the minimum Akaike Information Criterion.

6The results are smaller in magnitude than those of Agerton and others, who estimate 37 jobs per rig in the month the rig was added and 224 jobs in the long run. One possible explanation for the difference is their study includes all 50 states in the United States and uses data beginning in 1990, while the present study uses data beginning in 1976 and only focuses on the major oil- and gas-producing states. Restricting the sample to the same time frame as Agerton and others resulted in a slightly larger employment response compared with the full sample, but still smaller compared with their results, suggesting some employment response may occur from neighboring non-energy producing states.

7They estimate that a 50 percent decline in the price of oil would reduce total employment in seven continental states: Wyoming (-4.3 percent), Oklahoma (-2.3 percent), North Dakota (-2.0 percent), Louisiana (-1.6 percent), Texas (-1.2 percent), New Mexico (-0.7 percent), and West Virginia (-0.7 percent).

8Models were also estimated allowing the employment response from changes in rigs to vary across the 12 states in the analysis. Hypothesis testing was done two different ways: by testing individual state coefficients against a global coefficient using Arkansas as the reference category or by dropping the global variables ($\Delta$ rig$_{t}$, ..., $\Delta$ rig$_{t-k}$) and including all the state coefficients. In both cases, a joint test was used to determine if the varying state coefficients were different from the global coefficient or if the state coefficients were different from each other. In both setups, only the $\Delta$ rig$_{t-1}$ was statistically different across states. The other variables ($\Delta$ rig$_{t}$, $\Delta$ rig$_{t-2}$, ..., $\Delta$ rig$_{t-k}$) were not statistically different. As a result, the simpler model was preferred.
References


