THREE ESSAYS ON MONETARY POLICY

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ABSTRACT

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This dissertation contains three empirical studies on monetary policy.

The first chapter investigates the impact of banking deregulation on the effectiveness of monetary policy and provides new evidence on how bank-level heterogeneity affects the lending channel of transmission. Exploiting the staggered deregulation of interstate banking in the U.S. throughout the 1980's, I find that the deregulation strengthens the effect of monetary policy on bank lending, doubling the response of loan growth to monetary shocks. This effect occurs primarily for small and relatively illiquid banks, pointing to a strengthening of the bank lending channel. After deregulation this subset of banks engages in a larger substitution of securities for bank loans following a contractionary monetary shock. Changes in bank market structure and loan portfolio composition cannot explain these effects of the deregulation. By contrast, the findings point to a dilution in the strength of bank-borrower customer relationships and a stronger propensity of banks to cut loans to their customers.

The second chapter studies the response of stock prices to monetary policy, distinguishing effects of exogenous shocks from “Delphic" shocks that reveal the Federal Reserve's macroeconomic forecasts. A measure of Federal Reserve private information that exploits differences in central bank and market forecasts is used to decompose monetary policy surprises into these separate components. Contractionary policy shocks of either type lower stock prices with exogenous shocks having a larger negative effect. There is also some evidence of an asymmetry; when FOMC meetings are unscheduled or when the fed funds rate reverses direction, stock prices actually rise in response to a contractionary Delphic shock.

The third chapter examines the response of real personal income in eight United States regions to monetary policy shocks using a structural VAR framework. The external instruments approach

is used for identification. I split the sample into two periods 1958:Q1 – 1992:Q4 and 1993:Q1-2015:Q2 and find markedly different responses between the two. In the early period real personal income decreases in all regions following a contractionary shock while in the later period little response is seen. I investigate two potential reasons why there has been a reduction in differential regional responses to monetary policy over time. The evidence suggests that the reduction may be associated with a homogenization in regional industry composition over recent decades.

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CHAPTER 1

BANK REGULATION AND MONETARY POLICY TRANSMISSION: EVIDENCE FROM THE U.S. STATES LIBERALIZATION

1.1 Introduction

The impact of regulatory changes in recent decades on the U.S. banking industry has been well documented.[1] A relatively unexplored aspect of these regulatory changes has been their effect on monetary policy. As a recent literature documents, structural features of the banking sector can influence the responsiveness of lending to monetary policy.[2] Bank lending is an important mechanism through which monetary policy is transmitted to the broader economy. For both policymakers and bank regulators it is therefore important to know how changes in banking regulation may impact the effectiveness of monetary policy. In this paper we address these issues by exploiting the natural experiment provided by the staggered state-level removal of geographic banking restrictions throughout the 1980's.

We find that lending becomes more responsive to monetary policy after a bank's home state removes interstate geographic banking restrictions.[3] After a state removes interstate restrictions the response of real lending growth to monetary policy doubles, however the removal of intrastate restrictions has no effect. More precisely, our results indicate that interstate banking deregulation strengthens the bank lending channel of monetary policy transmission. Kashyap and Stein (2000) establish that the bank lending channel is operative for small and relatively illiquid banks. We find that interstate deregulation increases the sensitivity of lending to monetary policy primarily for

[1] See Jayaratne and Strahan (1998), Berger, Demsetz, and Strahan (1999), Berger and DeYoung (2001), Stiroh and Strahan (2003), and Berger, Demirguc-Kunt, Levine, and Haubrich (2004) among others.

[2] See Adams and Amel (2011), Olivero, Li, and Jeon (2011), and Amidu and Wolfe (2013).

[3] There are two main types of restrictions: those on interstate (out-of-state) banking and those on intrastate (within-state) branching. Interstate deregulation allows out-of-state bank holding companies to acquire and operate in-state banks. Intrastate deregulation allows banks headquartered within a state to open additional branches through mergers and acquisitions.

small banks and that the effect is larger for relatively illiquid banks, pointing to a strengthening of the bank lending channel.

We consider a variety of possible explanations for the greater impact of monetary policy after interstate deregulation. Deregulation increases average bank market power, increases local banking concentration, and decreases state banking concentration. Amidu and Wolfe (2013), Yang and Shao (2016), and Adams and Amel (2011) find that lending is more responsive to monetary policy for banks with greater market power or banks located in more highly concentrated local markets. However, these changes in bank market structure cannot account for the effect of deregulation, as we find that banks with greater market power are less responsive to monetary policy, and that concentration has no impact on the relationship between policy and lending. Den Haan, Sumner, and Yamashiro (2007) find that commercial and industrial loans increase following a contractionary monetary policy shock while real estate and consumer loans decrease. We find all three types of loans become more sensitive to monetary policy after deregulation at roughly the same magnitude, ruling out the possibility that deregulation's impact on monetary policy is driven by changes in the composition of bank loan portfolios.

One mechanism that arises as a potential candidate for rationalizing our findings is a change in the intensity of bank-borrower relationships and the accompanying propensity of banks to shield their customers from negative shocks. Ashcraft (2006) finds that stand alone banks are more responsive to monetary policy than banks affiliated with a holding company. We find this is true prior to interstate deregulation, but that affiliated banks actually become more responsive post-deregulation. After the removal of interstate restrictions small banks affiliated with a holding company are unique in responding to contractionary monetary policy by more strongly adjusting the asset side of their balance sheets towards securities and away from lending. The literature has found that bank-customer relationships can play an important role in the availability of loans and in cushioning firms from contractionary shocks. However their strength can be diluted by bank mergers and acquisitions, especially when these entail consolidation across geographically distant markets.[4] One explanation for our results is that banks affiliated with holding companies engage in more transactional lending than relationship lending. After the deregulation and associated consolidation process these banks become more inclined to curtail loans in response to an adverse monetary shock.[5]

Finally, we investigate the impact of deregulation for loan growth at the aggregated state-level. The effect of interstate deregulation on the response of total loan growth to monetary policy is negative but insignificant. However the effect on aggregate lending from a subsample of small banks affiliated with bank holding companies is negative, significant, and relatively large at -8%. These banks make up 16% of total lending on average, hence there is a non-negligible effect on total lending at the state-level.

The rest of the paper unfolds as follows. Section 1.2 details a brief history of geographic banking regulation in the United States. Section 2.3 discusses the data and estimation. Section 1.4 presents the main results and investigates the role of the bank lending channel. Section 1.5 explores potential explanations. Section 1.6 documents the effect of deregulation for aggregate lending at the state-level, and section 2.5 concludes.

1.2 Geographic Banking Regulation

Since the 19th century most U.S. states have imposed restrictions on the ability of banks to expand geographically [6]. These restrictions typically included an outright ban on out-of-state banks owning in-state banks as well as strict limitations on the number of branches that an in-state bank can operate. Deregulation of these restrictions took place in the majority of states from the mid-1970's to mid-1990's. Over this time frame every state other than Hawaii began to allow interstate banking and 35 different states removed restrictions on intrastate branching [7].

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[4] See Berger and Udell (1995), Berger and Udell (2002), Degryse and Ongena (2005), Minetti (2011), and Araujo and Minetti (2011).

[5] See Peek and Rosengren (1998), Calomiris and Karceski (2000), Sapienza (2002), Bofondi and Gobbi (2006), and Berger and Bouwman (2009) on the effect of mergers, entry, and organizational structure on lending practices.

[6] See Kroszner and Strahan (1999) for a detailed history

[7] 14 states already allowed intrastate branching and one, Iowa, did not deregulate at all

Interstate banking was effectively banned by the Douglas amendment to the Bank Holding Company Act of 1956. The amendment stated that a bank holding company (BHC) could not acquire an out-of-state bank unless the state the bank is located in has passed a statue explicitly allowing such transactions. Maine was the first state to pass such a statue and began allowing out-of-state bank holding companies to acquire Maine banks in 1978. Deregulation picked up in the 1980's, particularly after passage of the federal Garn-St Germain Act of 1982, which amended the Bank Holding Company Act to allow out-of-state bank holding companies to acquire failed banks or thrifts in any other state. States began entering reciprocal regional or national agreements through which bank holding companies in any state which had agreed to the arrangement could purchase banks operating in any of the other states. 38 states joined such an agreement between 1984 and 1988 [8].

Restrictions on intrastate branching were often removed in three steps. First, BHC's would be allowed to own multiple banks within one state, with each subsidiary operating as a separate institution - e.g., a depositor at one subsidiary could not access funds at a different subsidiary. Second, banks were allowed to establish additional branches through mergers and acquisitions (M&A). Importantly, this allowed BHC's operating within a state to convert their subsidiaries into branches of a single bank. Finally, unrestricted branching was allowed in which banks were free to open new within-state branches as they pleased. The literature has focused on the second step, allowing branching via M&A, as the most important one. Most states had removed restrictions on in-state BHC expansion by the mid-1970's. Of the 15 who removed such restrictions after 1975, this often occurred around the same time that M&A branching restrictions were removed. Similarly, most states allowed unrestricted branching only a short time after allowing M&A branching.

Table 1.1 lists the year for which each state and the District of Columbia began to allow branching via M&A and interstate banking [9]. Congress passed the Riegle-Neal Interstate Banking and Branching Efficiency Act in 1994, which allowed for national interstate banking and branching,

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[8] Amel (1993)

[9] Dates from Amel (1993) and Kroszner and Strahan (1999).

effectively ending the period of state-level deregulation. The legislation went fully into effect in 1997 but many states adopted early in mid-1995. Thus the period of interest for state-level deregulation is from 1976 (when U.S. bank-level data becomes available) to 1994.

1.3 Data and Estimation

1.3.1 Monetary Policy Data

Conventional measures of monetary policy, such as the federal funds rate, can be problematic for two reasons. First, such measures are endogenous, i.e. they change in response to past and contemporaneous economic conditions. Second and more importantly, they reflect anticipatory movements by the monetary policymaker. Romer and Romer (2004) seek to surmount these issues by devising a new series of monetary policy shocks. First, they construct a series of intended federal funds rate changes around FOMC meetings by combining information from the *Weekly Report of the Manger of Open Market Operations* and narrative accounts of each FOMC meeting. Second, using the Fed's internal Greenbook forecasts, they purge the series of variation attributable to forecasts of future macroeconomic activity through the following regression:

$$\begin{aligned}\Delta ff_m = \alpha + \beta ffb_m + \sum_{i=-1}^{2} \gamma_i \Delta\widetilde{y}_{mi} + \sum_{i=-1}^{2} \lambda_i (\Delta\widetilde{y}_{mi} - \Delta\widetilde{y}_{m-1,i}) \\ + \sum_{i=-1}^{2} \varphi\widetilde{\pi}_{mi} + \sum_{i=-1}^{2} \theta(\widetilde{\pi}_{mi} - \widetilde{\pi}_{m-1,i}) + \rho\widetilde{u}_{m0} + \epsilon_m\end{aligned} \tag{1.1}$$

where Δff_m is the change in the intended federal funds rate at meeting m, ffb_m is the level of the intended funds rate prior to meeting m, $\Delta\widetilde{y}$ is forecasted real output growth, $\widetilde{\pi}$ is forecasted inflation, and $\widetilde{u}$ is the forecasted unemployment rate. Note that the previous period and contemporaneous forecasts of output growth and inflation are included in addition to forecasts of the next two quarters [10]. The residual of the above estimated equation, $\widehat{\epsilon_m}$, then becomes a cleaner measure of monetary policy shocks purged of endogenous and anticipatory variation. This measure will be our baseline indicator of monetary policy and will henceforth be referred to as the RR shock series.

[10] The previous period forecasts are typically observed data.

Using the change in the effective fed funds rate as a measure of monetary policy may be particularly troublesome when estimating the effect of monetary policy on bank lending. Bluedorn, Bowdler, and Kochc (2017) provide evidence that such estimates at the individual bank-level are quite sensitive to the measure of monetary policy used. They argue that the RR shocks eliminate some of the major sources of endogenous variation plaguing other measures of policy. For instance, suppose the FOMC increases the fed funds rate due to anticipated higher output growth in the coming quarters. Higher output growth is likely to be associated with an increased demand for bank loans. A regression of the change in bank lending on lagged changes in the fed funds rate may therefore show a positive correlation, i.e. that contractionary monetary policy is associated with increased bank lending. Such an increase in the fed funds rate will not show up in the RR shocks however, mitigating such endogeneity concerns.

We use an updated series of RR shocks from Coibion, Gorodnichenko, Kueng, and Silvia (2012). The series is initially calculated at the frequency of FOMC meetings then aggregated to a quarterly average. The updated RR shocks as well as the change in the effective fed funds rate are plotted in Figure 1.1. The RR shock is smaller in magnitude than the change in the fed funds rate, which is unsurprising given that it is a residual of the latter. The two series typically move together and have a high positive correlation of 0.82. There is a noticeable period of outliers for both series from 1979 to 1982. During this period the Federal Reserve was targeting non-borrowed reserves (NBR) rather than the fed funds rate which resulted in large and volatile gyrations in the funds rate. Our baseline specifications include year or quarter dummy variables to account for this period.

1.3.2 Banking Data

Bank-level data is from the Consolidated Reports of Condition and Income ("Call Reports") which all banks in the U.S. are required to file on a quarterly basis with the Federal Financial Institutions Examinations Council (FFIEC). We follow Kashyap and Stein (2000) and Den Haan, Sumner, and Yamashiro (2002) in defining our sample as all commercial banks which are insured, have positive assets, and are located in the fifty states or Washington, D.C. Since mergers typically create discontinuities in the acquiring bank's balance sheet, a bank observation is dropped from the sample in any quarter in which a merger occurs. To prevent outliers from driving the results a bank-quarter is dropped whenever total loan growth is more than five standard deviations away from that quarter's average loan growth. Additionally, a bank-quarter is dropped if there are not four preceding quarterly observations for total loan growth. This leaves slightly over 900,000 observations from 16,000 different banks in the sample.

Summary statistics for bank-level variables of interest are reported in table 1.2. The first two columns show summary statistics for the entire sample (1976Q2-1994Q4). The third and fourth columns show summary statistics for the early part of the sample (1976Q2-1985Q4) when a majority of states had not deregulated. The fifth and sixth columns show summary statistics for the later part of the sample (1986Q1-1994Q4) when a majority of states had deregulated. The main bank-level variable of interest is real loan growth[11]. Over the entire sample average quarterly loan growth at a single bank is 1.13% with a standard deviation of 7.25%. Average real loan growth across all banks is plotted in figure 1.2. The series is relatively stable across the sample except for the period of NBR targeting in the early 1980's, which features a sharp drop. The share of total U.S. credit included in our sample is substantial. Figure 1.3 plots aggregated commercial bank lending in our data as a share of total private credit in the U.S. Over this time period commercial bank lending in our sample accounts for 30-43% of all private sector credit.

The Call Reports do not directly include data on loan rates. However, following Jayaratne and Strahan (1998) and Zarutskie (2013), a proxy for the average interest rate on a bank's loan portfolio can be calculated as total interest and fee income on loans divided by total loans[12]. Interest and fee income on loans is reported on a year to date basis. Hence, the previous quarter's value is subtracted from the current value to obtain a quarterly measure. Interest and fee income on loans is reported biannually prior to 1983. In order to use our full sample we replace the missing first quarter observations with half of the second quarter value and the missing third quarter observations

[11] Call report loan data is in nominal terms; we adjust for inflation using CPI.

[12] Jayaratne and Strahan (1998) uses this approach to study the effects of deregulation on loan pricing. Zarutskie (2013) studies the effects of deregulation and securitization on loan pricing.

with the average of the second and fourth quarter values. All results below are robust to leaving the missing values empty however. The annualized mean of a bank's average loan rate is roughly 11.5% for the entire sample, with a standard deviation just over 4%. The average loan rate across all banks is plotted in figure 1.4. As with real loan growth, there are large variations in the early 1980's before stabilizing for the rest of the sample.

Loan growth for the three major loan categories are included as well. Real estate lending saw the largest average growth over the sample at 2.16% per quarter. Commercial and industrial (C&I) lending growth averaged 0.76% for the entire sample, and saw a large drop from 1.63% in the early part of the sample to -0.33% in the later part. Similarly. consumer lending grew an average of 1.04% in the early part of the sample before falling to -0.27% in the later part. Each categories average share of total lending reflects these growth trends as the share of real estate lending grew over the sample while the share of C&I and consumer lending decreased.[13]

Other bank-level variables of interest include total assets, security holdings, liquidity ratio, equity ratio, and bank holding company affiliation. Average bank assets almost double from the early part of the sample to the later part, with a mean of $173 million for the entire sample. We follow Kashyap and Stein (2000) in defining our securities variable. There is not a consistent variable tracking securities in the Call Reports over the entire sample. Prior to 1984 total securities is calculated as the sum of U.S. Treasury securities, U.S. government agency and corporate obligations, obligations of states and political subdivisions, all other bonds, stocks, and securities, and fed funds sold and securities purchased under agreements to resell. From 1984 to 1993 it is calculated as the sum of the book value of total investment securities, assets held in trading accounts, and fed funds sold. A consistent definition is not available for 1994, the final year of our sample. Average security holdings in a quarter double from the early part of the sample to the later part, with an overall average of $38 million. Liquidity ratio is defined as the ratio of cash and reserves to total liabilities. The average liquidity ratio for the sample is 0.09. Equity ratio is measured as the ratio of total equity to total assets and is stable across the sample with a mean of 0.09. Finally,

[13]Zarutskie (2013) studies these trends in detail.

affiliation with a bank holding company increases greatly over this time frame, as restrictions on bank expansion and acquisition are removed. Three measures of bank market structure are reported: the Lerner Index, which measures a bank's market power, county-level HHI, which measures local banking concentration, and state-level HHI, which measures state banking concentration. All three measures increase from the early to late part of the sample.

Summary statistics split by bank size are reported in table 1.3. As is conventional in the literature, small banks are defined as any bank under the 95th percentile in total assets for a given quarter. Large banks are defined as any bank above the 95th percentile for a given quarter.[14] Average assets for small banks over the entire sample is \$51 milllion, whereas average assets for large banks is much larger at \$2.5 billion. Loan growth is higher on average for small banks at 1.15% versus 0.86% for large banks. Average loan rates are similar for both. Real estate lending makes up the largest share of loans for both although it is a higher share for small banks. Large banks have higher liquidity ratios and lower equity ratios on average, and are more likely to be affiliated with a bank holding company. Large banks also have higher average market power.

1.3.3 Estimation

How did deregulation of geographic banking restrictions impact the effectiveness of monetary policy? In answering this question we follow the literature in specifying two distinct types of deregulation: intrastate branching deregulation and interstate banking deregulation. To determine the effect of each type of deregulation on monetary transmission we estimate a dynamic panel

[14]Note that these definitions allow for banks to move between size categories over time.

regression:

$$
\begin{aligned}
\Delta log(L_{ist}) = c &+ \sum_{j=1}^{4} \alpha_j \Delta log(L_{ist-j}) + \sum_{j=0}^{4} \mu_j MP_{t-j} + \gamma_1 INTRA_{st} + \gamma_2 INTER_{st} \\
&+ \sum_{j=0}^{4} \phi_j (MP_{t-j} * INTRA_{st}) + \sum_{j=0}^{4} \varphi_j (MP_{t-j} * INTER_{st}) + \sum_{j=0}^{4} \beta_j NATIONAL_{t-j} \\
&+ \sum_{j=0}^{4} \delta_j STATE_{st-j} + \sum_{k=1}^{3} \psi_k QUARTER_{kt} + \sum_{k=1}^{17} \xi_k YEAR_{kt} + \eta_i + \epsilon_{ist}
\end{aligned}
\tag{1.2}
$$

where the dependent variable is real loan growth of bank i, located in state s, in quarter t. The independent variables include 4 lags of bank i's loan growth, the contemporaneous value and 4 lags of monetary policy shocks, a dummy variable equaling 1 if state s permits in-state branching via M&A in quarter t, an analogous dummy variable equaling 1 if interstate banking is allowed in state s during quarter t, and interactions between the monetary policy shocks and deregulation dummies. Also included are the contemporaneous values and 4 lags of national and state control variables, quarter dummy variables, year dummy variables, and a bank fixed effect.

The national-level variables include change in real GDP, change in the personal consumption expenditures (PCE) index, and the CRSP value weighted stock return index. The state-level variables include percentage change in personal income and change in the U.S. Federal Housing Finance Agency all-transactions house price index. Quarter dummies are included to control for seasonality in lending. Year dummies are included to control for additional macro-level phenomena occurring during this time period, e.g. the gradual phaseout of regulation Q, the Fed regime of targeting non-borrowed reserves, and the Great Moderation. Alternate specifications with varying levels of fixed effects and time dummies are presented below, with the most comprehensive dropping all national-level variables in favor of quarterly fixed effects.

The coefficients of interest are the sum of the $\phi_j' s$ and sum of the $\varphi_j' s$. A significant $\sum_{j=0}^{4} \phi_j$ would indicate that monetary policy has a significantly different impact on bank lending following intrastate branching deregulation. A significant $\sum_{j=0}^{4} \varphi_j$ would indicate the same for interstate banking deregulation. We have no prior expectation regarding the sign of the coefficients, as the effect of deregulation on loan sensitivity to monetary policy is theoretically ambiguous.

1.4 Results

1.4.1 Impact of Deregulation

Equation 1.2 is estimated over the sample 1976Q2 - 1994Q4. Results for the summed coefficients of interest are presented in panel (a) of table 1.4. Results for all coefficients are presented in table 1.5. Columns (1) through (5) in table 1.4 display results from a variety of specifications, with column (4) reporting the baseline specification depicted in equation 1.2. Columns (1)-(3) provide results for more loosely specified variations of equation 1.2 and column (5) provides results for a more tightly specified variation. In the first four columns the summed coefficients of the monetary policy indicator are negative and jointly significant at the 1% level [15]. A contractionary 100 basis point exogenous monetary policy shock reduces lending by roughly 1-2% over the following four quarters [16]. The summed coefficients on the interaction between intrastate branching deregulation and monetary policy are small and insignificant in all five columns, indicating that intrastate deregulation has no effect on loan sensitivity to monetary policy.

The summed coefficients on the interaction between the interstate banking deregulation dummy and the monetary policy indicator are negative and significant in all five columns. An exogenous, contractionary monetary policy shock reduces lending by an additional 1.38-4.26% for a bank located in a state that has removed interstate banking restrictions [17]. According to the first four columns, the total effect of a contractionary monetary policy shock on lending for a bank located in a deregulated state is a decline of 2.5-4.1%. The baseline specification in column (4) indicates that the sensitivity of lending to monetary policy essentially doubles following interstate deregulation.

[15] Column (5) reports results including time fixed effects which are perfectly collinear with national-level variables such as the monetary policy indicator.

[16] One standard deviation of the monetary policy indicator is 70 basis points, hence a contractionary one standard deviation shock reduces lending by 0.8-1.4% over the next four quarters.

[17] A contractionary one standard deviation shock reduces lending by an additional 1-3%.

Column (5) includes the strongest controls for time-specific macro variation, and indicates that the effect of interstate deregulation is even stronger than that reported in column (4).

There is significant overlap in years that both types of restrictions are deregulated for a given state. To check that inclusion of both sets of deregulation dummies is not biasing the results in panel (a) equation 1.2 is estimated separately for each type of deregulation. Panel (b) presents the summed coefficients of interest for estimating equation 1.2 with interstate deregulation dummy and interactions only. Similarly, panel (c) presents results for estimating equation 1.2 with intrastate deregulation dummy and interactions only. Both panels are consistent with the baseline results, confirming that lending becomes more sensitive to monetary policy after interstate banking deregulation and that intrastate branching deregulation has no effect.

As discussed in section 1.3.1, our preferred measure of monetary policy is the RR shock series rather than a traditional measure such as the fed funds rate. To check whether the baseline results are driven by the choice of monetary policy indicator, equation 1.2 is also estimated with the quarterly change in the fed funds rate as the monetary policy indicator. Results using the fed funds rate are presented in panel (d). Once again, a contractionary monetary policy shock leads to a significant decline in lending over the following four quarters. According to columns (1)-(4), a 100 basis point increase in the federal funds rate leads to a 0.37-0.92% decline in lending over the next year.[18] Intrastate deregulation once again has no effect.

Columns (1)-(3) of panel (d) report that lending is less sensitive to monetary policy after interstate deregulation. Columns (4) and (5), which more completely control for unobserved macro variation, are consistent with the results in panel (a) however. The summed coefficients in columns (4) and (5) suggest that lending declines by an additional 0.66-1.02% after a state has removed interstate restrictions. The smaller magnitudes and positive coefficients in columns (1)-(3) are not surprising. The endogeneity and anticipatory components of the fed funds rate, which the RR shocks control for, would naturally lead to a less pronounced effect or even opposite effect of policy. Regardless, the richer specifications in panel (d) indicate that lending responds more

[18]This is in line with estimates from Ashcraft (2006), who finds that a 100 basis point increase in the federal funds rate decreases bank lending by 0.45%.

strongly to policy after interstate deregulation, suggesting that choice of monetary policy variable is not driving our results.

An additional concern raised in section 1.3.1 is that outliers in the monetary policy indicator (as well as real loan growth) during the Fed's period of non-borrowed reserve (NBR) targeting are driving the results. To explicitly control for the NBR targeting period we estimate two other variations of equation 1.2 with results reported in table 1.6. Column (1) shows results including a NBR dummy variable which equals 1 from 1979Q4-1982Q3 and 0 otherwise. Column (2) interacts the NBR dummy with the contemporaneous value and lags of the monetary policy indicator. Column (1) shows that the baseline results hold up when including the NBR dummy: lending declines by 1.71% prior to interstate deregulation and by an additional 2.33% after deregulation. The negative and significant coefficient on the NBR dummy indicates that lending growth was lower during the NBR targeting regime. Interestingly, in column (2) the summed coefficients on the monetary policy indicator are positive and significant while the summed coefficients on the interaction between the NBR dummy and monetary policy are negative and significant. Monetary policy therefore has a strongly negative effect on lending during the NBR period. For our purposes, the key result is the negative and significant coefficient on the interaction between interstate deregulation and monetary policy, which confirms that the greater sensitivity of lending to policy after interstate deregulation is not being driven by the NBR targeting regime.

The results in table 1.4 indicate that lending becomes more responsive to monetary policy along the quantity dimension following interstate deregulation. Next, we examine how deregulation impacts the sensitivity of lending to monetary policy along the price dimension. As discussed in section 1.3.2, direct data on loan rates is not available through the Call Reports. We can proxy for the average rate on a banks loan portfolio through the ratio of interest income on loans to quantity of total loans however. This ratio is referred to as a bank's average loan rate in the following.

Table 1.7 presents results for estimating equation 1.2 with average loan rate as the dependent variable.[19] Column (1) of table 1.7 shows that average loan rates significantly increase following a

[19] In the following we focus on the richer specifications including year dummies or time fixed

monetary tightening. For the four quarters following a 100 basis point exogenous and contractionary monetary policy shock average loan rates increase by 69 basis points. The interaction between the intrastate deregulation dummy and monetary policy is small and insignificant in both columns (1) and (2), indicating that the removal of intrastate branching restrictions had no effect on the sensitivity of loan pricing to monetary policy.

The interaction between the interstate deregulation dummy and monetary policy is positive and significant in both columns, indicating that loan pricing becomes more sensitive to monetary policy after interstate banking restrictions are removed. According to column (1), a bank located in a state that has removed interstate restrictions increases its average loan rate by an additional 113 basis points following a 100 basis point exogenous monetary tightening, which is more than double the average increase for a bank in a state that has not deregulated. Column (2) reports a somewhat smaller magnitude, indicating that a bank in a deregulated state increases its average loan rate by an additional 47 basis points following a monetary tightening. Regardless, this is a meaningful response as it is roughly two-thirds larger than that of a bank in a state which prohibits interstate banking.

From 1976-1982 interest and fee income on loans is only reported in the second and fourth quarters. For the above results we fill in the missing first and third quarter values so that first quarter average loan rate is equal to the second quarter observation, and so that third quarter average loan rate is equal to the fourth quarter observation. To check that replacing these missing values is not driving the above results we re-estimate equation 1.2 for an abbreviated sample from 1983-1994. Results are presented in columns (3) and (4) of table 1.7. The summed coefficients on the monetary policy indicator in column (3) are no longer significant at the 10% level, but the magnitude is similar and the standard errors are not large. The summed coefficients on the interaction between the interstate deregulation dummy and monetary policy remain positive and significant in both columns (3) and (4). These subsample results confirm that replacing the missing observations from 1976-82 is not driving the results in columns (1) and (2).

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effects, i.e. the specifications corresponding to columns (4) and (5) in table 1.4.

1.4.2 Role of Bank Lending Channel

These results raise the question: why does interstate banking deregulation strengthen the effect of monetary policy on lending? To investigate, we examine bank-level heterogeneity across a variety of dimensions. The literature has established multiple characteristics which influence the strength of the bank lending channel of monetary policy. Such characteristics include bank size (Kashyap and Stein (1995)), liquidity (Kashyap and Stein (2000)), and capitalization (Kishan and Opiela (2000)). In this section we study the role of bank-level heterogeneity in explaining the greater sensitivity of lending to monetary policy after interstate deregulation and the implications for the lending channel of transmission.

Kashyap and Stein (1995) find that small banks are more sensitive to monetary policy than larger banks. Similarly, Kashyap and Stein (2000) find that small and relatively illiquid banks are most strongly affected by monetary policy. Cetorelli and Goldberg (2012) also report that global banks are less responsive to monetary policy. We therefore investigate how heterogeneity across size and domestic/foreign status is related to interstate deregulation's impact on monetary policy effectiveness. To investigate, we estimate equation 1.2 separately for small banks, large banks, and branches of foreign banks operating in the United States. Consistent with the literature, we define a small bank as any bank below the cross-sectional 95th percentile in total assets within a given quarter. Correspondingly, a large bank is defined as any above the 95th percentile in total assets for a given quarter.

Results are presented in panel (a) of table 1.8. Columns (1)-(2) have results for small banks, (3)-(4) for large banks, and (5)-(6) for foreign banks. The summed coefficients in the first row show that both small and large banks have a roughly 2% decline in lending for the four quarters following a 100 basis point contractionary monetary policy shock prior to deregulation. The response of lending from foreign banks is insignificant. The second row shows that intrastate branching deregulation has no effect of the sensitivity of small bank lending, although it may have a small negative effect on large bank lending. Interestingly, intrastate branching deregulation seems to make branches of foreign banks much more sensitive to policy. The third row shows that interstate banking deregulation only affects small banks. The coefficients are very similar to the baseline results for all banks, as the response of small bank lending to a monetary shock doubles after deregulation.

The results in panel (a) are consistent with Kashyap and Stein (1995) and Kashyap and Stein (2000). As an additional check, we estimate 1.2 with average loan rate as the dependent variable for both small and large bank samples. Foreign banks do not report interest and fee income on loans, hence we cannot calculate average loan rates for them. Results are presented in table 1.9. The first row of table 1.9 confirms that both small and large banks increase loan rates following a monetary tightening. Columns (1) and (3) suggest that following interstate deregulation the sensitivity of loan pricing to policy increases for both small and large banks. Column (2) confirms this for small banks, however the summed coefficient for the interaction of interstate deregulation and monetary policy is small and insignificant for large banks in column (4). These results provide further support that the effect of interstate deregulation impacts monetary transmission through small banks.

Kashyap and Stein (2000) find that the bank lending channel operates through small and relatively illiquid banks. To investigate the role of liquidity we estimate equation 1.2 by liquidity quartile, where the 1st quartile includes the least liquid banks in a given quarter and the 4th quartile includes the most liquid.[20] Results are presented in table 1.10. Panel (a) displays results for all banks. Prior to deregulation all four quartiles respond similarly to monetary policy, declining by roughly 2% for the four quarters following a contractionary shock. After interstate deregulation the least liquid banks are more strongly affected, with the most liquid banks in the 4th quartile not responding any more strongly. Panel (b) presents results for small banks only and panel (c) for large banks only. These panels confirm that the overall effect is being driven by the small banks. According to the specification using time fixed effects all four quartiles become more sensitive to policy after interstate deregulation, but the increase in response to policy is decreasing in liquidity. Column (1) in panel (c) indicates the least liquid large banks may become slightly more sensitive to policy after interstate deregulation, however column (2) does not confirm this. Overall, there is

[20] We use a narrower measure of liquidity - the ratio of cash and reserves to total liabilities - than Kashyap and Stein (2000) for ease of interpretation.

little to no effect on large banks across liquidity quartiles.

Kishan and Opiela (2000) find that the effect of monetary policy on lending is stronger for relatively undercapitalized banks, particularly small ones. We once again estimate equation 1.2, this time by equity ratio quartile, where the 1st quartile includes the least capitalized banks in a given quarter and the 4th quartile includes the most highly capitalized banks. Equity ratio is calculated as total equity divided by total assets. Results are presented in table 1.11. Panel (a) displays results for all banks. Prior to deregulation all four quartiles respond similarly to policy. After interstate deregulation banks in all four quartiles become more responsive to policy, with an additional decline in lending growth of 3.54-4.14% according to the specifications with time fixed effects. The increased response is slightly larger for banks in the 1st and 2nd quartiles, but not large enough enough to suggest that capitalization plays a major role in explaining the greater sensitivity of lending to policy after interstate deregulation. Panel (b) presents results for small banks only and panel (c) presents results for large banks. Once again, it is primarily small banks that become more sensitive after deregulation.

1.5 Potential Explanations

The previous section establishes that following the removal of interstate banking restrictions monetary policy has a stronger effect on lending for small and relatively illiquid banks. This implies that interstate banking deregulation strengthens the bank lending channel of monetary transmission. In this section we investigate three potential explanations for the strengthening of the lending channel after deregulation. These explanations include changes in bank market structure, changes in loan portfolio composition, and changes in bank-borrower relationships following deregulation.

1.5.1 Bank Market Structure

The effects of geographic banking deregulation have been widely discussed in the literature. Jayaratne and Strahan (1998), Evanoff and Ors (2008) and Chortareas, Kapetanios, and Ventouri (2016) find that deregulation increased efficiency in the banking sector. Stiroh and Strahan (2003) report that deregulation improved competitive dynamics by reallocating market share to better performing banks. Zou, Miller, and Malamud (2011) offer mixed evidence, arguing that deregulation increased efficiency of small banks but decreased efficiency of medium-sized banks. Similarly, Berger and DeYoung (2001) find both positive and negative links between geographic expansion and bank efficiency. Rhoades (2000) argues that nationwide banking concentration increased from 1980-1998, in part due to geographic deregulation, and Jeon and Miller (2003) find that deregulation is significantly correlated with higher state-level concentration.

Additionally, a relatively new literature has examined the relationship between banking market structure and monetary policy transmission. In cross-country studies using bank-level measures of market power Fungáčová, Solanko, and Weill (2014) and Leroy (2014) find that lending is less sensitive to monetary policy when banks have greater market power. On the other hand, Amidu and Wolfe (2013) and Yang and Shao (2016) find that lending is more sensitive to policy when banks have greater market power. The only published study on bank market structure and monetary transmission in the U.S. is Adams and Amel (2011) which takes market concentration at the local level (MSA or county) as the measure of market structure. They use annual Community Reinvestment Act data on new loan origination for a sample running from 1996-2004, and their results show that monetary policy has a weaker effect on bank lending in more highly concentrated markets.

The effect of geographic deregulation on banking market structure is not clear, nor is the effect of market structure on monetary policy effectiveness. In this section we test how each type of deregulation impacted bank market power and banking concentration, at both the local and state level. Additionally, we examine whether changes in market power and concentration can explain the increased sensitivity of lending to policy following interstate deregulation. The measure of market power used is a bank-level Lerner index and the measures of concentration used are the Herfindahl-Hirschman Index (HHI), calculated at the local (county) and state levels.

The Lerner index is a measure of a banks market power, calculated as the difference between price of output and marginal cost, divided by marginal cost. In calculating the Lerner index we follow Fungáčová, Solanko, and Weill (2014) among others. The average price of bank production is proxied by the ratio of total revenues to total assets. The marginal cost is calculated by estimating a translog cost function with one output and three input prices. The output price is total assets and the input prices are the price of labor, price of fixed assets, and price of borrowed funds (interest on deposits). The cost function is specified as follows:

$$\begin{aligned} log(TC_{it}) &= \alpha_0 + \alpha_1 log(y_{it}) + 0.5\alpha_2 (log(y_{it}))^2 + \sum_{j=1}^{3} \beta_j log(w_{j,it}) \\ &+ \sum_{j=1}^{3}\sum_{k=1}^{3} \beta_{jk} log(w_{j,it}) * log(w_{k,it}) + \sum_{j=1}^{3} \gamma_j log(y_{it}) * log(w_{j,it}) + \rho_t + \eta_i + \epsilon_{it} \end{aligned} \tag{1.3}$$

Where y is total assets and $\sum_{j=1}^{3} w_j$ are the three input prices. Quarter dummies and bank fixed effects are included. Symmetry and linear homogeneity restrictions are imposed on input prices. Total cost is the sum of the three input prices. Marginal cost can then be calculated from the estimated coefficients:

$$MC = (TC/y) * (\alpha_1 + \alpha_2 log(y) + \sum_{j=1}^{3} log(w_j)) \tag{1.4}$$

The resulting Lerner index, calculated as (P-MC)/MC, is a bank-level measure of market power, with a value of 0 representing a perfectly competitive bank (P=MC) and a value of 1 representing a pure monopolist. Since expense data is available only biannually until 1983 we fill the missing first and third quarter observations with the average Lerner Index of the previous and following quarters.

The Herfindahl-Hirschman Index (HHI) is calculated as the summed squares of firm market shares within an industry:

$$HHI = \sum_{i=1}^{N} {s_i}^2 \tag{1.5}$$

where s is the market share of firm i and there are N banks in the market. Hence in a monopoly, where a single banks's market share is equal to 100%, the HHI index would be 1. On the opposite end of the spectrum, the HHI for a decentralized market with many firms would be close to zero. We calculate HHI at both the county and state levels, as concentration at the local level and at the state level may be quite different.

Each of the three bank structure measures are regressed on the deregulation dummies and controls in the following specification:

$$BMS_{ist} = c + \gamma_1 INTRA_{st} + \gamma_2 INTER_{st} + \delta STATE_{st} + \beta BANK_{ist-1} + \rho_t + \eta_i + \epsilon_{ist} \tag{1.6}$$

Results are presented in panel (a) of table 1.12. The first row shows that intrastate branching deregulation increased county-level banking concentration but had no effect on the Lerner index or state-level concentartion [21]. Interstate deregulation also increased county-level concentration, along with increasing the Lerner index and decreasing state-level concentration. These results indicate that the removal of interstate banking restrictions increased bank market power, increased local concentration, and decreased state concentration.

Now that we have documented the effect of interstate deregulation on a variety of bank market structure measures, we examine how these measures are related to the the sensitivity of loan pricing to monetary policy. To do so we estimate an alternative version of equation 1.2, with the bank market structure variables interacted with the monetary policy indicator.

$$\begin{aligned}\Delta log(L_{ist}) = c &+ \sum_{j=1}^{4}\alpha_j \Delta log(L_{ist-j}) + \sum_{j=0}^{4}\mu_j MP_{t-j} + \gamma BMS_{ist} + \sum_{j=0}^{4}\phi_j (MP_{t-j} * BMS_{ist}) \\ &+ \sum_{j=0}^{4}\beta_j NATIONAL_{t-j} + \sum_{j=0}^{4}\delta_j STATE_{st-j} + \sum_{k=1}^{3}\psi_k QUARTER_{kt} \\ &+ \sum_{k=1}^{17}\xi_k YEAR_{kt} + \eta_i + \epsilon_{ist}\end{aligned} \tag{1.7}$$

The summed coefficients on the interaction between bank market structure and monetary policy, $\sum_{j=0}^{4}\phi_j$, informs us of the differential response of bank loan pricing to monetary policy depending

[21]Note: the state HHI regression is ran at the state-level rather than the bank-level.

on a banks market power, local market concentration, and state concentration [22]. Results are presented in panel (b) of table 1.12. Columns (1), (3), and (5) show results for estimating equation 1.7 with each bank market structure variable without the deregulation dummy and interactions. Columns (2),(4), and (6) show results for estimating equation 1.7 with each bank market structure variable as well as the interstate deregulation dummy and interactions.

Across all six columns a contractionary monetary policy shock results in a decrease in lending over the following four quarters, with the decrease being significant for all columns. The first column reports that banks with a higher Lerner index (i.e. greater market power) are less sensitive to monetary policy. A bank which is a pure monopolist (Lerner = 1) decreases lending by 0.48% for the four quarters following a monetary tightening whereas a perfectly competitive bank (Lerner = 0) decreases lending by 2.91%. Column (2) confirms that the effect of policy on lending increases by roughly 2% after interstate deregulation as in the baseline results. Columns (3)-(6) report that county-level and state-level concentration have no effect on loan response to monetary policy. Column (4) and column (6) also confirm that interstate banking deregulation increases the sensitivity of lending to monetary policy.

The results in table 1.12 indicate that interstate deregulation did not affect loan sensitivity through banking competition or market structure. Banking concentration has no impact on the sensitivity of lending to monetary policy. Increased bank market power weakens the impact of policy on lending. Since interstate deregulation increased bank market power but strengthened the impact of policy on lending, the effect of deregulation could not have been driven by change in market power. As a final investigation we estimate equation 1.2 for subsamples corresponding to Lerner index quartile and local HHI quartile. While deregulation may not have operated through increasing market power or concentration it is possible that banks were asymmetrically impacted depending on their competitive environment. We therefore investigate the role of market structure heterogeneity on the effect of deregulation.

Table 1.13 shows the effect of deregulation by Lerner index quartile, with the 1st quartile having

[22]Note: The Lerner Index is included with one lag to reduce simultaneity concerns.

the lowest market power (and hence being relatively more competitive) and with the 4th quartile having the highest market power (and hence being relatively less competitive). Panel (a) shows results for all banks, panel (b) shows results for small banks only, and panel (c) shows results for large banks only. There is no clear trend across quartiles, as all four respond more strongly after interstate deregulation, particularly the first and fourth quartiles. Once again, only small banks respond more strongly after interstate deregulation, as there is no effect for large banks. Similarly, table 1.14 shows the effect of deregulation by county HHI, with the 1st quartile having the lowest concentration and the 4th quartile having the highest concentration. Panel (a) shows results for all banks, panel (b) shows results for small banks, and panel (c) shows results for large banks. Interstate deregulation has a significant effect across all four quartiles, once again driven by small banks. Bank market structure therefore seems to play no role in the greater sensitivity of lending to monetary policy after the removal of interstate restrictions.

1.5.2 Loan Portfolio Composition

Den Haan, Sumner, and Yamashiro (2007) find that certain types of loans are more sensitive to monetary policy than others. Interstate deregulation may therefore increase certain types of lending which are more sensitive to policy. Den Haan, Sumner, and Yamashiro (2007) examine loan portfolio response to monetary policy at the aggregate level and find differential responses depending on loan type. Real estate and consumer loans decrease following a monetary tightening but commercial and industrial (C&I) loans actually increase. In explaining these results the authors suggest that adjusting loan portfolio composition may be an optimal response to monetary shocks for a variety of reasons.

Focusing on total lending may therefore hide important compositional effects. First, we check whether interstate deregulation altered the average composition of a bank's loan portfolio. Panel (a) of table 1.15 shows the effect of deregulation on the average share of each loan category (relative to total loans). Intrastate and interstate deregulation both significantly decrease C&I and real estate lending as a share of total loans. Interstate deregulation significantly increases the share of consumer lending. The coefficients for each category share are small however, as share of loans going to consumer lending increases by just 0.37% after deregulation. This makes it implausible that a change in loan portfolio composition is driving the baseline results.

To investigate further, equation 1.2 is estimated separately for each of the three main loan categories (C&I, real estate, and consumer) with results presented in panel (b) of table 1.15. Interestingly, and inconsistent with Den Haan, Sumner, and Yamashiro (2007), columns (1), (3), and (5) report that each loan category responds negatively to a monetary tightening [23]. While the summed coefficients on the interaction between interstate deregulation and monetary policy are not significant for the baseline specification, the alternate specification including time fixed effects shows that each category becomes more sensitive to policy following deregulation, and at a similar magnitude as total lending in table 1.4. Since each type of lending responds to interstate deregulation in a similar manner it appears that the greater sensitivity of overall lending to monetary policy after deregulation cannot be explained by changes in loan portfolio composition.

1.5.3 Bank-Borrower Relationships

A third potential explanation for our results is a dilution of bank-borrower customer relationships and a greater propensity of banks to cut lending following interstate deregulation. Petersen and Rajan (1994) find that bank-borrower relationships increase credit availability for bank customers. Cole, Goldberg, and White (2004) find that large banks make lending decisions based on standard financial criteria whereas small banks employ greater discretion based on impressions of borrower characteristics. Bonaccorsi di Patti and Gobbi (2001) report that acquisition and entry into new markets tends to reduce credit supply. These results suggest that increased entry into new markets and increased concentration following deregulation may weaken relationships between banks and borrowers, leading to a greater decline in lending following a contractionary monetary shock.

To investigate we estimate equation 1.2 for two subsamples: banks that are affiliated with a

[23] There are important differences between this study and Den Haan, Sumner, and Yamashiro (2007) however as they use aggregate data in a VAR framework for a sample that extends to 2004.

BHC and stand alone banks that are unaffiliated with a holding company. Affiliated banks are more likely to operate within a centralized organizational structure that is less sensitive to local borrower characteristics. If the strengthening of the bank lending channel is driven by a weakening of bank-borrower relationships we would therefore expect affiliated banks to be more strongly affected. Results are presented in panel (a) of table 1.16. Columns (1)-(2) show results for stand alone banks and columns (3)-(4) show results for BHC affiliated banks. Ashcraft (2006) has previously found that the bank lending channel is stronger for stand alone banks than for affiliated banks. Consistent with these results, columns (1) and (3) show that stand alone banks respond more strongly to monetary policy than affiliated banks pre-deregulation. However after interstate deregulation affiliated banks become significantly more sensitive than stand alone banks. Column (1) indicates that interstate deregulation does not significantly impact stand alone banks. Column (2) suggests stand alone banks become somewhat more sensitive to policy after deregulation. Columns (3) and (4) indicate that affiliated banks become significantly more responsive to monetary policy after deregulation, by a relatively large magnitude of 2.7-5.16%. Panel (b) presents results for small banks only and panel (c) for large banks only. Once again, the overall effect is driven by small banks, as the BHC affiliated small banks respond more strongly than stand alone small banks.

Heterogeneity across bank size, liquidity, and BHC affiliation therefore appear to be driving the effect of interstate deregulation on monetary policy. Small banks, less liquid banks, and banks affiliated with a BHC are most strongly impacted by deregulation. Therefore, we further split the sample to account for all three characteristics. Equation 1.2 is estimated across liquidity ratio quartile for four groups: small affiliated banks, small stand alone banks, large affiliated banks, and large stand alone banks. Panel (a) of table 1.17 shows the effect of interstate deregulation by liquidity quartile for small BHC-affiliated banks; panel (b) for small stand alone banks; panel (c) for large BHC-affilaited banks; and panel (d) for large stand alone banks. The results confirm that deregulation primarily leads to small and affiliated banks becoming more sensitive to monetary policy, and that the effect is decreasing in liquidity.[24]

[24]The least liquid small stand alone banks and the 2nd quartile of large stand alone banks also

Next, we test why small affiliated banks are most strongly affected. To do so we look more broadly at the asset side of a bank's balance sheet. We once again estimate equation 1.2 across liquidity quartile for small banks based upon their BHC affiliation, but now with total asset growth as the dependent variable in one specification and with securities growth as the dependent variable in a second specification. Table 1.18 presents results. Panel (a) shows how interstate deregulation impacts the sensitivity of asset growth to monetary policy for small affiliated banks. Panel (b) shows the same effect for small stand alone banks. Panel (c) shows how interstate deregulation impacts the sensitivity of securities growth to monetary policy for small affiliated banks. Panel (d) shows the same effect for small stand alone banks. Noticeably, small affiliated banks adjust both assets and securities in response to a monetary shock whereas small stand alone banks do not adjust either. Small affiliated banks below the 4th quartile in liquidity see a relatively small decline in assets for the four quarters following a monetary policy shock. As seen in table 1.17, these banks are reducing lending to a relatively large degree. On the other hand, panel (c) in table 1.18 shows that they increase securities holdings in response to a contractionary shock (except for the 3rd quartile), resulting in an overall small decline in assets. Thus it appears that relatively illiquid small banks affiliated with a BHC respond uniquely to monetary policy after interstate deregulation, by shifting the asset-side of their balance sheets away from lending and towards securities.

We find that the bank lending channel of transmission strengthens primarily for small, relatively illiquid banks affiliated with a BHC. These banks are unique in more strongly adjusting the asset-side of their balance sheets towards securities and away from loans following a contractionary monetary shock. These results are consistent with the notion that interstate deregulation weakens bank-borrower relationships and increases the propensity of banks to cut lending in response to a contractionary monetary shock.

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become more sensitive to policy after deregulation. There are very few large stand alone banks, hence the relatively large and weakly significant coefficient for the 2nd quartile in panel (d) should be interpreted with caution.

1.6 Aggregate Effects

We have documented that bank lending becomes more sensitive to monetary policy following interstate banking deregulation, particularly for small banks and banks affiliated with a bank holding company. In this section we aggregate our bank-level data to the state-level to investigate the state-level effects of deregulation. Table 1.20 presents results for estimating equation 1.2 with state-level variables.[25] Column (1) presents results with state-level real loan growth from all banks as the dependent variable. The interaction between interstate deregulation and monetary policy is negative but insignificant, indicating that deregulation has no effect on aggregate state-level loan growth.

To investigate further we aggregate state loans separately for four different categories of banks. The four categories are the same as those focused on in section 1.5.3: small BHC affiliated banks, small stand alone banks, large BHC affiliated banks, and large stand alone banks. Table 1.19 presents summary statistics for the share of total loans from each type of bank. Figure 1.5 plots each groups loan share over the entire sample. For the whole sample 61% of total lending comes from large affiliated banks with small affiliated banks having the next largest share at 16%. The average share of small stand alone banks drops by half, from 16% to 8% from the early part of the sample to the later part. The shares of the other three groups increase over this time frame, with small affiliated banks having the largest increase from 13% to 18%.

We once again estimate equation 1.2 with aggregate loan growth from each of the four bank categories as the dependent variable. Results are presented in table 1.20. Interstate deregulation only impacts aggregate lending from small affiliated banks. Following a 100 basis point contractionary shock lending growth from all small and affiliated banks within a state declines by 8% over the following four quarters. Small affiliated banks make up on average 16% of total lending over the sample, hence a back-of-the-envelope calculation indicates that after interstate deregulation state lending growth declines by an additional (8% x 0.16) = 1.28% following a contractionary shock. This rough estimate is in-line with the summed coefficients on the interstate-monetary policy interaction term in the first column of table 1.20 for all banks. While the magnitude is not

[25] The results shown are from the specification with time fixed effects rather than year dummies.

large, it is noteworthy that interstate banking deregulation results in a greater response of state-level loan growth to monetary policy in addition to the stronger response at the individual bank-level.

1.7 Conclusion

This paper examines the relationship between bank regulation and monetary policy. From the mid-1970's to mid-1990's a majority of states removed restrictions on geographic bank expansion. There were two types of restrictions: those on out-of-state ownership of in-state banks (interstate) and those on within-state branching (intrastate). By exploiting the staggered timing of state-level deregulation we find that interstate banking deregulation, but not intrastate branching deregulation, increases the sensitivity of lending to monetary policy. The response of real loan growth to monetary policy doubles following interstate deregulation.

More specifically, interstate banking deregulation strengthens the bank lending channel of monetary transmission, as monetary policy has a greater effect on small and relatively illiquid banks after deregulation. We consider a variety of explanations for these results. Though deregulation increases bank market power and local banking concentration, neither of these changes in bank market structure can explain the increased sensitivity of loans to monetary policy. Deregulation impacts all three major loan categories similarly, also ruling out the possibility that the greater response of lending is driven by changes in loan portfolio composition.

On the other hand, we find that banks affiliated with a bank holding company are most strongly impacted by deregulation. After deregulation small banks affiliated with a bank holding company respond to monetary policy through a larger substitution of securities for bank loans. These results point to a weakening of bank-borrower relationships and an increased propensity of banks to cut lending as the mechanism behind interstate deregulation's strengthening of monetary policy transmission. Finally, we find that interstate banking deregulation leads to a greater effect of monetary policy on loan growth at the aggregate state-level in addition to at the individual bank-level. Further investigation into the aggregate effects of interstate banking deregulation remains an intriguing avenue for future work.

APPENDIX

Table 1.1: Timing of State Deregulation

State	Intrastate branching via M&A	Interstate banking
Alabama	1981	1987
Alaska	<1970	1982
Arizona	<1970	1986
Arkansas	1994	1989
California	<1970	1987
Colorado	1991	1988
Connecticut	1980	1983
Delaware	<1970	1988
Washington, DC	<1970	1985
Florida	1988	1985
Georgia	1983	1985
Hawaii	1986	*
Idaho	<1970	1985
Illinois	1988	1986
Indiana	1989	1986
Iowa	*	1991
Kansas	1987	1992
Kentucky	1990	1984
Louisiana	1988	1987
Maine	1975	1978
Maryland	<1970	1985
Massachusetts	1984	1983
Michigan	1987	1986
Minnesota	1993	1986
Mississippi	1986	1988
Missouri	1990	1986
Montana	1990	1993
Nebraska	1985	1990
Nevada	<1970	1985
New Hampshire	1987	1987
New Jersey	1977	1986
New Mexico	1991	1989
New York	1976	1982
North Carolina	<1970	1985
North Dakota	1987	1991
Ohio	1979	1985
Oklahoma	1988	1987
Oregon	1985	1986
Pennsylvania	1982	1986
Rhode Island	<1970	1984
South Carolina	<1970	1986
South Dakota	<1970	1988
Tennessee	1985	1985
Texas	1988	1987
Utah	1981	1984
Vermont	1970	1988
Virginia	1978	1985
Washington	1985	1987
West Virginia	1987	1988
Wisconsin	1990	1987
Wyoming	1988	1987

Column 1 lists the year that each state allowed branch banking through mergers and acquisitions. Column 2 lists the year each state entered into an interstate banking agreement with other states. * indicates that a state had not deregulated before 1994.

Table 1.2: Summary Statistics - All Banks

	Whole Sample		1976-1985		1986-1994	
All banks	Mean	Std Dev	Mean	Std Dev	Mean	Std Dev
Real loan growth - Total (%)	1.13	(7.25)	1.39	(7.30)	0.81	(7.17)
Avg loan rate (annualized %)	11.43	(4.06)	11.99	(4.77)	10.74	(2.83)
Real loan growth - C&I (%)	0.76	(24.13)	1.63	(24.32)	-0.33	(23.85)
Real loan growth - RE (%)	2.16	(15.08)	2.18	(16.77)	2.13	(12.66)
Real loan growth - Con (%)	0.46	(17.35)	1.04	(17.58)	-0.27	(17.03)
C&I Share of Lending	0.21	(0.14)	0.22	(0.14)	0.20	(0.13)
RE Share of Lending	0.40	(0.19)	0.34	(0.17)	0.47	(0.18)
Con share of lending	0.24	(0.14)	0.26	(0.14)	0.20	(0.13)
Assets ($)	173 mil	(2 bil)	122 mil	(1.6 bil)	235 mil	(2.5 bil)
Securities ($)	38 mil	(269 mil)	27 mil	(183 mil)	54 mil	(355 mil)
Liquidity Ratio	0.09	(0.23)	0.10	(0.06)	0.08	(0.34)
Equity Ratio	0.09	(0.03)	0.09	(0.03)	0.09	(0.04)
BHC Affiliation	0.53	(0.50)	0.39	(0.49)	0.70	(0.46)
Lerner Index	0.31	(0.09)	0.30	(0.08)	0.32	(0.09)
County HHI	0.33	(0.22)	0.31	(0.21)	0.35	(0.23)
State HHI	0.11	(0.11)	0.10	(0.10)	0.12	(0.12)
Number of banks	16,014		14,835		14,242	

This table reports summary statistics for bank-level variables of interest. The first two columns have statistics for the entire sample (1976Q2 - 1994Q4). The third and fourth columns have statistics for the early part of the sample (when the majority of states had not deregulated). The fifth and sixth columns have statistics for the later part of the sample (when the majority of states had deregulated).

Table 1.3: Summary Statistics - by Bank Size

	Whole Sample		1976-1985		1986-1994	
Panel (a): small banks	Mean	Std Dev	Mean	Std Dev	Mean	Std Dev
Real loan growth - Total (%)	1.15	(7.31)	1.40	(7.38)	0.83	(7.20)
Avg loan rate (annualized %)	11.43	(0.04)	11.98	(4.77)	10.74	(2.63)
Real loan growth - C&I (%)	0.78	(24.51)	1.66	(24.79)	-0.32	(24.12)
Real loan growth - RE (%)	2.20	(15.30)	2.24	(17.09)	2.16	(12.70)
Real loan growth - Con (%)	0.48	(17.54)	1.07	(17.85)	-0.26	(17.11)
C&I Share of Lending	0.21	(0.14)	0.22	(0.14)	0.20	(0.13)
RE Share of Lending	0.40	(0.19)	0.35	(0.17)	0.47	(0.18)
Con share of lending	0.24	(0.14)	0.27	(0.14)	0.20	(0.13)
Assets($)	51 mil	(58 mil)	38 mil	(40 mil)	68 mil	(72 mil)
Securities ($)	17 mil	(20 mil)	13 mil	(14 mil)	23 mil	(26 mil)
Liquidity Ratio	0.10	(0.24)	0.10	(0.06)	0.08	(0.35)
Equity Ratio	0.09	(0.03)	0.09	(0.03)	0.09	(0.04)
BHC Affiliation	0.51	(0.50)	0.37	(0.48)	0.69	(0.46)
Lerner Index	0.30	(0.09)	0.29	(0.08)	0.31	(0.09)
County HHI	0.33	(0.22)	0.31	(0.21)	0.35	(0.23)
State HHI	0.11	(0.11)	0.10	(0.10)	0.12	(0.12)
Number of banks	15,481		14,264		13,625	
Panel (b): large banks	Mean	Std Dev	Mean	Std Dev	Mean	Std Dev
Real loan growth - Total (%)	0.86	(6.09)	1.13	(5.63)	0.52	(6.61)
Avg loan rate (annualized %)	11.53	(5.09)	12.17	(4.78)	10.74	(5.35)
Real loan growth - C&I (%)	0.39	(15.16)	1.15	(12.59)	-0.59	(17.86)
Real loan growth - RE (%)	1.30	(10.07)	1.09	(8.50)	1.58	(11.75)
Real loan growth - Con (%)	0.08	(13.35)	0.44	(11.42)	-0.38	(15.41)
C&I Share of Lending	0.30	(0.14)	0.32	(0.13)	0.27	(0.15)
RE Share of Lending	0.36	(0.17)	0.32	(0.14)	0.41	(0.19)
Con share of lending	0.24	(0.16)	0.25	(0.12)	0.23	(0.19)
Assets($)	2.5 bil	(8.7 bil)	1.7 bil	(6.8 bil)	3.4 bil	(10.5 bil)
Securities ($)	447 mil	(1.1 bil)	306 mil	(765 mil)	640 mil	(1.5 bil)
Liquidity Ratio	0.12	(0.08)	0.14	(0.08)	0.09	(0.07)
Equity Ratio	0.07	(0.02)	0.07	(0.02)	0.07	(0.03)
BHC Affiliation	0.83	(0.37)	0.75	(0.43)	0.94	(0.24)
Lerner Index	0.37	(0.11)	0.34	(0.09)	0.41	(0.12)
County HHI	0.33	(0.20)	0.31	(0.19)	0.35	(0.21)
State HHI	0.11	(0.11)	0.10	(0.10)	0.12	(0.12)
Number of banks	1,215		931		1,023	

This table reports summary statistics for bank-level variables of interest. Panel (a) reports statistics for small banks, defined as all banks under the 95th percentile in total assets in a given quarter. Panel (b) reports statistics for large banks, defined as all banks above the 95th percentile in total assets in a given quarter. The first two columns have statistics for the entire sample (1976Q2 - 1994Q4). The third and fourth columns have statistics for the early part of the sample (when the majority of states had not deregulated). The fifth and sixth columns have statistics for the later part of the sample (when the majority of states had deregulated).

Table 1.4: Impact of Deregulation on Lending Response to Monetary Policy

sum of coefficients	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**
Panel (a): baseline results					
MP	-0.0111***	-0.0115***	-0.0121***	-0.0202***	-
	(0.0014)	(0.0013)	(0.0014)	(0.0021)	
Intra*MP	0.0023	0.0026	0.0022	-0.0005	-0.0010
	(0.0029)	(0.0027)	(0.0029)	(0.0030)	(0.0031)
Inter*MP	-0.0142***	-0.0139***	-0.0138***	-0.0208**	-0.0426***
	(0.0046)	(0.0043)	(0.0045)	(0.0094)	(0.0112)
Panel (b): interstate deregulation only					
MP	-0.0109***	-0.0109***	-0.0116***	-0.0203***	-
	(0.0014)	(0.0014)	(0.0015)	(0.0022)	
Inter*MP	-0.0126***	-0.0122***	-0.0124***	-0.0209**	-0.0424***
	(0.0041)	(0.0040)	(0.0042)	(0.0084)	(0.0113)
Panel (c): intrastate deregulation only					
MP	-0.0108***	-0.0112***	-0.0118***	-0.0205***	-
	(0.0013)	(0.0012)	(0.0012)	(0.0018)	
Intra*MP	-0.0013	-0.0008	-0.0012	-0.0023	-0.0032
	(0.0025)	(0.0024)	(0.0026)	(0.0027)	(0.0033)
Panel (d): fed funds rate as MP indicator					
MP	-0.0092***	-0.0091***	-0.0099***	-0.0037***	-
	(0.0007)	(0.0008)	(0.0009)	(0.0014)	
Intra*MP	0.0015	0.0014	0.0017	0.0006	0.0006
	(0.0011)	(0.0012)	(0.0012)	(0.0010)	(0.0010)
Inter*MP	0.0051***	0.0051***	0.0053***	-0.0066**	-0.0102***
	(0.0014)	(0.0014)	(0.0015)	(0.0028)	(0.0030)
observations	823,659	823,659	823,659	823,659	823,659
STATE	Yes	Yes	Yes	Yes	Yes
NATIONAL	Yes	Yes	Yes	Yes	-
State Fixed Effects	-	Yes	-	-	-
Bank Fixed Effects	-	-	Yes	Yes	Yes
Linear Time Trend	Yes	Yes	Yes	-	-
Year Dummies	-	-	-	Yes	-
Time Fixed Effects	-	-	-	-	Yes

This table reports results from estimating equation 1.2. Panel (a) reports the baseline results. Panel (b) reports results for estimating equation 1.2 with interstate deregulation only and panel (c) reports results for estimating equation 1.2 with intrastate deregulation only. Panel (d) reports results using the quarterly change in the fed funds rate as the monetary policy indicator, rather than the RR shocks. Robust standard errors clustered at the state-level are in parentheses. * indicates statistical significance at the 10% level. ** indicates statistical significance at the 5% level. *** indicates statistical significance at the 1% level.

Table 1.5: Impact on Lending Response: All Coefficients - Baseline Model

Dependent variable: Real Loan Growth (1976Q2 - 1994Q4)							
Variable	Coefficient	Variable	Coefficient	Variable	Coefficient	Variable	Coefficient
Loan Growth (t-1)	0.100***	CRSP(t-4)	0.0491**	INTRA*MP	-0.000882	1983 Dummy	0.00975***
	(0.0126)		(0.0186)		(0.000764)		(0.00267)
Loan Growth (t-2)	0.0157	PI	0.000959***	INTRA*MP(t-1)	-0.000437	1984 Dummy	0.00646***
	(0.0105)		(0.000293)		(0.000745)		(0.00220)
Loan Growth (t-3)	0.0395***	PI(t-1)	0.00150***	INTRA*MP(t-2)	0.000659	1985 Dummy	-0.0129***
	(0.00487)		(0.000403)		(0.000844)		(0.00189)
Loan Growth (t-4)	0.166***	PI(t-2)	0.00187***	INTRA*MP(t-3)	0.000435	1986 Dummy	-0.00734***
	(0.0114)		(0.000299)		(0.000844)		(0.00138)
GDP	-4.85e-07	PI(t-3)	0.000437*	INTRA*MP(t-4)	-0.000322	1987 Dummy	-0.00888***
	(6.31e-06)		(0.000220)		(0.000927)		(0.00222)
GDP(t-1)	-1.64e-06	PI(t-4)	0.000708***	INTER*MP	-0.00878***	1988 Dummy	0.00219
	(8.31e-06)		(0.000209)		(0.00262)		(0.00259)
GDP(t-2)	-4.23e-05***	HPI	0.000477***	INTER*MP(t-1)	0.00108	1989 Dummy	-0.00105
	(6.47e-06)		(8.85e-05)		(0.00261)		(0.00245)
GDP(t-3)	3.73e-05***	HPI(t-1)	0.000588***	INTER*MP(t-2)	0.000507	1990 Dummy	-0.00739***
	(5.19e-06)		(0.000107)		(0.00243)		(0.00237)
GDP(t-4)	1.29e-05*	HPI(t-2)	0.000726***	INTER*MP(t-3)	-0.00653***	1991 Dummy	-0.00166
	(6.66e-06)		(8.75e-05)		(0.00213)		(0.00298)
PCE	-0.00388*	HPI(t-3)	0.000608***	INTER*MP(t-4)	-0.00713***	1992 Dummy	-0.00758**
	(0.00214)		(9.15e-05)		(0.00197)		(0.00305)
PCE(t-1)	-0.000401	HPI(t-4)	0.000333***	Q2 Dummy	0.0208***	1993 Dummy	-0.000698
	(0.00229)		(6.50e-05)		(0.00184)		(0.00392)
PCE(t-2)	0.0114***	MP	0.00224***	Q3 Dummy	0.00834***	1994 Dummy	0.0147***
	(0.00263)		(0.000685)		(0.00150)		(0.00495)
PCE(t-3)	-0.0229***	MP(t-1)	-0.00866***	Q4 Dummy	0.00400***	Constant	-0.00467
	(0.00295)		(0.000613)		(0.00137)		(0.00510)
PCE(t-4)	-0.00294	MP(t-2)	-0.00855***	1978 Dummy	-0.0120***		
	(0.00274)		(0.000600)		(0.00106)	Observations	823,659
CRSP	0.0156	MP(t-3)	-0.00286***	1979 Dummy	-0.0283***	Number of banks	15,990
	(0.0115)		(0.000456)		(0.00237)	R-squared	0.124
CRSP(t-1)	0.0553***	MP(t-4)	-0.00241***	1980 Dummy	-0.0296***		
	(0.0156)		(0.000440)		(0.00268)		
CRSP(t-2)	0.0552***	INTRA	-0.000335	1981 Dummy	0.0101**		
	(0.0143)		(0.00185)		(0.00420)		
CRSP(t-3)	0.102***	INTER	0.00172	1982 Dummy	0.00766***		
	(0.0144)		(0.00163)		(0.00192)		

This table reports full results from estimating equation 1.2 with the baseline specification. Robust standard errors clustered at the state-level are in parentheses. * indicates statistical significance at the 10% level. ** indicates statistical significance at the 5% level. *** indicates statistical significance at the 1% level.

Table 1.6: Robustness: NBR Period

sum of coefficients	**(1)**	**(2)**
MP	-0.0171***	0.0239***
	(0.0022)	(0.0079)
Intra*MP	-0.0006	-0.0009
	(0.0030)	(0.0029)
Inter*MP	-0.0233**	-0.0340***
	(0.0093)	(0.0104)
NBR	-0.0048***	-0.0125***
	(0.0015)	(0.0018)
NBR*MP	-	-0.0406***
		(0.0074)
observations	823,659	823,659
STATE	Yes	Yes
NATIONAL	Yes	Yes
Bank Fixed Effects	Yes	Yes
Year Dummies	Yes	Yes

This table reports results from estimating equation 1.2 with controls for the period of non-borrowed reserve (NBR) targeting from 1979-1982. Column (1) includes a dummy variable equalling 1 for quarters during the NBR regime and equalling 0 otherwise. Column (2) includes the NBR dummy and an interaction between the dummy and the monetary policy indicator. Robust standard errors clustered at the state-level are in parentheses. * indicates statistical significance at the 10% level. ** indicates statistical significance at the 5% level. *** indicates statistical significance at the 1% level.

Table 1.7: Impact on Loan Pricing Response to Monetary Policy

Dependent variable: Avg Loan Rate				
	1976-1994		**1983-1994**	
sum of coefficients	(1)	(2)	(3)	(4)
MP	0.0069***	-	0.0074	-
	(0.0008)		(0.0046)	
Intra*MP	0.0006	0.0005	0.0080***	0.0081***
	(0.0021)	(0.0011)	(0.0023)	-0.0014
Inter*MP	0.0113***	0.0047**	0.0055*	0.0036**
	(0.0020)	(0.0018)	(0.0028)	(0.0016)
observations	822,792	822,792	494,975	494,975
STATE	Yes	Yes	Yes	Yes
NATIONAL	Yes	-	Yes	-
Bank Fixed Effects	Yes	Yes	Yes	Yes
Year Dummies	Yes	-	Yes	-
Time Fixed Effects	-	Yes	-	Yes

This table reports results from estimating equation 1.2 with average loan rate as the dependent variable. Columns (1) and (2) report results for the full sample with missing Q1 and Q3 observations filled for 1976-1982. Columns (3) and (4) report reports with an abbreviated sample for robustness. Robust standard errors clustered at the state-level are in parentheses. * indicates statistical significance at the 10% level. ** indicates statistical significance at the 5% level. *** indicates statistical significance at the 1% level.

Table 1.8: Impact on Lending Response: by Bank Size

By bank size						
	Small Banks		**Large Banks**		**Foreign Banks**	
sum of coefficients	(1)	(2)	(3)	(4)	(5)	(6)
MP	-0.0202***	-	-0.0216***	-	0.0157	-
	(0.0022)		(0.0037)		(0.0644)	
Intra*MP	0.0001	-0.0005	-0.0056	-0.0058*	-0.0997***	-0.0940***
	(0.0033)	(0.0032)	(0.0034)	(0.0032)	(0.0231)	(0.0252)
Inter*MP	-0.0212**	-0.0439***	-0.0092	-0.0081	-0.0467	-0.0417
	(0.0093)	(0.0110)	(0.0097)	(0.0131)	(0.0274)	(0.0390)
observations	787,027	787,027	36,632	36,632	12,679	12,679
STATE	Yes	Yes	Yes	Yes	Yes	Yes
NATIONAL	Yes	-	Yes	-	Yes	-
Bank Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Year Dummies	Yes	-	Yes	-	Yes	-
Time Fixed Effects	-	Yes	-	Yes	-	Yes

Panel (a) reports results from estimating equation 1.2 broken into three categories: small banks (those under the 95th percentile in total assets), large banks (those above the 95th percentile in total assets), and branches of foreign banks. Robust standard errors clustered at the state-level are in parentheses. * indicates statistical significance at the 10% level. ** indicates statistical significance at the 5% level. *** indicates statistical significance at the 1% level.

Table 1.9: Impact on Loan Pricing: by Bank Size

Dependent variable: Avg loan rate				
	Small		**Large**	
sum of coefficients	(1)	(2)	(3)	(4)
MP	0.0067***	-	0.0110***	-
	(0.0009)		(0.0014)	
Intra*MP	0.0010	0.0009	-0.0045*	-0.0045***
	(0.0022)	(0.0012)	(0.0022)	(0.0010)
Inter*MP	0.0111***	0.0042**	0.0129***	0.0011
	(0.0020)	(0.0019)	(0.0029)	(0.0020)
observations	786,207	786,207	36,585	36,585
STATE	Yes	Yes	Yes	Yes
NATIONAL	Yes	-	Yes	-
Bank Fixed Effects	Yes	Yes	Yes	Yes
Year Dummies	Yes	-	Yes	-
Time Fixed Effects	-	Yes	-	Yes

This table reports results from estimating equation 1.2 with average loan rate as the dependent variable. Columns (1) and (2) report results for small banks only (those under the 95th percentile in total assets). Columns (3) and (4) report reports for large banks only (those above the 95th percentile in total assets). Robust standard errors clustered at the state-level are in parentheses. * indicates statistical significance at the 10% level. ** indicates statistical significance at the 5% level. *** indicates statistical significance at the 1% level.

Table 1.10: Impact on Lending Response: by Bank Liquidity

All banks - by liquidity ratio quartile								
Panel (a):	**1st**		**2nd**		**3rd**		**4th**	
sum of coefficients	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
MP	-0.0194***	-	-0.0206***	-	-0.0207***	-	-0.0219***	-
	(0.0027)		(0.0027)		(0.0022)		(0.0030)	
Intra*MP	0.0064	0.0052	0.0023	0.0015	-0.0006	-0.0007	-0.0070	-0.0072**
	(0.0043)	(0.0049)	(0.0031)	(0.0030)	(0.0028)	(0.0023)	(0.0044)	(0.0036)
Inter*MP	-0.0332**	-0.0625***	-0.0200*	-0.0491***	-0.0127	-0.0259**	-0.0084	-0.0243
	(0.0128)	(0.0166)	(0.0109)	(0.0106)	(0.0090)	(0.0104)	(0.0100)	(0.0152)
observations	208,273	208,273	207,506	207,506	205,939	205,939	201,941	201,941
Small banks - by liquidity ratio quartile								
Panel (b):	**1st**		**2nd**		**3rd**		**4th**	
sum of coefficients	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
MP	-0.0196***	-	-0.0207***	-	-0.0208***	-	-0.0215***	-
	(0.0027)		(0.0027)		(0.0022)		(0.0033)	
Intra*MP	0.0067	0.0055	0.0025	0.0017	0.0007	0.0005	-0.00072	-0.0076*
	(0.0044)	(0.0048)	(0.0033)	(0.0030)	(0.0029)	(0.0024)	(0.0051)	(0.0038)
Inter*MP	-0.0340***	-0.0635***	-0.0200*	-0.0502***	-0.0121	-0.0257**	-0.0095	-0.0267*
	(0.0125)	(0.0172)	(0.0110)	(0.0106)	(0.0094)	(0.0107)	(0.0104)	(0.0151)
observations	204,559	204,559	201,126	201,126	195,307	195,307	186,035	186,035
Large banks - by liquidity ratio quartile								
Panel (c):	**1st**		**2nd**		**3rd**		**4th**	
sum of coefficients	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
MP	-0.0106	-	-0.0212***	-	-0.0195***	-	-0.0261***	-
	(0.0198)		(0.0073)		(0.0053)		(0.0054)	
Intra*MP	0.015	0.0115	0.0025	0.0033	-0.0111***	-0.0109***	-0.0044	-0.0048
	(0.0181)	(0.0168)	(0.0074)	(0.0072)	(0.0037)	(0.0034)	(0.0059)	(0.0041)
Inter*MP	-0.0308	-0.0460	-0.0169	0.0138	0.0018	0.0173	-0.0053	-0.0253
	(0.0311)	(0.0538)	(0.0234)	(0.0228)	(0.0120)	(0.0112)	(0.0157)	(0.0225)
observations	3,714	3,714	6,380	6,380	10,362	10,362	15,906	15,906
STATE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
NATIONAL	Yes	-	Yes	-	Yes	-	Yes	-
Bank Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year Dummies	Yes	-	Yes	-	Yes	-	Yes	-
Time Fixed Effects	-	Yes	-	Yes	-	Yes	-	Yes

Panel (a) reports results from separately estimating equation 1.2 for all banks that fall into the 1st, 2nd, 3rd, and 4th quartiles of liquidity ratio within a given quarter. Panel (b) reports results for small banks only and panel (c) reports results for large banks only. Liquidity ratio is measured as total cash and reserves divided by total liabilities. Robust standard errors clustered at the state-level are in parentheses. * indicates statistical significance at the 10% level. ** indicates statistical significance at the 5% level. *** indicates statistical significance at the 1% level.

Table 1.11: Impact on Lending Response: by Bank Capitalization

	All banks - by equity ratio quartile							
Panel (a)	**1st**		**2nd**		**3rd**		**4th**	
sum of coefficients	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
MP	-0.0206***	-	-0.0190***	-	-0.0211***	-	-0.0200***	-
	(0.0025)		(0.0021)		(0.0029)		(0.0035)	
Intra*MP	-0.0009	-0.0009	0.0015	0.0008	-0.0032	-0.0037	0.0035	0.0026
	(0.0034)	(0.0028)	(0.0035)	(0.0034)	(0.0042)	(0.0033)	(0.0031)	(0.0039)
Inter*MP	-0.0219*	-0.0427***	-0.0235**	-0.0414***	-0.0134	-0.0354***	-0.0096	-0.0369**
	(0.0113)	(0.0109)	(0.0104)	(0.0108)	(0.0099)	(0.0117)	(0.0109)	(0.0165)
observations	204,740	204,740	208,100	208,100	209,731	209,731	201,088	201,088
	Small banks - by equity ratio quartile							
Panel (b):	**1st**		**2nd**		**3rd**		**4th**	
sum of coefficients	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
MP	-0.0201***	-	-0.0189***	-	-0.0213***	-	-0.0200***	-
	(0.0027)		(0.0021)		(0.0029)		(0.0035)	
Intra*MP	-0.0014	-0.0017	0.0023	0.0018	-0.0020	-0.0025	0.0041	0.0032
	(0.0036)	(0.0029)	(0.0038)	(0.0034)	(0.0045)	(0.0034)	(0.0032)	(0.0040)
Inter*MP	-0.0211*	-0.0480**	-0.0250**	-0.0427***	-0.0142	-0.0359***	-0.0111	-0.0381**
	(0.0120)	(0.0103)	(0.0101)	(0.0107)	(0.0099)	(0.0118)	(0.0104)	(0.0165)
observations	181,399	181,399	200,779	200,779	206,024	206,024	198,825	198,825
	Large banks - by equity ratio quartile							
Panel (c):	**1st**		**2nd**		**3rd**		**4th**	
sum of coefficients	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
MP	-0.0251***	-	-0.0251**	-	-0.0149	-	-0.0242	-
	(0.0038)		(0.0095)		(0.0135)		(0.0376)	
Intra*MP	-0.0009	-0.0007	-0.0056	-0.0064	-0.0285**	-0.0278***	-0.0111	-0.0141
	(0.0048)	(0.0040)	(0.0051)	(0.0064)	(0.0116)	(0.0078)	(0.0098)	(0.0136)
Inter*MP	-0.0182*	-0.0034	0.0120	0.0004	-0.0021	-0.0067	0.0603	-0.0166
	(0.0094)	(0.0129)	(0.0243)	(0.0307)	(0.0250)	(0.0398)	(0.0511)	(0.0731)
observations	23,341	23,341	7,321	7,321	3,707	3,707	2,263	2,263
STATE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
NATIONAL	Yes	-	Yes	-	Yes	-	Yes	-
Bank Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year Dummies	Yes	-	Yes	-	Yes	-	Yes	-
Time Fixed Effects	-	Yes	-	Yes	-	Yes	-	Yes

Panel (a) reports results from separately estimating equation 1.2 for all banks that fall into the 1st, 2nd, 3rd, and 4th quartiles of equity ratio within a given quarter. Panel (b) reports results for small banks only and panel (c) reports results for large banks only. Equity ratio is measured as total equity divided by total assets. Robust standard errors clustered at the state-level are in parentheses. * indicates statistical significance at the 10% level. ** indicates statistical significance at the 5% level. *** indicates statistical significance at the 1% level.

Table 1.12: Market Structure

Panel (a)	Effect of deregulation on market structure		
Dependent Variable:	**Lerner Index**	**County HHI**	**State HHI**
Intra	-0.0020	0.0181***	-0.0055
	(0.0021)	(0.0018)	(0.0106)
Inter	0.0043*	0.0079***	-0.0193*
	(0.0023)	(0.0020)	(0.0104)
observations	853,404	857,525	3,825
State Fixed Effects	-	Yes	Yes
Bank Fixed Effects	Yes	-	-
Time Fixed Effects	Yes	Yes	Yes

Panel (b)	Dependent variable: real loan growth					
sum of coefficients	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**
MP	-0.0291***	-0.0287***	-0.0204***	-0.0200***	-0.0197***	-0.0193***
	(0.0034)	(0.0034)	(0.0020)	(0.0024)	(0.0023)	(0.0025)
LI*MP	0.0243***	0.0253***	-	-	-	-
	(0.0084)	(0.0081)				
County_HHI*MP	-	-	-0.0019	-0.0012	-	-
			(0.0031)	(0.0031)		
State_HHI*MP	-	-	-	-	-0.0272	-0.0245
					(0.0200)	(0.0203)
Inter*MP	-	-0.0206**	-	-0.0205**	-	-0.0199**
		(0.0085)		(0.0085)		(0.0085)
observations	819,992	819,992	823,659	823,659	823,659	823,659
STATE	Yes	Yes	Yes	Yes	Yes	Yes
NATIONAL	Yes	Yes	Yes	Yes	Yes	Yes
Bank Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Year Dummies	Yes	Yes	Yes	Yes	Yes	Yes

Panel (a) reports the effect of deregulation on the three bank market structure variables: Lerner index (proxy for market power), county-level HHI (concentration), and state-level HHI (concentration). Panel (b) reports results from estimating equation 1.7 with the three bank market structure variables. Odd columns include the interaction between the bank market structure and monetary policy only. Even columns include the interaction between interstate deregulation and monetary policy as well. Robust standard errors clustered at the state-level are in parentheses. * indicates statistical significance at the 10% level. ** indicates statistical significance at the 5% level. *** indicates statistical significance at the 1% level.

Table 1.13: Impact on Lending Response: by Bank Market Power

	All banks - by lerner index quartile							
Panel (a):	**1st**		**2nd**		**3rd**		**4th**	
sum of coefficients	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
MP	-0.0184***	-	-0.0201***	-	-0.0214***	-	-0.0211***	-
	(0.0025)		(0.0025)		(0.0027)		(0.0032)	
Intra*MP	0.0027	0.0021	0.0015	0.0013	0.0006	0.0000	-0.0049	-0.0055
	(0.0038)	(0.0040)	(0.0037)	(0.0031)	(0.0030)	(0.0039)	(0.0036)	(0.0033)
Inter*MP	-0.0235*	-0.0537***	-0.0197**	-0.0355***	-0.0066	-0.0271**	-0.0160	-0.0405***
	(0.0129)	(0.0130)	(0.0075)	(0.0123)	(0.0080)	(0.0107)	(0.0122)	(0.0143)
observations	202,018	202,018	207,650	207,650	207,048	207,048	206,943	206,943
	Small banks - by lerner index quartile							
Panel (b):	**1st**		**2nd**		**3rd**		**4th**	
sum of coefficients	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
MP	-0.0182***	-	-0.0199***	-	-0.0211***	-	-0.0216***	-
	(0.0025)		(0.0025)		(0.0028)		(0.0033)	
Intra*MP	0.0028	0.0022	0.0018	0.0016	0.0003	-0.0004	-0.0027	-0.0034
	(0.0040)	(0.0042)	(0.0038)	(0.0033)	(0.0032)	(0.0042)	(0.0041)	(0.0031)
Inter*MP	-0.0246*	-0.0567***	-0.0200***	-0.0363***	-0.0065	-0.0286***	-0.0180	-0.0434***
	(0.0129)	(0.0132)	(0.0075)	(0.0124)	(0.0082)	(0.0108)	(0.0125)	(0.0150)
observations	199,197	199,197	202,937	202,937	199,059	199,059	185,843	185,843
	Large banks - by lerner index quartile							
Panel (c):	**1st**		**2nd**		**3rd**		**4th**	
sum of coefficients	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
MP	-0.0300**	-	-0.0304***	-	-0.0306***	-	-0.0177***	-
	(0.0142)		(0.0093)		(0.0059)		(0.0064)	
Intra*MP	0.0094	0.0084	-0.0020	-0.0020	0.0100*	0.0101**	-0.0172***	-0.0172**
	(0.0088)	(0.0090)	(0.0066)	(0.0050)	(0.0053)	(0.0042)	(0.0052)	(0.0071)
Inter*MP	-0.0238	0.0538	-0.0206	0.0063	-0.0056	-0.0043	-0.0076	-0.0148
	(0.0667)	(0.0931)	(0.0221)	(0.0285)	(0.0129)	(0.0152)	(0.0118)	(0.0153)
observations	2,821	2,821	4,713	4,713	7,989	7,989	21,109	21,109
STATE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
NATIONAL	Yes	-	Yes	-	Yes	-	Yes	-
Bank Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year Dummies	Yes	-	Yes	-	Yes	-	Yes	-
Time Fixed Effects	-	Yes	-	Yes	-	Yes	-	Yes

This table reports results for estimating equation 1.2 across Lerner index quartile, where the 1st quartile has the lowest market power and the 4th has the highest market power. Panel (a) reports results for all banks, panel (b) reports results for small banks (below the 95th percentile in assets), and panel (c) reports results for large banks (above the 95th percentile in assets).

Table 1.14: Impact on Lending Response: by Market Concentration

	All banks - by HHI quartile							
Panel (a):	**1st**		**2nd**		**3rd**		**4th**	
sum of coefficients	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
MP	-0.0202***	-	-0.0178***	-	-0.0194***	-	-0.0232***	-
	(0.0030)		(0.0033)		(0.0022)		(0.0026)	
Intra*MP	0.0155	0.0129**	-0.0037	-0.0038	-0.0227	-0.0034	0.0018	0.0013
	(0.0091)	(0.0064)	(0.0032)	(0.0041)	(0.0042)	(0.0035)	(0.0026)	(0.0031)
Inter*MP	-0.0154	-0.0264*	-0.0205***	-0.0411**	-0.0207**	-0.0448***	-0.0210*	-0.0406***
	(0.0145)	(0.0148)	(0.0068)	(0.0182)	(0.0101)	(0.0133)	(0.0107)	(0.0130)
observations	204,761	204,761	206,920	206,920	206,337	206,337	205,641	205,641
	Small banks - by HHI quartile							
Panel (b):	**1st**		**2nd**		**3rd**		**4th**	
sum of coefficients	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
MP	-0.0196***	-	-0.0178***	-	-0.0191***	-	-0.0238***	-
	(0.0030)		(0.0035)		(0.0023)		(0.0026)	
Intra*MP	0.0111	0.0122*	-0.0025	-0.0026	-0.0021	-0.0030	0.0021	0.0015
	(0.0089)	(0.0071)	(0.0037)	(0.0040)	(0.0046)	(0.0036)	(0.0028)	(0.0031)
Inter*MP	-0.0162	-0.0307*	-0.0176***	-0.0373**	-0.0207**	-0.0457***	-0.0224**	-0.0430***
	(0.0147)	(0.0156)	(0.0065)	(0.0184)	(0.0103)	(0.0132)	(0.0108)	(0.0132)
observations	196,482	196,482	197,437	197,437	196,086	196,086	197,022	197,022
	Large banks - by HHI quartile							
Panel (c):	**1st**		**2nd**		**3rd**		**4th**	
sum of coefficients	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
MP	-0.0228***	-	-0.0258***	-	-0.0262***	-	-0.0099	-
	(0.0080)		(0.0064)		(0.0052)		(0.0094)	
Intra*MP	0.0008	0.0011	0.0018	0.0019	-0.0068	-0.0067	-0.0030	-0.0036
	(0.0187)	(0.0142)	(0.0071)	(0.0071)	(0.0045)	(0.0044)	(0.0091)	(0.0046)
Inter*MP	-0.0099	-0.0038	-0.0312	-0.0233	-0.0226	-0.0157	-0.0126	-0.0165
	(0.0378)	(0.0516)	(0.0200)	(0.0268)	(0.0142)	(0.0145)	(0.0158)	(0.0101)
observations	8,279	8,279	9,483	9,483	10,251	10,251	8,619	8,619
STATE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
NATIONAL	Yes	-	Yes	-	Yes	-	Yes	-
Bank Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year Dummies	Yes	-	Yes	-	Yes	-	Yes	-
Time Fixed Effects	-	Yes	-	Yes	-	Yes	-	Yes

This table reports results for estimating equation 1.2 across county-level HHI quartile, where the 1st quartile has the lowest market concentration and the 4th has the highest market concentration. Panel (a) reports results for all banks, panel (b) reports results for small banks (below the 95th percentile in assets), and panel (c) reports results for large banks (above the 95th percentile in assets).

Table 1.15: Loan Portfolio Composition

Effect of deregulation on category share of total loans			
Panel (a)			
	C&I Share	**RE Share**	**Con Share**
Intra	-0.0043***	-0.0060***	0.0017
	(0.0008)	(0.0020)	(0.0015)
Inter	-0.0064***	-0.0174***	0.0037*
	(00013)	(0.0023)	(0.0022)
observations	857,525	857,525	857,525
BANK	Yes	Yes	Yes
STATE	Yes	Yes	Yes
Bank Fixed Effects	Yes	Yes	Yes
Time Fixed Effects	Yes	Yes	Yes

By loan category						
Panel (b)						
	C&I Loans		**Real Estate Loans**		**Consumer Loans**	
sum of coefficients	(1)	(2)	(3)	(4)	(5)	(6)
MP	-0.0225***	-	-0.0158***	-	-0.0379***	-
	(0.0043)		(0.0031)		(0.0029)	
Intra*MP	-0.0141**	-0.0152***	0.0024	0.0012	0.0020	0.0007
	(0.0070)	(0.0055)	(0.0038)	(0.0030)	(0.0037)	(0.0045)
Inter*MP	-0.0230	-0.0434**	-0.0104	-0.0401***	0.0046	-0.0365***
	(0.0189)	(0.0194)	(0.0088)	(0.0102)	(0.0104)	(0.0127)
observations	737,753	737,753	795,076	795,076	778,630	778,630
STATE	Yes	Yes	Yes	Yes	Yes	Yes
NATIONAL	Yes	-	Yes	-	Yes	-
Bank Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Year Dummies	Yes	-	Yes	-	Yes	-
Time Fixed Effects	-	Yes	-	Yes	-	Yes

Panel (a) reports the effect of deregulation on the share of total loans for each of the three major loan categories: commercial and industrial loans, real estate loans, and consumer loans. Panel (b) reports results from estimating equation 1.2 for the three loan categories. Robust standard errors clustered at the state-level are in parentheses. * indicates statistical significance at the 10% level. ** indicates statistical significance at the 5% level. *** indicates statistical significance at the 1% level.

Table 1.16: Impact on Lending Response: by BHC Affiliation

All banks - by BHC affiliation				
Panel (a)	**Stand Alone**		**Affiliated**	
sum of coefficients	(1)	(2)	(3)	(4)
MP	-0.0236***	-	-0.0151***	-
	(0.0020)		(0.0026)	
Intra*MP	0.0004	0.0003	-0.0018	-0.0032
	(0.0026)	(0.0026)	(0.0057)	(0.0047)
Inter*MP	-0.0057	-0.0252**	-0.0269***	-0.0516***
	(0.0098)	(0.0125)	(0.0098)	(0.0125)
observations	376,569	376,569	447,090	447,090
Small banks - by BHC affiliation				
Panel (b):	**Stand Alone**		**Affiliated**	
sum of coefficients	(1)	(2)	(3)	(4)
MP	-0.0236***	-	-0.0149***	-
	(0.0020)		(0.0028)	
Intra*MP	0.0004	0.0003	-0.00003	-0.0022
	(0.0026)	(0.0027)	(0.0072)	(0.0054)
Inter*MP	-0.0053	-0.0253**	-0.0283***	-0.0548***
	(0.0100)	(0.0126)	(0.0099)	(0.0125)
observations	370,452	370,452	416,575	416,575
Large banks - by BHC affiliation				
Panel (c):	**Stand Alone**		**Affiliated**	
sum of coefficients	(1)	(2)	(3)	(4)
MP	-0.0172	-	-0.0207***	-
	(0.0116)		(0.0040)	
Intra*MP	-0.0018	-0.0023	-0.0062*	-0.0063
	(0.0067)	(0.0037)	(0.0033)	(0.0042)
Inter*MP	-0.0394	-0.0389*	-0.0055	-0.0049
	(0.0266)	(0.0223)	(0.0114)	(0.0144)
observations	6,117	6,117	30,515	30,515
STATE	Yes	Yes	Yes	Yes
NATIONAL	Yes	-	Yes	-
Bank Fixed Effects	Yes	Yes	Yes	Yes
Year Dummies	Yes	-	Yes	-
Time Fixed Effects	-	Yes	-	Yes

Panel (a) reports results from separately estimating equation 1.2 for stand alone banks and banks affiliated with a BHC. Panel (b) reports results for small banks only and panel (c) reports results for large banks. A bank is affiliated with a BHC if they have a direct or regulatory holder identification number in a given quarter. * indicates statistical significance at the 10% level. ** indicates statistical significance at the 5% level. *** indicates statistical significance at the 1% level.

Table 1.17: Impact on Lending Response: by Size, Liquidity, and BHC Affiliation

Dependent Variable: Real Loan Growth				
Panel (a):	Small, BHC Affiliated - by liquidity ratio quartile			
Quartile:	**1st**	**2nd**	**3rd**	**4th**
Inter*MP	-0.0780***	-0.0683***	-0.0318**	-0.0235
	(0.0241)	(0.0124)	(0.0141)	(0.0169)
observations	110,076	106,942	103,685	95,872
Panel (b):	Small, Stand Alone - by liquidity ratio quartile			
Quartile:	**1st**	**2nd**	**3rd**	**4th**
Inter*MP	-0.0395***	-0.0143	-0.0132	-0.0265
	(0.0139)	(0.0119)	(0.0132)	(0.0181)
observations	94,483	94,184	91,622	90,163
Panel (c):	Large, BHC Affiliated - by liquidity ratio quartile			
Quartile:	**1st**	**2nd**	**3rd**	**4th**
Inter*MP	-0.0015	0.0260	0.0178	-0.0263
	(0.0586)	(0.0223)	(0.0131)	(0.0219)
observations	3,045	5,057	8,615	13,798
Panel (d):	Large, Stand Alone - by liquidity ratio quartile			
Quartile:	**1st**	**2nd**	**3rd**	**4th**
Inter*MP	-0.0820	-0.1319*	0.0562	-0.0221
	(0.2522)	(0.0774)	(0.0506)	(0.0561)
observations	669	1,323	2,017	2,108
Bank Fixed Effects	Yes	Yes	Yes	Yes
Time Fixed Effects	Yes	Yes	Yes	Yes

This table reports results from estimating equation 1.2 by bank liquidity ratio quartile, with the 1st quartile being the least liquid and the 4th quartile being the most liquid. Panel (a) reports results for small banks affiliated with a bank holding company. Panel (b) reports results for small, stand alone banks. Panel (c) reports results for large banks affiliated with a bank holding company. Panel (d) reports results for large, stand alone banks.

Table 1.18: Balance Sheet Adjustment: by Size, Liquidity, and BHC Affiliation

Dependent Variable: Asset Growth				
Panel (a):	Small, BHC Affiliated - by liquidity ratio quartile			
Quartile:	**1st**	**2nd**	**3rd**	**4th**
Inter*MP	-0.0165*	-0.0168*	-0.0253**	0.0197*
	(0.0093)	(0.0093)	(0.0100)	(0.0108)
Panel (b):	Small, Stand Alone - by liquidity ratio quartile			
Quartile:	**1st**	**2nd**	**3rd**	**4th**
Inter*MP	-0.0129	-0.0110	-0.0012	-0.0127
	(0.0111)	(0.0121)	(0.0124)	(0.0154)
Dependent Variable: Securities Growth				
Panel (c):	Small, BHC Affiliated - by liquidity ratio quartile			
Quartile:	**1st**	**2nd**	**3rd**	**4th**
Inter*MP	0.0617*	0.0698**	-0.0626**	0.0773*
	(0.0371)	(0.0283)	(0.0298)	(0.0456)
Panel (d):	Small, stand alone - by liquidity ratio quartile			
Quartile:	**1st**	**2nd**	**3rd**	**4th**
Inter*MP	0.0161	-0.0368	0.0037	0.0456
	(0.0371)	(0.0403)	(0.0397)	(0.0448)
Bank Fixed Effects	Yes	Yes	Yes	Yes
Time Fixed Effects	Yes	Yes	Yes	Yes

Panels (a) and (b) reports results from estimating equation 1.2 with asset growth as the dependent variable. Panel (a) reports results for small banks affiliated with a BHC. Panel (b) reports results for small, stand alone banks. Panels (c) and (d) reports results from estimating equation 1.2 with securities growth as the dependent variable. Panel (c) reports results for small banks affiliated with a BHC. Panel (d) reports results for small, stand alone banks. The sample is split by liquidity quartile, with the 1st quartile including the least liquid banks and the 4th quartile including the most liquid.

Table 1.19: Share of National Lending

Share of Total Loans (National)			
	Whole Sample	1976 - 1985	1986 - 1994
Small Affiliated	0.16	0.13	0.18
Small Stand Alone	0.12	0.16	0.08
Large Affiliated	0.61	0.60	0.62
Large Stand Alone	0.11	0.11	0.12

This table reports the share of total loans at the national level for four categories of banks: small banks (below the 95th percentile in assets) affiliated with a bank holding company (BHC), small stand alone banks, large banks (above the 95th percentile in assets) affiliated with a BHC, and large stand alone banks. Column 1 presents average share for the entire sample (1976-1994), column 2 presents average share for the early part of the sample (when the majority of states had not deregulated), and column 3 presents average share for the later part of the sample (when the majority of states had deregulated).

Table 1.20: Impact on Loan Growth Response: State-Level Results

State-Level Results			
sum of coefficients	**All Banks**	**Small Affiliated**	**Small Stand Alone**
Intra*MP	0.0047	-0.0162	0.0241
	(0.0090)	(0.0259)	(0.0266)
Inter*MP	-0.0189	-0.0801*	0.1372
	(0.0399)	(0.0424)	(0.1092)
observations	3,621	3,539	3,621
	Large Affiliate	**Large Stand Alone**	
Intra*MP	0.0386	-0.0613	
	(0.0300)	(0.0617)	
Inter*MP	-0.0174	0.1382	
	(0.0536)	(0.1206)	
observations	3,367	1,639	
State Fixed Effects	Yes	Yes	Yes
Time Fixed Effects	Yes	Yes	Yes

This table reports results from estimating equation 1.2 with data aggregated at the state-level. The dependent variables for each respective column are real loan growth for all loans within a state, real loan growth for all small BHC affiliated banks within a state, real loan growth for all small stand alone banks within a state, real loan growth for all large BHC affiliated banks within a state, and real loan growth for all large stand alone banks within a state.

Figure 1.1: Monetary Policy Shock Series

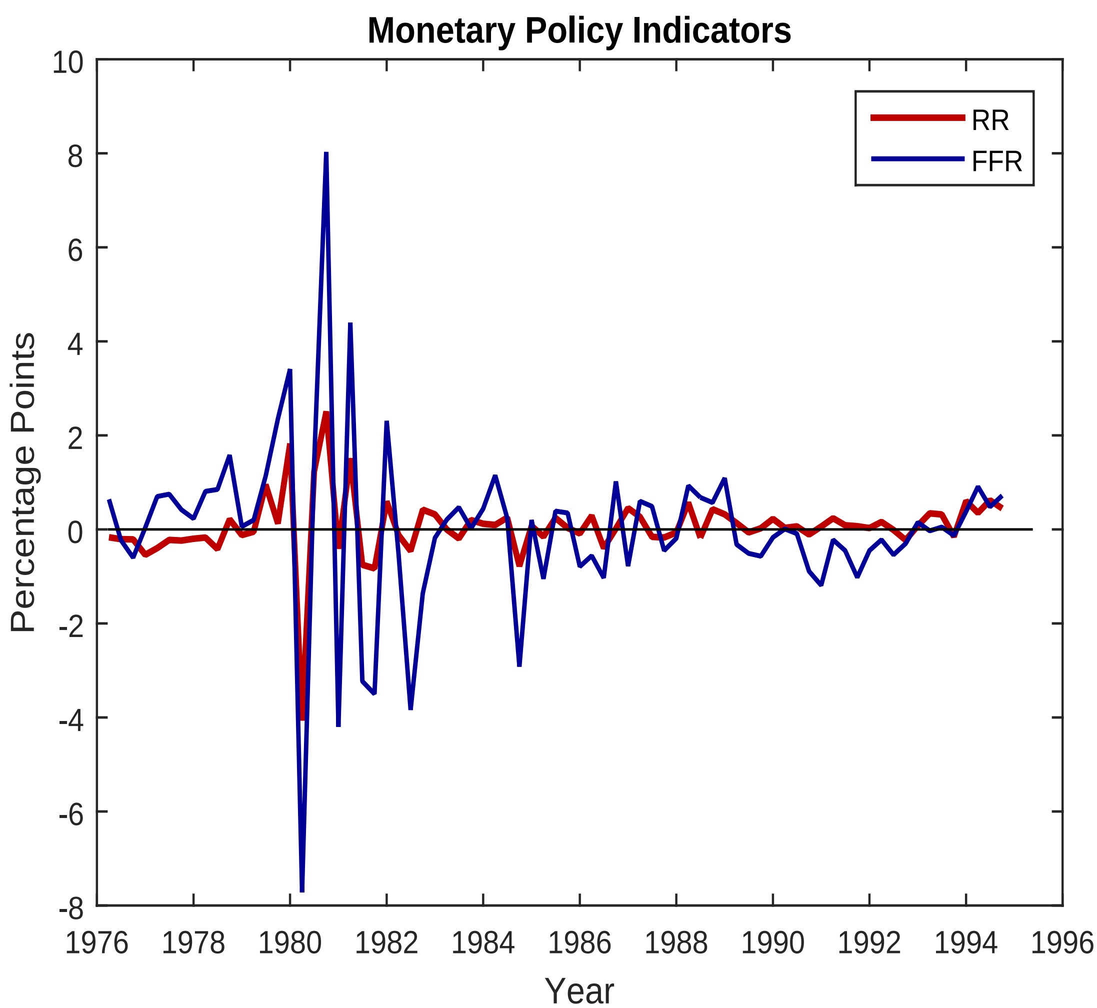


Figure 1.2: Real Loan Growth

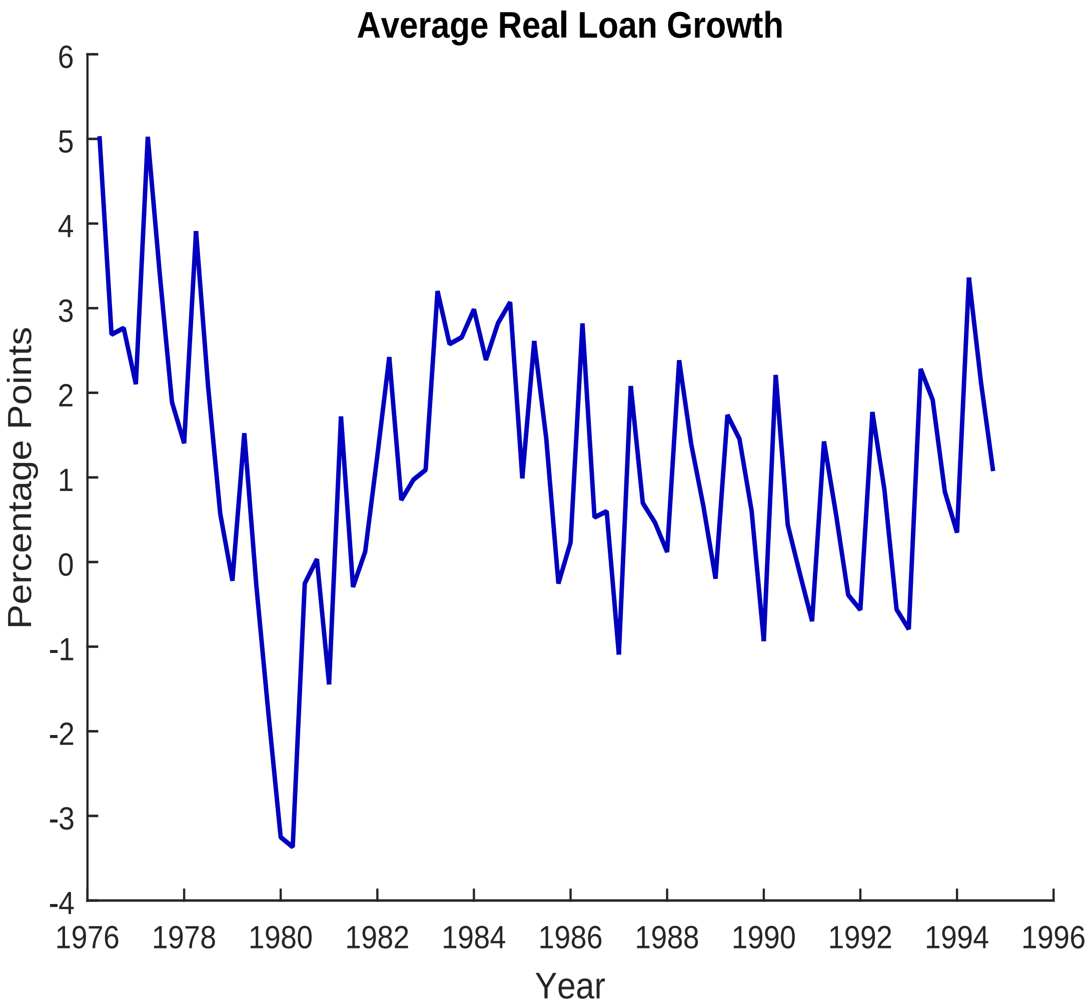


Figure 1.3: Bank Credit to Total Private U.S. Credit

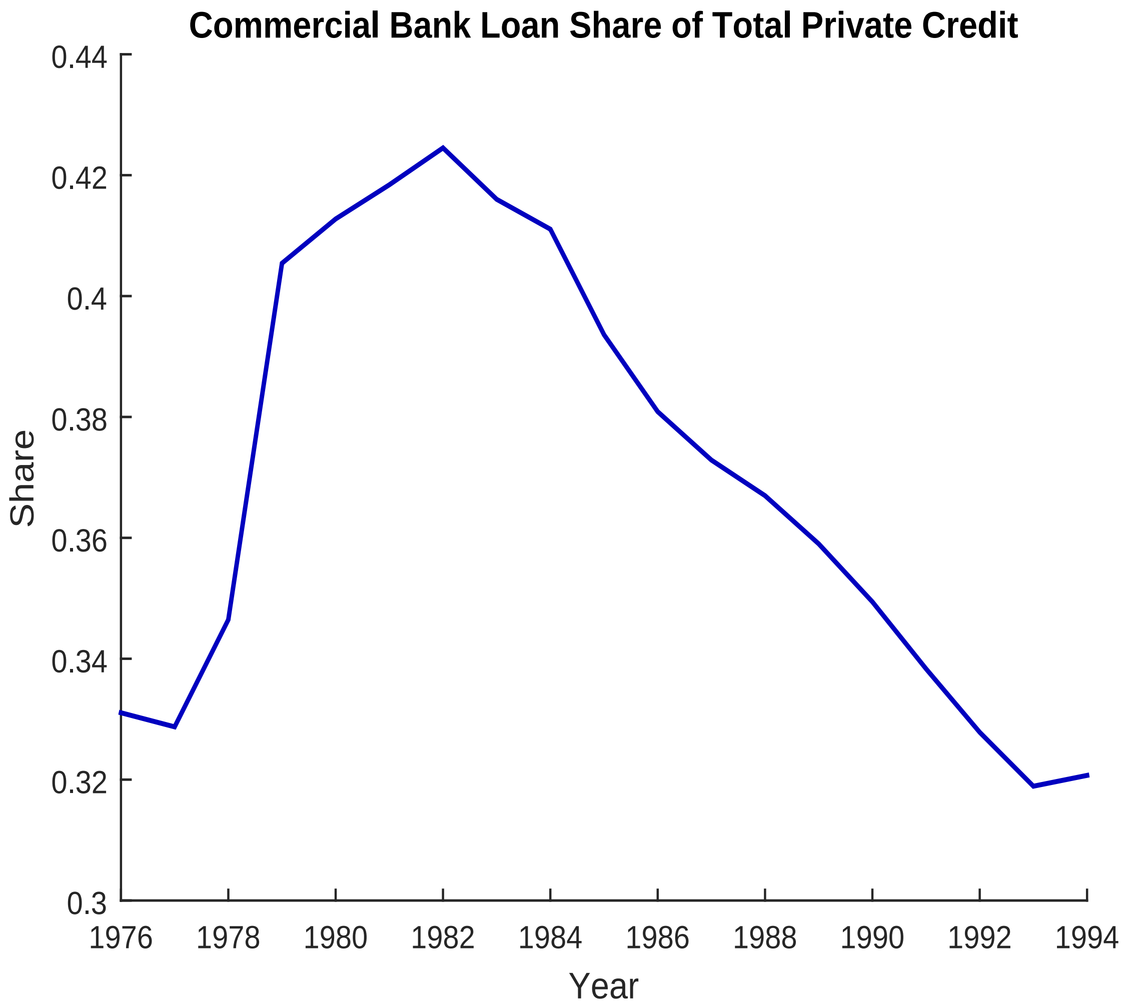


Figure 1.4: Average Loan Rate

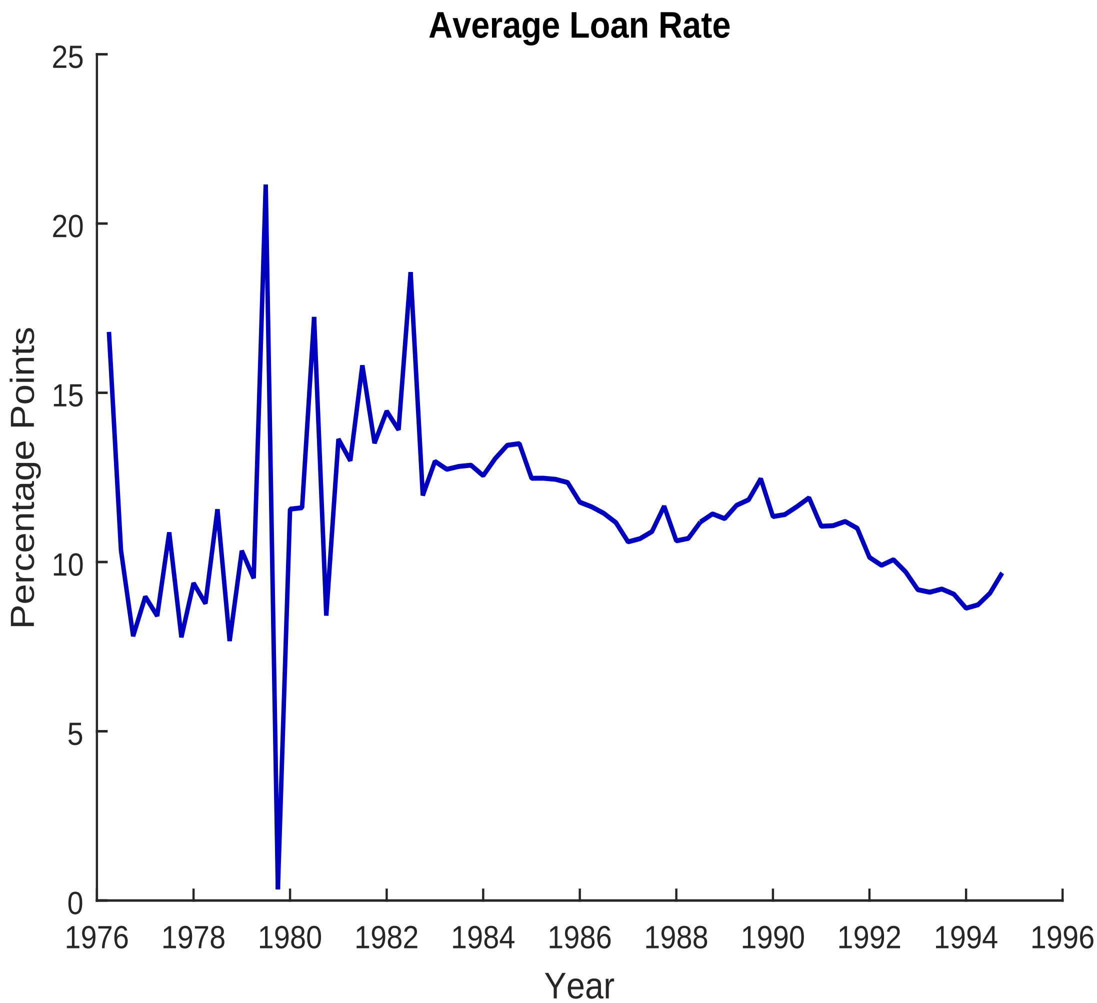
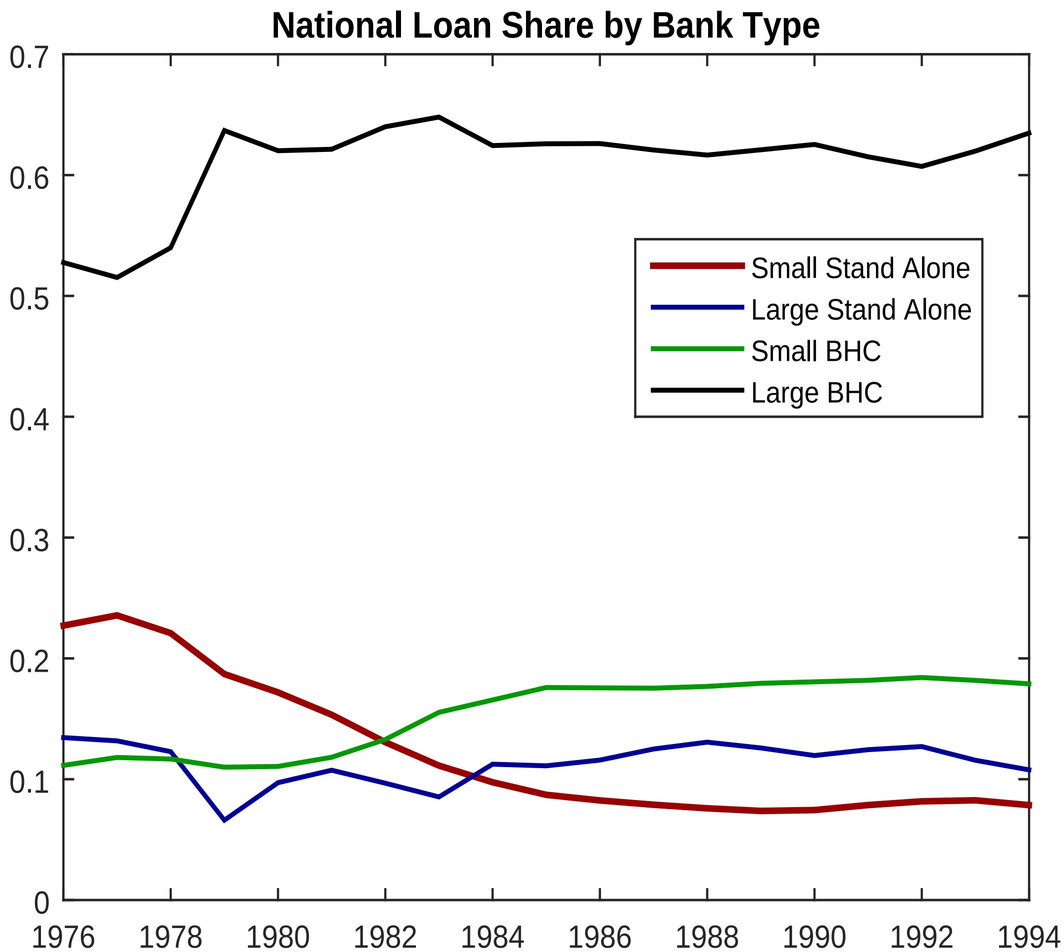


Figure 1.5: Bank Type Share of National Lending



CHAPTER 2

FEDERAL RESERVE PRIVATE INFORMATION AND THE STOCK MARKET

Joint work with Aeimit Lakdawala

2.1 Introduction

Uncovering the nature of the monetary policy transmission mechanism continues to be an important issue in macroeconomics. The large body of literature on this topic has identified a variety of channels through which monetary policy can affect the economy. However recent research has emphasized a new so-called “Fed Information" channel whereby a signal from the central bank that reveals information about economic fundamentals can affect agents’ expectations and thus the economy (see for example Campbell, Fisher, Justiniano, and Melosi (2016) and Nakamura and Steinsson (2017)). In this paper we aim to shed light on this Fed information effect through the lens of the stock market. Specifically, we study how the stock market responds to monetary policy by explicitly separating exogenous shocks from shocks that reveal information about economic activity (labeled “Delphic" shocks following Campbell, Evans, Fisher, and Justiniano (2012)). We focus on the stock market reaction as it is an important component of the overall monetary policy transmission mechanism which can drive economic activity by affecting wealth, cost of capital and overall expectations.

We build on the framework of Bernanke and Kuttner (2005) (BK henceforth) and use an identification strategy based on high-frequency futures market data. Since stock prices should not react to policy changes that are already anticipated, changes in futures prices that occur in a narrow window around the Federal Open Market Committee (FOMC) announcements are used to construct a measure of monetary policy surprise. Given the growing importance of Federal Reserve communication,[1] we extend the federal funds target rate based monetary policy surprise used by

[1] For early work on the importance of Federal Reserve communication see Gürkaynak, Sack,

BK to also include any communication about unexpected future changes in monetary policy. This is done using an extended set of futures data with a variety of maturities, starting from the current month up to 4 quarters ahead.

Our estimation methodology proceeds in two steps. First, we decompose the futures based monetary policy surprise measure into an exogenous component and a Delphic component. In carrying out this decomposition we take the view that Federal Reserve signals about economic activity should surprise the futures market only if they reveal any private information that the Federal Reserve possesses. This private information could arise either due to asymmetric information underlying the forecasts or due to a difference in forecasting models. It is important to point out that our framework does not require that the Federal Reserve actually has superior information relative to the market (*à* la Romer and Romer (2000)). In other words, even in a hypothetical case where the market knows its forecast is more accurate, the Federal Reserve's forecast may be useful to the market since policy actions will be based on that forecast.

To capture this private information we construct a measure that combines market survey data with the Federal Reserve's internal forecasts. Specifically, our measure is defined as the difference between the Greenbook forecasts produced by the Federal Reserve Board's staff and the consensus forecast from the market based Blue Chip survey. The first step involves running a regression of monetary policy surprise on our measure of private information. The regression results suggest that monetary policy surprises are "predictable" using the private information variable. Moreover, the estimates imply that when the Greenbook forecast is more optimistic relative to the market's forecast, it is related to a positive monetary policy surprise (i.e. a contractionary surprise). Note that this regression can only be run ex-post and not in real-time as the Greenbook forecasts are publicly released with a five year lag. But the statistically significant and systematic relationship between the monetary policy surprise and Federal Reserve private information suggests that a portion of the futures market reaction is attributable to differences in forecasts.[2]

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and Swanson (2005). For a more recent study see Feroli, Greenlaw, Hooper, Mishkin, and Sufi (2017).

[2]We would like to point out that our measure of private information may not perfectly capture

The second step in our estimation involves studying the stock market response to the fitted value (i.e. Delphic component) and the residual (clean measure of an exogenous monetary policy shock) of the first step regression. We layout a simple conceptual framework to understand how exogenous and Delphic shocks can affect stock prices differently. Under some simple conditions, the stock response to an exogenous shock is expected to be negative, while that of the Delphic shock can be either positive or negative. Our baseline results using data from 1991 to 2011 find a stock response to the exogenous monetary policy shock that is similar to BK.[3] A hypothetical surprise increase of 100 basis points in the expected path of the fed funds rate over the next 4 quarters results in about a 5.7% fall in the S&P 500 index. On the other hand, a contractionary Delphic shock of the same size reduces stock prices by about 2.1%; a statistically significant difference relative to the exogenous monetary policy shock response. Thus, on average stock prices fall in response to surprise contractionary shocks, whether they are exogenous or Delphic in nature. But we also find some evidence for an asymmetry in the stock response on certain FOMC meetings, especially concerning Delphic shocks. These episodes occur when FOMC policy actions were enacted at unscheduled dates (also called inter-meeting moves) or when there is a reversal in the direction of the change in the fed funds rate target (also called turning points). On these particular FOMC meetings, the stock market falls more in response to a contractionary exogenous monetary policy shock but actually *rises* in response to a contractionary Delphic shock. Previous studies have found differential effects of monetary policy shocks on unscheduled FOMC meetings (BK and Faust, Swanson, and Wright (2004a) among others). Our results suggest that this is partly due to the Delphic component of the monetary policy surprise at these meetings that has been previously unexplored in the literature.

To complement our high-frequency analysis and to understand the economic reasons behind the observed stock price response, we perform a decomposition of stock prices using the framework

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the true underlying information differences. We would like to observe both the FOMC members' and the market's macro forecasts closer to the FOMC announcement (ideally just a few minutes before the announcement). Unfortunately, data at this frequency is not available and we believe our measure using the Greenbook and Blue Chip forecasts is the best proxy based on existing data.

[3] The end date of the sample is restricted by the most recently available Greenbook data.

of Campbell and Ammer (1993). This methodology uses a monthly vector autoregression to break down current excess stock returns into revisions of the expectation of discounted future dividends, the real interest rate, and future excess returns. We find some suggestive evidence that on average the response of excess returns to exogenous shocks is mostly due to changes in expected future excess returns and dividends, while the excess return response to a Delphic shock is primarily attributed to changes in expected dividends. These vector autoregression results confirm the asymmetric effects of monetary policy actions (especially the Delphic shocks) on unscheduled and turning point FOMC meetings. The stock response to Delphic shocks on these meetings appears to be driven mostly by movements in the expected future excess returns.

This paper lies at the intersection of two distinct strands of the literature. First, there is a long line of work that builds on the high frequency approach of BK to study the effect of monetary policy on stock prices. Gürkaynak, Sack, and Swanson (2005) and more recently Kurov (2012) and Eijffinger, Mahieu, and Raes (2017) expand on this work by separately estimating the stock response to surprises to the federal funds rate and surprises in forward guidance. There has also been work exploring the cross-sectional firm level stock price reactions to monetary policy, see Gorodnichenko and Weber (2016), Ehrmann and Fratzscher (2004), Ippolito, Ozdagli, and Perez-Orive (2013), Maio (2013), Jansen and Tsai (2010) and Laeven and Tong (2012) among others. While our analysis focuses exclusively on a narrow window around FOMC meetings, there is intriguing new evidence that discusses other occasions on which the Federal Reserve communicates to the public (for example in speeches made by FOMC members). These are explored in more detail by Cieslak, Morse, and Vissing-Jorgensen (2016), Lucca and Moench (2015) and Neuhierl and Weber (2017). However, all these papers use the composite monetary policy surprise measure, while the focus of our paper is to separate the effect of Delphic monetary shocks from the exogenous monetary policy shocks. Second, this paper is also related to the growing literature on how central bank signals about fundamentals can affect economic activity. Campbell, Fisher, Justiniano, and Melosi (2016) and Nakamura and Steinsson (2017) empirically highlight the role of Delphic signals and their effect on survey expectations. Melosi (2016) and Tang (2015) provide evidence of this channel using a dynamic stochastic general equilibrium model while Lakdawala (2017) uses a structural vector autoregression framework. The stock market response results in this paper are consistent with this literature. In light of the growing evidence of the signaling channel of monetary policy, we advocate accounting for the asymmetric effects on these meetings to get the full picture of the monetary transmission mechanism.

2.2 Stock Prices and Monetary Policy

To identify the effect of monetary policy on stock prices, one cannot directly regress stock prices on the central bank's policy instrument (for example the short-term interest rate). The endogenous reaction of both stock prices and the central bank's policy instrument to common economic conditions leads to the classic simultaneous equation bias. Thus the literature has tried to isolate exogenous variation in the policy instrument to overcome this problem. Following the work of BK, an important strategy involves high-frequency identification using federal funds futures contracts. In this section we first outline a simple framework to understand futures based identification, with a special emphasis on why central bank private information can matter. This treatment is closely related to the framework laid out in Miranda-Agrippino (2016). Next we extend the framework and discuss how stock prices may respond differently to an interest rate change by the central bank depending on if the change reflects an exogenous monetary policy shock or if it reflects a signal about the central bank's private information.

2.2.1 Monetary Policy Surprise from Futures Data

Let $p_t^{(h)}$ be the price of a futures contract at time t that matures in $t + h$. The underlying asset for this futures contract is the federal funds rate.[4] Thus we can write

$$p_t^{(h)} = i_{t+h|t} + \zeta_t^{(h)} \tag{2.1}$$

[4]Note that technically the fed funds futures contract trades as 100 - the average effective fed funds rate, but we are omitting the "100 -" component for simplicity.

where $i_{t+h|t} = E_t i_{t+h}$ is the expected fed funds rate at $t + h$ and $\zeta_t^{(h)}$ is the risk-premium. There is an ongoing debate in the literature about the relevance of risk-premia in fed funds futures markets, but they are not crucial to our analysis and we will set them to zero in the illustrative model.[5]

The next step is to consider a general monetary policy rule where the central bank changes the short-term interest rate i_t in response to current, lagged and forecasts of certain indicators of economic activity.

$$i_t = g^{CB}\left(\widehat{\Omega}_{t|t}^{CB}\right) + e_t \tag{2.2}$$

where e_t represents a monetary policy shock and $g^{CB}(.)$ is the central bank's reaction function. $\widehat{\Omega}_{t|t}^{CB}$ contains the central bank information set available at time t, including any current information that is used to form forecasts. The hat denotes the fact that the central bank estimates the values of the relevant variables based on their information set.[6]

An important convention in the monetary policy literature is that e_t is assumed to be an exogenous shock, i.e. it is unrelated to economic activity. Thus if we can estimate e_t, then we can regress stock prices on e_t to identify the effects of monetary policy. One strategy for identification is to study changes in fed funds futures data around FOMC announcements, following BK.

Consider the futures contract maturing at the end of the current month (i.e. $h = 0$). Specifically, consider the futures prices of this contract measured just before the FOMC announcement

$$p_{t-\varepsilon}^{(0)} = i_{t|t-\varepsilon} = g\left(\widehat{\Omega}_{t|t}^{M}\right) \tag{2.3}$$

The M superscript denotes the fact that the futures price will reflect expectations based on the market's information set, $\widehat{\Omega}_{t|t}^{M}$. We are making the assumption that the market has full knowledge of the central bank's reaction function, i.e. $g^{CB}(.) = g^{M}(.) = g(.)$. Below, we provide an alternate derivation of our estimating equation where we relax this assumption.

[5]Piazzesi and Swanson (2008) find that fed funds futures risk-premia are slow-moving and do not change much around FOMC announcements. On the other hand, Miranda-Agrippino (2016) finds a bigger role for risk-premia.

[6]In general $\Omega_{k|t}^{j}$ denotes the period k estimates of the fundamentals in the monetary policy reaction function based on the information available to j in period t.

The key assumption in the futures based identification is that no other macro news announcements are released in the window between $t - \varepsilon$ and t. Thus we have that $\widehat{\Omega}_{t|t-\varepsilon} = \widehat{\Omega}_{t|t}$. Now consider the futures price after the FOMC announcement.

$$p_t^{(0)} = i_{t|t} = g\left(\widehat{\Omega}_{t|t}^{CB}\right) + e_t \tag{2.4}$$

Note that the information set that is relevant to the short rate set by the central bank is its own information set. The monetary policy surprise is measured as the change in the futures contract

$$\begin{aligned} mps_t &= p_t^{(0)} - p_{t-\varepsilon}^{(0)} \\ &= g\left(\widehat{\Omega}_{t|t}^{CB}\right) - g\left(\widehat{\Omega}_{t|t}^{M}\right) + e_t \\ &= g\left(\widehat{\Omega}_{t|t}^{CB} - \widehat{\Omega}_{t|t}^{M}\right) + e_t \end{aligned} \tag{2.5}$$

where the last equality holds if we assume a linear reaction function $g(.)$ for the central bank. There is an alternative way to derive equation 2.5 without resorting to the assumption that the market has full knowledge of the central bank's reaction function. In this case we will assume $g^{CB}(.)$ to represent the central bank's actual monetary policy stance given its estimates of the relevant fundamentals, rather than just the reaction function component of its rule, i.e. $p_t^{(0)} = i_{t|t} = g^{CB}\left(\widehat{\Omega}_{t|t}^{CB}\right)$. The price of the futures contract just before the FOMC announcement is given by $p_{t-\varepsilon}^{(0)} = i_{t|t-\varepsilon} = g^{M}\left(\widehat{\Omega}_{t|t}^{M}\right)$ where $g^M(.)$ is not assumed to be the same as $g^{CB}(.)$. Then if $g^{CB}(.)$ and $g^M(.)$ are linear we can write the monetary policy surprise as

$$\begin{aligned} mps_t &= p_t^{(0)} - p_{t-\varepsilon}^{(0)} = g^{CB}\left(\widehat{\Omega}_{t|t}^{CB}\right) - g^{M}\left(\widehat{\Omega}_{t|t}^{M}\right) \\ &= g^{CB}\left(\widehat{\Omega}_{t|t}^{CB}\right) - g^{M}\left(\widehat{\Omega}_{t|t}^{M}\right) - g^{CB}\left(\widehat{\Omega}_{t|t}^{M}\right) + g^{CB}\left(\widehat{\Omega}_{t|t}^{M}\right) \\ &= g^{CB}\left(\widehat{\Omega}_{t|t}^{CB} - \widehat{\Omega}_{t|t}^{M}\right) + g^{CB}\left(\widehat{\Omega}_{t|t}^{M}\right) - g^{M}\left(\widehat{\Omega}_{t|t}^{M}\right) \\ &= g^{CB}\left(\widehat{\Omega}_{t|t}^{CB} - \widehat{\Omega}_{t|t}^{M}\right) + e_t \end{aligned} \tag{2.6}$$

In this case the exogenous monetary policy shock $e_t \equiv g^{CB}\left(\widehat{\Omega}_{t|t}^{M}\right) - g^{M}\left(\widehat{\Omega}_{t|t}^{M}\right)$ has a specific interpretation and represents the central bank and the market translating the same fundamentals into different monetary policy stances. On the other hand, the exogenous monetary policy shock from 2.5 represented a broader and more conventional measure of an exogenous monetary policy shock.

Regardless of the approach taken to derive equation 2.5 (or 2.6), it is clear that in the special case that the information set of the central bank and the market coincide, the monetary policy surprise recovers the exogenous monetary policy shock. However the assumption of no asymmetric information may not be tenable. There is a growing body of literature suggesting a role for central bank signals about macro fundamentals. Nakamura and Steinsson (2017) find a "Fed information effect" where Fed communication affects agents' expectation of future economic activity. Melosi (2016) sets up a DSGE model with an explicit signalling channel of monetary policy and finds that it has empirically relevant effects. Finally, Tang (2015) also finds that the empirical patterns in the U.S. inflation data are consistent with the existence of a signalling channel. While this a nascent literature, it does seem to suggest that the "signalling/information" channel is important. In this paper we add to this literature by studying the response of the stock market and testing whether it responds differently to Delphic shocks when compared to traditional exogenous monetary policy shocks.

While the derivation presented above used the futures contract expiring in the current month, we can show more generally that the analysis used to derive equation 2.5 (or 2.6) also applies to futures contracts that expire not in the current month, but in the future. These surprises likewise capture an exogenous component, which is a signal about shocks to the interest rate that are expected to occur in the future. But the surprises also capture a signal about future shocks to the interest rate that are related to central bank private information about macroeconomic fundamentals (i.e the Delphic shocks).

In the first step of the estimation procedure we separate the monetary policy surprises into i) exogenous component and ii) private information component. Equation 2.5 suggests that a simple linear regression will suffice as long as we can construct a variable that measures the difference in the information set of the central bank relative to the market. Essentially we need a private information variable that captures $\widehat{\Omega}^{CB}_{t|t} - \widehat{\Omega}^{M}_{t|t}$. In section 2.3.2 below we discuss in detail how we create this variable using forecast data. With this variable in hand, we run the following regression.

$$mps_t = c + \gamma \left(\widehat{\Omega}_{t|t}^{CB} - \widehat{\Omega}_{t|t}^{M} \right) + e_t \tag{2.7}$$

Using this equation we construct the residual $\widehat{e_t}$ and the fitted value $\widehat{\gamma} \left(\widehat{\Omega}_{t|t}^{CB} - \widehat{\Omega}_{t|t}^{M} \right)$. In the next step of the estimation procedure we regress the change in the stock price on the residual and fitted value.

$$\Delta S_t = \alpha + \beta_1 \widehat{e_t} + \beta_2 \widehat{\gamma} \left(\widehat{\Omega}_{t|t}^{CB} - \widehat{\Omega}_{t|t}^{M} \right) + u_t \tag{2.8}$$

where S_t is the stock price and Δ represents the change in a narrow window around the FOMC announcement. What should we expect for the sign of the two coefficients β_1 and β_2? Next we layout a simple “model-free" theoretical framework that can help us understand the related issues.

2.2.2 Stock Price Response to Exogenous and Delphic Shocks

Here we provide the key intuition of how the two different shocks can affect stock prices through their effects on discount rates and cash-flow news. In the online appendix we provide a conceptual framework where this intuition is fleshed out in more detail.

Consider a surprise increase in the interest rate by the central bank that is solely due to an exogenous monetary policy shock. In conventional models where monetary policy has real effects this translates to bad news about future cash flows and higher discount rates. Thus both discount rates and cash flow news work to create a fall in stock prices. This is the traditional channel of how monetary policy affects the stock market and suggests that β_1 from equation 2.8 above should be negative.

But monetary policy can have an additional effect if the change in the interest rate is related to revelation of central bank private information. A surprise increase in the interest rate in this case can have an ambiguous effect on stock prices, because there are distinct and potentially opposing effects. First, consider the effect of a contractionary shock on expectations of future cash flows. If the rise in interest rates has a contractionary effect on the economy, it will mean bad news about future cash flows. However this decision to increase interest rates could be driven by the central bank's forecast being more optimistic relative to the market. This Delphic signal could lead the market to revise their expectations of economic activity upwards in response. There is some recent empirical work suggesting that central bank signals can directly affect private sector beliefs about future economic activity. Melosi (2016) builds a model with an explicit signaling channel of monetary policy. The model incorporates a mechanism that could lead agents to expect higher inflation in response to a signal tied to an increase in the interest rate. In a similar vein, Nakamura and Steinsson (2017) sketch a model where the central bank can affect the market's expectations about the natural rate of interest. In their model an increase in the interest rate can cause the market to revise upwards their expectation of the natural rate, leading to a rise in economic activity. Finally, in a recent paper Campbell, Fisher, Justiniano, and Melosi (2016) use similarly constructed private information variables and show that the component of the monetary policy surprises that is related to optimistic Fed private information predicts upward revisions of economy activity by forecasters. This upward revision of expectations will mean good news about future cash flows. Thus a contractionary Delphic shock can be expected to raise stock prices through its effect on future cash flows. However, since it is a contractionary shock we would expect it to raise discount rates and thus lower stock prices. This latter effect goes in the opposite direction of the effect that works through cash flows, leaving the overall sign ambiguous.

To summarize, the conceptual framework suggests that we should have a strong prior for β_1 to be negative but there is uncertainty about the sign of β_2 as it can reasonably be expected to be either positive or negative.

2.3 Data

We use the S&P 500 index to measure the response of the stock market. The prices are measured in a 30 minute window around FOMC announcements, starting at 10 minutes before the announcement and ending 20 minutes after the announcement. For our baseline results, we use the sample period 1991-2011. There are 188 total FOMC policy decisions over this time frame. We drop a total of five data points. We exclude 8/17/2007, 11/25/2008, and 4/27/2011 due to data unavailability for those dates. We also drop 9/17/2001 and 3/18/2009 following Campbell, Fisher, Justiniano, and Melosi (2016). This leaves 183 observations in our sample. In the next subsection we detail the construction of the monetary policy surprise and conclude this section by discussing the private information variables constructed from Greenbook and Blue Chip forecasts.

2.3.1 Monetary Policy Surprise

Our measure of the surprise change in monetary policy is constructed from interest rate futures contracts, as in Kuttner (2001). Federal funds rate and Eurodollar futures contracts capture the market's expectations about future Federal Reserve actions. Changes in these futures contracts around FOMC announcements therefore serve as a measure of the change in policy that is unanticipated by the market. Since any expected change in policy will already be priced into financial assets, the reaction of asset prices to monetary policy should be entirely due to this surprise component.

We want the monetary policy surprise measure to capture surprises to expectations about future fed funds rate changes, in addition to any surprise to the current month's fed funds rate target. Thus to construct our measure of the monetary policy surprise, we follow Gürkaynak, Sack, and Swanson (2005) and use five futures contracts: the current month's fed funds futures, the 3-month ahead fed funds futures, and the 2-quarter, 3-quarter, and 4-quarter ahead Eurodollar futures.[7] For the baseline results, the surprise in each contract is measured as the change in the futures rate in a 30 minute window (10 minutes before to 20 minutes after) around FOMC policy decisions as in Gürkaynak, Sack, and Swanson (2005). But we also discuss results obtained using a broader daily window. Taken together, the five contracts contain rich information about the short and medium term path of expected interest rates.

To summarize this information in a parsimonious way we perform a principal components analysis. Let X denote a T x 5 matrix of the change in the price of the 5 futures contracts, where T is the number of FOMC meetings. We can then perform a principal components analysis of the

[7] For comparison, Bernanke and Kuttner (2005) use only the current month fed funds futures contract in their baseline results.

futures price changes

$$X = F\Lambda + \widetilde{\eta} \tag{2.9}$$

where F are factors, Λ are factor loadings, and $\widetilde{\eta}$ is an error term. The first principal component of F explains more than 80% of the total variation across all the contracts. We therefore use this first principal component as our baseline measure of monetary policy surprises.[8] Figure 2.1 plots this monetary policy surprise measure using both the 30 minute and daily window. The two series display a high degree of correlation with some minor discrepancies around the financial crisis in 2008 and in the early 1990s. To facilitate interpretation of our results below, we normalize the policy surprise such that its effect on the four quarter ahead Eurodollar futures contract is equal to unity. Thus the coefficient from a regression of stocks on the monetary policy surprise will measure the effect on the stock market of a 1% surprise rise in the expected path of the fed funds rate over the next 4 quarters.

2.3.2 Federal Reserve Private Information

Our measure of Federal Reserve private information is constructed using the FOMC Greenbook forecasts and the private sector Blue Chip forecasts, and is similar to the approach used in Barakchian and Crowe (2013) and Campbell, Fisher, Justiniano, and Melosi (2016).

The Fed's Greenbook forecasts represent the information set of the central bank $\widehat{\Omega}^{CB}_{t|t}$ from equation 2.7, while the Blue Chip forecasts proxy for the market's information set $\widehat{\Omega}^{M}_{t|t}$. Greenbook forecasts are constructed by the Federal Reserve Board's staff a week prior to every scheduled FOMC policy meeting and are released to the public following a roughly five year lag. Blue Chip forecasts are compiled from market professionals on a monthly basis and released on the 10th of every month. For each FOMC policy decision (t) the corresponding measure of Fed private information is calculated as the most recent Greenbook forecast minus the last Blue Chip forecast prior to the policy decision that is of the same forecast horizon as the relevant Greenbook forecast.

[8]This is essentially identical to the measure used in Nakamura and Steinsson (2017) which they call the “policy news shock"

In table 2.1, for each FOMC meeting we list the corresponding Greenbook and Blue Chip forecast dates.

Each set of forecasts predicts the values of macroeconomic variables on a quarterly basis. For the 1991-2011 sample we use the following four variables: real GDP, CPI, industrial production, and the civilian unemployment rate. For each variable, both set of forecasts contain at least five different forecast horizons: the current quarter forecast, the quarter ahead forecast, two quarter ahead forecast, three quarter ahead forecast, and four quarter ahead forecast. Our measure of private information for variable i at forecast horizon j is:

$$\widehat{\Omega}^{CB}_{i,t+j|t} - \widehat{\Omega}^{M}_{i,t+j|t} \tag{2.10}$$

These variables are plotted in figure 2.2. A few interesting points stand out. These variables are persistent and for each variable as the forecast horizon increases, the persistence rises. This suggests that the Federal Reserve's internal forecasts are not completely inferred by the market based on FOMC meeting actions and announcements. This is especially true for the longer-horizon forecasts. For a given variable, in addition to the autocorrelation for each individual forecast horizon, the private information variables for different horizons are also correlated with one another. Forecast horizons that are "closer" to each other are more highly correlated. For example, the 4 quarter ahead forecast is quite highly correlated with the 3 quarter ahead forecast but not with the nowcast.

These patterns guide us in choosing the private information measures that will be used in the regression analysis below. First, given the high cross-correlation among the private information variables of different horizons (for a given variable) we use only the nowcast and the 4 quarter ahead forecast. Next, given the high persistence of the private information variables, we include the first lag in our regression. Thus our baseline specification will have the contemporaneous and first lag of the nowcast (0 quarter ahead forecast) and 4 quarter ahead forecast for four macro variables: GDP, CPI, Industrial Production and Unemployment. Thus we have a total of 16 private information variables that capture the relevant information. A potential alternative is to follow the approach of Campbell, Fisher, Justiniano, and Melosi (2016) and construct a short and long factor for each variable using principal component analysis. We found that the short factor and long factors correlate very highly with the nowcast and the 4 quarter ahead forecasts.

2.4 Results

2.4.1 Stock Prices and Monetary Policy Surprise

We start by exploring the relationship between changes in the S&P 500 index (ΔS_t) and our measure of monetary policy surprise (mps_t) detailed in the previous section. Table 2.2 reports the summary statistics for these two measures using both a tight window and broad window around FOMC announcements. The tight window measures the change from 10 minute before to 20 minutes after the announcement. The broad window is just the daily change. The correlation between the tight and broad measures of the monetary policy surprise is high (0.81), while the correlation is lower for stock returns (0.47). For the policy surprise, moving to a broader window increases the standard deviation slightly, but it does so considerably more for the stock return. Thus stock returns in the broad window appear to have more noise relative to the tight window. The table also provides information separated by unscheduled FOMC meetings and meetings that correspond to “turning points" (which are instances when the federal funds rate target is changed in the direction opposite to previous changes). The specific dates for the unscheduled and turning point FOMC meetings are listed in table 2.1. There has been some discussion in the literature that FOMC meetings of these two types are “unusual" relative to the other meetings. BK document that stock price reactions are much larger on turning point FOMC meetings. Faust, Swanson, and Wright (2004a) find that monetary policy surprises on unscheduled FOMC meetings are more likely to reveal information about the state of the economy, i.e. suggesting a role for Delphic shocks (using our terminology). Finally, using a regime-switching model Davig and Gerlach (2006) show that for a “high volatility" regime from 1998 to 2002 the effect of monetary policy surprises on stock prices is mainly driven by unscheduled meetings. We will discuss the importance of these particular episodes for stock prices in more detail below and in section 2.4.3. For now, we want to point out that all three papers use data up to the early 2000s (2002 for BK and 2003 for Faust, Swanson, and Wright (2004a) and

Davig and Gerlach (2006)). Extending the data up to 2011, we notice that both monetary policy surprises and stock returns are substantially more volatile on unscheduled and turning point days, consistent with the idea that these meetings are somewhat different.

Table 2.3 presents the results from the regression of ΔS_t on mps_t using the 30 minute window with robust standard errors in parentheses. $R^2 > 0.3$ provides support for the assumption that monetary policy surprises are major drivers of stock prices in this narrow window. Consistent with BK, the specification in column (1) reports a significant decline in the S&P 500 following a positive monetary policy surprise (i.e. an unexpected tightening of monetary policy). A 1% surprise rise in the expected path of the fed funds rate over the next 4 quarters results in a 5.1% fall in stock prices.[9] This coefficient is precisely estimated with statistical significance at the 1% level.[10] Column 2 presents regression results where the monetary policy surprise is interacted with a dummy variable that jointly represents FOMC meetings that are unscheduled and those associated with turning points. Column 3 and 4 presents the interaction results where the dummy variable is separated into unscheduled meetings and turning point meetings. The stock response to a monetary policy surprise is slightly lower in columns 2-4. The interaction coefficients are all negative but none of them are statistically significant. These negative point estimates suggest that if there is any evidence of asymmetry in the response of stock prices, it points to a larger negative response on unscheduled and turning point FOMC meetings. Since the standard errors are relatively large, it is reasonable to conclude that the response of stock prices to monetary policy surprises is stable across these different types of FOMC meetings.

Table 2.4 shows the regression results using the wider daily window. Column 1 shows that the response of stock prices is now statistically insignificant and much lower in magnitude relative to the tight window (-2.4% vs -5.1%). The R^2 is also substantially lower at .03. The daily stock

[9] Notice from table 2.2 that the standard deviation of the policy surprise is 7 basis basis points. This implies that a one standard deviation increase in the policy surprise leads to a 0.36% fall in stock prices.

[10] Our results are more strongly significant compared to studies that only use the current month federal funds futures contract in calculating their monetary policy surprise (see for example Gorodnichenko and Weber (2016)).

response in table 2.4 is also lower relative to the findings in BK. There are two main reasons why our daily results are different from BK's daily results. First, we use a broader measure of monetary policy surprise that captures forward guidance shocks, while BK just used federal funds rate surprises. And second, we extend the sample end date from 2002 to 2011. Similar to table 2.3, columns 2-4 show the regression results with dummy interactions for unscheduled and turning point FOMC meetings. The coefficients on the interactions are negative and two out of the three are not significant. Thus the daily data regressions confirm that the stock market response to monetary policy surprises is stable across the different FOMC meetings and if anything more likely to be negative in theses episodes.

Taken together, it is an indication that stock returns in the broad window have a lot more noise relative to the tight window. The underlying identifying assumption in this paper is that the relevant window around FOMC announcements does not contain any other important macroeconomic news event. In light of the above results, this identifying assumption is more credible with the tight window and motivates us to use the tight window for our benchmark results below in section 2.4.3. This is also consistent with the recommendation of Gürkaynak, Sack, and Swanson (2005) among others. To conclude this section, figure 2.3 shows a scatter plot of the stock return and the monetary policy surprise in the tight 30 minute window (which is our preferred measure that is used in the results below). There is a clear negative relationship. The black triangles mark the Unscheduled FOMC meetings while the red squares represent turning points, highlighting that the bigger monetary policy surprises occur at these two types of meetings.

2.4.2 Monetary Policy Surprise and Private Information

In section 2.3.2 we discussed the properties of the private information variables constructed from forecast data. An important implication was that the Federal Reserve does not seem to completely reveal all of its private information through the FOMC announcement. Thus we would like to use only the component of private information that is inferred by the market from the FOMC announcements. As discussed above, we proceed by first regressing the monetary policy surprise measure on the private information variables. The estimating equation is reproduced below

$$mps_t = c + \gamma_{i,j} \left(\widehat{\Omega}^{CB}_{i,t+j|t} - \widehat{\Omega}^{M}_{i,t+j|t} \right) + e_t \tag{2.11}$$

Table 2.5 shows the results from this regression using the nowcast and 4 quarter ahead forecasts for the GDP, CPI, Unemployment and Industrial Production private information variables. Given the persistent nature of the private information variables, we also include the first lag. The p-value jointly tests the null hypothesis that the private information variables have no explanatory power. This is rejected at the 1% level. The R^2 from the regression is 0.16, which is substantial but also highlights the fact that a major part of the monetary policy surprise is exogenous with respect to the Fed's private information.

In the conceptual framework sketched out in section 2.2.2, we emphasized that the response of stock prices to private information depends on how forecast differences are related to interest rate changes. The regression coefficients from table 2.5 can inform us about the sign. Note that a positive value for the private information variable for GDP, CPI and IP means that the Fed has a relatively optimistic forecast for the economy. For unemployment a positive sign implies the opposite. The first step regression is reported in table 2.5, where 0Q refers to the nowcast and 4Q refers to the four quarter ahead forecast. The sign of all the coefficients on the private information nowcast variables suggest that an optimistic forecast results in a positive value for $\widetilde{g}_t \equiv \widehat{\gamma}(\widehat{\Omega}^{CB}_{t|t} - \widehat{\Omega}^{M}_{t|t})$, i.e. a contractionary policy surprise. But not all the signs on the lagged variables have the signs consistent with this interpretation. For example, the coefficient on the lagged 4 quarter ahead forecast of IP implies that if the Fed has a more positive outlook for IP, that is related to an expansionary policy surprise. This is most likely a combination of some noise and the fact that there is a high amount of correlation in the content of the different private information variables. We have also run the first step regression with different combinations of private information variables (including using principal component analysis) and find that most of the coefficients are consistent with $\widetilde{g}_t$ being positive.

Figure 2.4 displays the exogenous monetary policy shock (residual) and Delphic shock (fitted value) over time, with summary statistics reported in table 2.6. The Delphic shock is typically of a smaller magnitude with a standard deviation roughly half that of the exogenous monetary policy shock. The standard deviation of the Delphic shock is roughly stable even when we narrow down to unscheduled or turning point FOMC meetings. On the other hand, the standard deviation of the exogenous monetary policy shock is much larger in these particular episodes. The Delphic shock displays a few notable episodes, with relatively large contractionary shocks in the late 90s and expansionary ones in the early 2000s and 2008-2009. The overall pattern of the exogenous monetary policy shock is similar to the monetary policy surprise, which is unsurprising given that the exogenous monetary policy shock explains around 80% of the variation of the monetary policy surprise.

2.4.3 Stock Price Response to Exogenous and Delphic Shocks

Now we are ready to run our second step regression. We regress the change in the S&P 500 index in the 30 minute window on the exogenous and Delphic shocks obtained from the first step discussed above. The estimating equation is

$$\Delta S_t = \alpha + \beta_1 \widehat{e}_t + \beta_2 \widehat{\gamma}_{i,j} \left(\widehat{\Omega}^{CB}_{i,t+j|t} - \widehat{\Omega}^{M}_{i,t+j|t} \right) + u_t \tag{2.12}$$

Since the regressors in this second step are generated in the first step, we have to account for the added sampling uncertainty. This is done by bootstrapping the standard errors. The key idea is to conduct the resampling at the beginning and thus to perform both steps of the two-step regression procedure for every bootstrap sample. We use $10,000$ replications in the bootstrap procedure.

The results are presented in table 2.7 with the bootstrapped standard errors in parentheses. Column 1 shows that the exogenous shock has a negative and significant effect on stock returns with a slightly larger magnitude than the monetary policy surprise. Specifically, a 1% surprise rise in the expected path of the fed funds rate over the next 4 quarters results in a precisely estimated 5.7% fall in stock prices (relative to the 5.1% fall for the monetary policy surprise).[11] The effect of

[11] The standard deviation of the exogenous shock is slightly lower relative to the monetary policy surprise. Thus the stock response to a one standard deviation exogenous monetary policy shock is essentially identical to the monetary policy surprise response.

the Delphic shock is also negative but much lower at -2.1%. While this coefficient by itself is not statistically significant, it is significantly different from the coefficient on the exogenous monetary policy shock (with a p-value for the difference of 0.05). As shown in table 2.6, exogenous monetary policy shocks are more volatile than Delphic shocks and we reinterpret the coefficients to get a better gauge of the size of the effects. Specifically, stock prices fall 0.34% and 0.06% in response to a one standard deviation exogenous monetary policy and Delphic shock respectively. An important implication is that on average surprise Federal Reserve decisions and announcements that are related to revelation of their private information have a lower effect (in terms of both economic and statistical significance) on the stock market as compared to actions that are exogenous shocks.

However, there is important asymmetry in the effect of these shocks. The second column shows the results where the exogenous monetary policy and Delphic shocks are interacted with a dummy variable that jointly represents FOMC meetings that are either unscheduled or are associated with turning points. The overall stock response is lower in magnitude for the exogenous monetary policy shock and higher in magnitude for the Delphic shock by about a percentage point. The interaction coefficient on the exogenous component is -3.6 implying that the total response of stock prices to exogenous monetary policy shocks on these particular FOMC meetings is substantially larger in magnitude at -8.2. With a higher variance of exogenous monetary policy shocks on these particular meetings, stock prices fall by 0.9% in response to a one standard deviation exogenous monetary policy shock. The interaction coefficient on the Delphic component is also large but *positive* at 14.6 (with a p-value of 0.04). The total response of stock prices to a Delphic shock on these particular FOMC meetings is 11.7 (with a p-value of 0.08). Even with a lower variance of Delphic shocks on these FOMC meetings, it implies a 0.35% *rise* in stock prices in response to a one standard deviation Delphic shock. Moreover, the difference between the total effect of exogenous monetary policy and Delphic shocks for these days is large and strongly significant (p-value < 0.01). Thus there appears to be a clear distinction in how the stock market interprets exogenous vs. Delphic monetary policy actions on these particular FOMC meetings.

The third and fourth columns show the results where the interaction for unscheduled FOMC meetings and turning point FOMC meetings is done separately. The same pattern is obtained with the interaction coefficients. Clearly, the standard errors are larger as there are a total of 17 observations for the unscheduled dates and only 8 for the turning point dates. Nevertheless the sign of the interaction coefficients on these particular dates continue to show a larger negative response to the exogenous monetary policy shock and a positive response to the Delphic shock.

Next we check the robustness of the results to sample selection. First, we consider the zero lower bound episode. Since late 2008, the fed funds rate has been stuck around zero and all the variation in our monetary policy surprise measure is driven by forward guidance surprises rather than any target rate change surprise. Furthermore, after hitting the zero lower bound, the Federal Reserve engaged in the unconventional policy of large scale asset purchases (i.e. quantitative easing (QE)), with the first announcement coming in late 2008. For FOMC meetings that involved announcements about QE it is plausible that these announcements did not affect the expected fed funds rate over the next two years (and thus the fed funds futures markets). Moreover it is reasonable to expect that the stock market would react to announcements that reveal information about QE.

To check whether our results are driven by this period, we rerun our estimation excluding the zero lower bound episode. The first two columns of table 2.8 present these results. Column 1a shows that the overall response to exogenous monetary policy shocks and Delphic shocks is similar to the baseline case reported in table 2.7, with similar standard errors as well. The interaction terms with the unscheduled and turning point FOMC meetings also paint a similar picture. Relative to the baseline results, on these particular FOMC meetings, the stock response to exogenous monetary policy shocks is slightly more negative and the response to Delphic shocks is slightly less positive.[12] Both the interaction terms are significant with p-values of 0.05 and 0.05 respectively.

Next we focus on the FOMC meetings in the early 1990s. Starting with February 1994, the FOMC started releasing a statement to accompany its monetary policy decision. To check if our results are driven by the 1991-1993 sample, we rerun the second step regressions using data starting with the February 1994 FOMC meeting. Columns 2a and 2b report these results. The

[12] We also tried truncating the sample in late 2007 to coincide with the beginning of turmoil in the financial markets. The results are very similar to the ones presented here.

overall response to both exogenous monetary policy and Delphic shocks is slightly larger for the post-1994 sample. For the interaction coefficients we find that the sign of the responses is similar to the baseline case. The magnitude of the effects is a little larger for the exogenous monetary policy shock and a little smaller for the Delphic shock on these particular FOMC meetings. However, the standard errors are somewhat larger in this case.

Finally, we control for the employment report when running our regressions. Recall that the underlying identifying assumption is that no other important macroeconomic event or announcement is occurring in the relevant window around the FOMC announcement. However, as pointed out by Gürkaynak, Sack, and Swanson (2005) there are a handful of FOMC meetings that coincide with macro news releases. Specifically, in the early 1990s there are 7 FOMC meetings that occur on the same day as the release of the employment report. Of special concern are 5 of these meetings that are unscheduled because if the Federal Reserve and the stock market are both responding to the employment report then our estimates will be mistakenly picking up that relationship. As discussed above, in constructing the stock price change and monetary policy surprises the narrow 30 minute window was preferred precisely to avoid this particular issue. Gürkaynak, Sack, and Swanson (2005) show that using the narrow 30 minute window does indeed help in circumventing this identification issue. Here we confirm that our main results are not affected by excluding the 7 FOMC meetings that coincide with the employment report. Column 3a of table 2.8 shows that the coefficients on the exogenous monetary policy and Delphic shocks are very similar to the baseline results in table 2.7. Column 3b shows that on the unscheduled and turning point FOMC meetings, the stock price response is in the same direction as the baseline results with the p-value on the interaction term for the exogenous monetary policy shock and the Delphic shock being 0.04 and 0.03 respectively. Excluding the employment report in fact makes the magnitude of these effects a little larger.

Overall, we conclude that our results are robust to sample selection. Next we use a VAR based decomposition to further understand the stock price response.

2.4.4 VAR Based Decomposition

Here we try to understand in more depth the reason behind the observed reaction of the stock market to monetary policy found in the previous section. In section 2.2.2 we discussed a broad but abstract framework where stock price movements can be broadly attributed to two main components: i) news about discount rates and ii) news about dividends (or cash flow news). In this section we use a more concrete decomposition of stock prices based on the work of Campbell and Shiller (1988) which calculates how much of the excess stock return can be attributed to expectations of future interest rates, excess returns and dividends. In this framework we can evaluate if the Delphic shock differentially affects the three component of the total excess stock return relative to the exogenous shock. Additionally we can investigate the decomposition effects of the asymmetry on turning point and unscheduled FOMC meetings.

The exact methodology used here follows the work of Bernanke and Kuttner (2005) and Campbell and Ammer (1993). The key idea is to decompose the current period's unexpected excess returns (e^y_{t+1}) into revisions of expectations of discounted future dividends ($\widetilde{e}^d_{t+1}$), future excess returns ($\widetilde{e}^y_{t+1}$) and the real interest rate ($\widetilde{e}^r_{t+1}$)[13]

$$e^y_{t+1} = \widetilde{e}^d_{t+1} - \widetilde{e}^r_{t+1} - \widetilde{e}^y_{t+1} \tag{2.13}$$

where

$$\begin{aligned} \widetilde{e}^d_{t+1} &= (E_{t+1} - E_t) \sum_{j=0}^{\infty} \rho^j \Delta d_{t+1+j} \\ \widetilde{e}^r_{t+1} &= (E_{t+1} - E_t) \sum_{j=0}^{\infty} \rho^j \Delta r_{t+1+j} \\ \widetilde{e}^y_{t+1} &= (E_{t+1} - E_t) \sum_{j=1}^{\infty} \rho^j \Delta y_{t+1+j} \end{aligned} \tag{2.14}$$

ρ is the steady state level of the price to dividend ratio and is set to .9962 following BK. The expectations terms in 2.14 need to be estimated to evaluate the decomposition in equation 2.13. A

[13]The details of the derivation can be found in Bernanke and Kuttner (2005) and Campbell and Ammer (1993).

vector autoregression is used to construct these expectations. Campbell and Ammer (1993) show how this relationship can be modeled using the variables of interest and any other variables that might be helpful in forecasting excess returns. The resulting model is a six variable VAR with one lag.

$$z_t = Az_{t-1} + w_t \tag{2.15}$$

The endogenous variables (z_t) include the excess stock return, real interest rate, relative 3-month T-bill rate, change in the 3-month T-bill rate, the dividend-price ratio, and the spread between the 10-year and 1-month Treasury yields. From this VAR we can estimate the variables of interest in equation 2.13 using the following equations

$$\begin{aligned} e^y_{t+1} &= s_y w_{t+1} \\ \widetilde{e}^y_{t+1} &= s_y \rho A (I - \rho A)^{-1} w_{t+1} \\ \widetilde{e}^r_{t+1} &= s_r (I - \rho A)^{-1} w_{t+1} \\ \widetilde{e}^d_{t+1} &= e^y_{t+1} + \widetilde{e}^r_{t+1} + \widetilde{e}^y_{t+1} \end{aligned} \tag{2.16}$$

where s_y and s_r are vectors with zeros and ones to pick out the relevant variables. The variance of the current excess equity return can be decomposed into the sum of the three variances and covariances.

$$\begin{gathered} Var(e^y_{t+1}) = Var(\widetilde{e}^d_{t+1}) + Var(\widetilde{e}^r_{t+1}) + Var(\widetilde{e}^y_{t+1}) \\ -2Cov(\widetilde{e}^d_{t+1}, \widetilde{e}^r_{t+1}) - 2Cov(\widetilde{e}^d_{t+1}, \widetilde{e}^y_{t+1}) + 2Cov(\widetilde{e}^y_{t+1}, \widetilde{e}^r_{t+1}) \end{gathered} \tag{2.17}$$

Using monthly data from 1991 to 2011 (to match our baseline estimation sample), we report the variance decomposition of excess equity returns in table 2.9. For ease of comparison, the first two columns present the results from BK where they use data from 1989 to 2002. The left column shows the total contribution to the variance while the second column shows the shares (divided by Var(e^y_{t+1})). The majority of variation in excess returns is accounted for by the variance in expected dividends and expected future excess returns. Relative to the BK results, our data suggest a slightly bigger role for dividends (42% vs. 32%) and a smaller role for future excess returns (28% vs.

38%). At this stage, we should mention that there is recent work that points out some potential issues with this framework. These concerns are primarily related to the residual based nature of the decomposition, see for example the work of Chen and Zhao (2009). Thus we do not want to place too much emphasis on how our results compare to BK because of the differences in the sample dates and how the monetary policy surprises are constructed. Rather, the main purpose of the analysis in this section is to compare how the decomposition varies between the exogenous and Delphic shocks. We can more reasonably expect that the shortcomings of this residual based decomposition are not systematically related to the manner in which we construct the exogenous and Delphic shocks. Thus our emphasis will be on the *difference* in the decomposition between the exogenous shock and Delphic shock rather than on the level of the effects themselves.

In this framework, a natural way to evaluate the effect of monetary policy is to include the exogenous and Delphic shock directly in the VAR. Denoting the estimated exogenous shock by $\widehat{e}_t$ and the estimated Delpic shock $\left[\widehat{\gamma_{i,j}}\left(\widehat{\Omega}^{CB}_{i,t+j|t} - \widehat{\Omega}^{M}_{i,t+j|t}\right)\right]$ by $\widetilde{g}_t$ we get

$$z_t = Az_{t-1} + \phi_1 \widehat{e}_t + \phi_2 \widetilde{g}_t + \widetilde{w}_t \tag{2.18}$$

The VAR is estimated at a monthly frequency which requires aggregating the monetary policy shocks from the FOMC meeting frequency to a monthly frequency. We follow a simple rule of summing up any monetary policy shocks in a given month to get the monthly number. We have also tried aggregating the monetary policy shocks following the methodology of Gertler and Karadi (2015a). The results from this alternative aggregation procedure are very similar to our baseline case and are presented in the online appendix.

Having estimated the VAR, we want to calculate the effect of the two monetary policy shocks on the discounted sums in equation 2.14. We can use the relationship outlined above in equation 2.16 together with the orthogonality of the monetary policy shocks. For example, consider the equation for the real interest rate

$$\widetilde{e}^{r}_{t+1} \;=\; s_r \left(I - \rho A\right)^{-1} w_{t+1} = s_r \left(I - \rho A\right)^{-1} \left(\phi_1 \widehat{e}_t + \phi_2 \widetilde{g}_t + \widetilde{w}_t\right) \tag{2.19}$$

From this equation the effect of the exogenous shock on the present value of current and expected future real rates is given by

$$s_r (I - \rho A)^{-1} \phi_1 \tag{2.20}$$

and the effect of the Delphic shock on the present value of current and expected future real rates is given by

$$s_r (I - \rho A)^{-1} \phi_2 \tag{2.21}$$

The response of the present value of current and expected future excess returns and dividends is calculated in a similar way. To account for the parameter uncertainty of the VAR coefficients in A, standard errors are calculated using the delta method following Campbell and Ammer (1993) and Bernanke and Kuttner (2005). Table 2.10 shows the response of the discounted sums to i) the composite monetary policy surprise, ii) the exogenous shock and iii) the Delphic shock. For ease of comparison we reproduce the results from BK in the first column where the sample runs from 1989 to 2002. In the next 3 columns we present the results where both the VAR and the monetary policy shocks are estimated using the 1991 to 2011 sample. For the second column we replace the exogenous and Delphic shocks with the composite monetary policy surprise in the VAR (equation 2.18). Relative to BK, the monetary policy surprise has a larger effect on current excess equity return. Note this is not surprising as our monetary policy surprise measure contains forward guidance surprises in addition to the federal funds rate surprises used in BK. However as found in BK, the current excess return is explained mostly by discounted sums of dividends and future excess returns.[14]

Relative to the composite monetary policy surprise, the exogenous shock (shown in the third column) has a very similar effect on current excess returns. The size of the impact is slightly larger (-17.5 vs. -16.7), which is consistent with the regressions from section 2.4.3. This larger negative response is driven mostly by a larger positive response of future excess returns (4.0 vs 3.6). The response to the Delphic shock are quite different, although the standard errors are substantially larger. The overall effect on current excess returns is smaller at -12.0. The most interesting aspect

[14]In recent work Maio (2013) and Weber (2015) similarly find that the effect of monetary policy is primarily driven by the response of expected future dividends.

is the composition of this response. The share of the dividend response is much bigger at -9.7, accounting for 81% of the total effect on current excess returns (relative to 66% for the exogenous shock).

Next we extend the above analysis to account for the differential effects on unscheduled and turning point FOMC meetings. This can be done in a straightforward manner using the framework of equation 2.18. Denote the unscheduled and turning point dummy by D_t.

$$z_t = Az_{t-1} + \widetilde{\phi}_1 \widehat{e}_t + \widetilde{\phi}_2 \widetilde{g}_t + \widetilde{\phi}_3 D_t + \widetilde{\phi}_4 \widehat{e}_t D_t + \widetilde{\phi_5} \widetilde{g}_t D_t + \widetilde{w}_t \tag{2.22}$$

Using this equation the effect on the various components can be calculated as above. For example, on unscheduled and turning point FOMC meetings the effect of the exogenous shock on the present value of current and expected future real rates is given by

$$s_r (I - \rho A)^{-1} \left(\widetilde{\phi}_1 + \widetilde{\phi}_4 \right) \tag{2.23}$$

and the effect of the Delphic shock is given by

$$s_r (I - \rho A)^{-1} \left(\widetilde{\phi}_2 + \widetilde{\phi}_5 \right) \tag{2.24}$$

Table 2.11 shows theses estimates. The response of current excess returns and its components to the exogenous shock ($\widetilde{\phi}_1$) is similar to that reported in table 2.10. The interaction effects of exogenous shocks ($\widetilde{\phi}_4$) are small as well. The overall response of current excess returns to a Delphic shock is more negative once we allow for the interaction (-21.1 vs. -12.0). This larger negative response on regular FOMC days is counteracted by a large *positive* response on unscheduled and turning point FOMC meetings. Specifically the total effect on these meetings ($\widetilde{\phi}_2 + \widetilde{\phi}_5 = 13.5$) is roughly the same size as the baseline effect from table 2.10 but with the opposite sign. This positive response is mainly driven by a large fall in the future excess return and to a lesser extent by a rise in dividends in response to contractionary Delphic shocks. The VAR decomposition exercise confirms that the stock market responds very differently to Delphic shocks that occur on unscheduled or turning point FOMC meetings. Moreover, the results point to a change in the risk premium as a major driver of this asymmetric response.[15] In recent work Hanson and Stein (2015) and Gertler and Karadi (2015a) find that monetary policy shocks have substantial effects on bond interest rate term premia. Our results show that, at least on certain FOMC dates, the stock risk premium also seems to respond to monetary policy shocks. We view our results as providing complementary evidence to this active area of research.

2.5 Conclusion

What are the effects of monetary policy on the economy? In this paper we aim to shed light on the relatively unexplored information (or signalling) channel of the monetary transmission mechanism. We conduct our analysis using the reaction of the stock market as a laboratory. By exploiting differences in central bank and private sector forecasts we construct a measure of Federal Reserve private information. We use this measure to separate monetary policy surprises into exogenous and Delphic shocks. Exogenous shocks are surprise changes in monetary policy which are unrelated to macroeconomic fundamentals whereas Delphic shocks are surprise changes in policy attributable to the Federal Reserve's private information about the state of the economy.

We find that, on average, stock prices fall more in response to contractionary exogenous shocks relative to Delphic ones. However, on unscheduled and turning point FOMC meetings, contractionary Delphic shocks actually result in an increase in stock prices. The results highlight an unconventional channel of monetary transmission where contractionary policy actions can stimulate the economy. An additional important implication of our results is that an FOMC that is concerned with financial market reaction should pay extra attention to its statements on turning point and unscheduled meetings.

A promising possibility for future work includes analyzing firm and industry level responses to the exogenous monetary policy and Delphic shocks. Heterogeneous firm-level responses may be informative about which kind of firms or industries are particularly sensitive to the revelation of Federal Reserve private information.

[15] While the response of future excess returns is precisely estimated (p-value < 0.01), standard errors in general are somewhat large and thus these results should be interpreted with some caution.

APPENDIX

Table 2.1: FOMC, Greenbook & Blue Chip Dates

FOMC	Greenbook	Blue Chip	Unsched/TP	FOMC	Greenbook	Blue Chip	Unsched/TP	FOMC	Greenbook	Blue Chip	Unsched/TP	FOMC	Greenbook	Blue Chip	Unsched/TP
8-Jan-91	12-Dec-90	10-Dec-90	X	23-May-95	17-May-95	10-May-95		19-Dec-00	13-Dec-00	10-Dec-00		29-Jun-06	21-Jun-06	10-Jun-06	
1-Feb-91	30-Jan-91	10-Jan-91	X	6-Jul-95	28-Jun-95	10-Jun-95	TP	3-Jan-01	13-Dec-00	10-Dec-00	X/TP	8-Aug-06	3-Aug-06	10-Jul-06	
7-Feb-91	30-Jan-91	10-Jan-91		22-Aug-95	16-Aug-95	10-Aug-95		31-Jan-01	25-Jan-01	10-Jan-01		20-Sep-06	13-Sep-06	10-Sep-06	
8-Mar-91	30-Jan-91	10-Jan-91	X	26-Sep-95	20-Sep-95	10-Sep-95		20-Mar-01	14-Mar-01	10-Mar-01		25-Oct-06	18-Oct-06	10-Oct-06	
27-Mar-91	20-Mar-91	10-Mar-91		15-Nov-95	8-Nov-95	10-Nov-95		18-Apr-01	14-Mar-01	10-Mar-01	X	12-Dec-06	6-Dec-06	10-Dec-06	
30-Apr-91	20-Mar-91	10-Mar-91	X	19-Dec-95	14-Dec-95	10-Dec-95		15-May-01	9-May-01	10-May-01		31-Jan-07	24-Jan-07	10-Jan-07	
15-May-91	8-May-91	10-May-91		31-Jan-96	26-Jan-96	10-Jan-96		27-Jun-01	20-Jun-01	10-Jun-01		21-Mar-07	14-Mar-07	10-Mar-07	
5-Jul-91	28-Jun-91	10-Jun-91		26-Mar-96	21-Mar-96	10-Mar-96		21-Aug-01	16-Aug-01	10-Aug-01		9-May-07	2-May-07	10-Apr-07	
6-Aug-91	28-Jun-91	10-Jun-91	X	21-May-96	16-May-96	10-May-96		2-Oct-01	27-Sep-01	10-Sep-01		28-Jun-07	20-Jun-07	10-Jun-07	
21-Aug-91	14-Aug-91	10-Aug-91		3-Jul-96	26-Jun-96	10-Jun-96		6-Nov-01	31-Oct-01	10-Oct-01		7-Aug-07	2-Aug-07	10-Jul-07	
13-Sep-91	14-Aug-91	10-Aug-91	X	20-Aug-96	15-Aug-96	10-Aug-96		11-Dec-01	5-Dec-01	10-Dec-01		18-Sep-07	12-Sep-07	10-Sep-07	TP
2-Oct-91	25-Sep-91	10-Sep-91		24-Sep-96	18-Sep-96	10-Sep-96		30-Jan-02	23-Jan-02	10-Jan-02		31-Oct-07	24-Oct-07	10-Oct-07	
30-Oct-91	25-Sep-91	10-Sep-91	X	13-Nov-96	6-Nov-96	10-Nov-96		19-Mar-02	13-Mar-02	10-Mar-02		11-Dec-07	5-Dec-07	10-Dec-07	
6-Nov-91	30-Oct-91	10-Oct-91		17-Dec-96	12-Dec-96	10-Dec-96		7-May-02	1-May-02	10-Apr-02		22-Jan-08	5-Dec-07	10-Dec-07	X
6-Dec-91	30-Oct-91	10-Oct-91	X	5-Feb-97	29-Jan-97	10-Jan-97		26-Jun-02	20-Jun-02	10-Jun-02		30-Jan-08	23-Jan-08	10-Jan-08	
18-Dec-91	11-Dec-91	10-Dec-91		25-Mar-97	19-Mar-97	10-Mar-97	TP	13-Aug-02	7-Aug-02	10-Aug-02		18-Mar-08	13-Mar-08	10-Mar-08	
20-Dec-91	11-Dec-91	10-Dec-91	X	20-May-97	15-May-97	10-May-97		24-Sep-02	18-Sep-02	10-Sep-02		30-Apr-08	23-Apr-08	10-Apr-08	
6-Feb-92	30-Jan-92	10-Jan-92		2-Jul-97	25-Jun-97	10-Jun-97		6-Nov-02	30-Oct-02	10-Oct-02		25-Jun-08	18-Jun-08	10-Jun-08	
1-Apr-92	25-Mar-92	10-Mar-92		19-Aug-97	14-Aug-97	10-Aug-97		10-Dec-02	4-Dec-02	10-Dec-02		5-Aug-08	30-Jul-08	10-Jul-08	
9-Apr-92	25-Mar-92	10-Mar-92	X	30-Sep-97	24-Sep-97	10-Sep-97		29-Jan-03	22-Jan-03	10-Jan-03		16-Sep-08	10-Sep-08	10-Sep-08	
20-May-92	14-May-92	10-May-92		12-Nov-97	6-Nov-97	10-Nov-97		18-Mar-03	13-Mar-03	10-Mar-03		8-Oct-08	10-Sep-08	10-Sep-08	X
2-Jul-92	26-Jun-92	10-Jun-92		16-Dec-97	11-Dec-97	10-Dec-97		6-May-03	30-Apr-03	10-Apr-03		29-Oct-08	22-Oct-08	10-Oct-08	
19-Aug-92	13-Aug-92	10-Aug-92		4-Feb-98	28-Jan-98	10-Jan-98		25-Jun-03	18-Jun-03	10-Jun-03		16-Dec-08	10-Dec-08	10-Dec-08	
4-Sep-92	13-Aug-92	10-Aug-92	X	31-Mar-98	25-Mar-98	10-Mar-98		12-Aug-03	6-Aug-03	10-Aug-03		28-Jan-09	22-Jan-09	10-Jan-09	
7-Oct-92	30-Sep-92	10-Sep-92		19-May-98	14-May-98	10-May-98		16-Sep-03	10-Sep-03	10-Sep-03		29-Apr-09	22-Apr-09	10-Apr-09	
18-Nov-92	12-Nov-92	10-Nov-92		1-Jul-98	24-Jun-98	10-Jun-98		28-Oct-03	22-Oct-03	10-Oct-03		24-Jun-09	17-Jun-09	10-Jun-09	
23-Dec-92	16-Dec-92	10-Dec-92		18-Aug-98	13-Aug-98	10-Aug-98		9-Dec-03	3-Dec-03	10-Nov-03		12-Aug-09	6-Aug-09	10-Aug-09	
4-Feb-93	29-Jan-93	10-Jan-93		29-Sep-98	23-Sep-98	10-Sep-98	TP	28-Jan-04	21-Jan-04	10-Jan-04		23-Sep-09	16-Sep-09	10-Sep-09	
24-Mar-93	17-Mar-93	10-Mar-93		15-Oct-98	23-Sep-98	10-Sep-98	X	16-Mar-04	11-Mar-04	10-Mar-04		4-Nov-09	29-Oct-09	10-Oct-09	
19-May-93	14-May-93	10-May-93		17-Nov-98	12-Nov-98	10-Nov-98		4-May-04	28-Apr-04	10-Apr-04		16-Dec-09	9-Dec-09	10-Dec-09	
8-Jul-93	30-Jun-93	10-Jun-93		22-Dec-98	16-Dec-98	10-Dec-98		30-Jun-04	23-Jun-04	10-Jun-04	TP	27-Jan-10	20-Jan-10	10-Jan-10	
18-Aug-93	11-Aug-93	10-Aug-93		3-Feb-99	28-Jan-99	10-Jan-99		10-Aug-04	5-Aug-04	10-Aug-04		16-Mar-10	10-Mar-10	10-Mar-10	
22-Sep-93	15-Sep-93	10-Sep-93		30-Mar-99	24-Mar-99	10-Mar-99		21-Sep-04	15-Sep-04	10-Sep-04		28-Apr-10	21-Apr-10	10-Apr-10	
17-Nov-93	10-Nov-93	10-Nov-93		18-May-99	13-May-99	10-May-99		10-Nov-04	3-Nov-04	10-Nov-04		23-Jun-10	16-Jun-10	10-Jun-10	
22-Dec-93	15-Dec-93	10-Dec-93		30-Jun-99	23-Jun-99	10-Jun-99	TP	14-Dec-04	8-Dec-04	10-Dec-04		10-Aug-10	4-Aug-10	10-Aug-10	
4-Feb-94	31-Jan-94	10-Jan-94	TP	24-Aug-99	18-Aug-99	10-Aug-99		2-Feb-05	26-Jan-05	10-Jan-05		21-Sep-10	15-Sep-10	10-Sep-10	
22-Mar-94	16-Mar-94	10-Mar-94		5-Oct-99	29-Sep-99	10-Sep-99		22-Mar-05	16-Mar-05	10-Mar-05		3-Nov-10	27-Oct-10	10-Oct-10	
18-Apr-94	16-Mar-94	10-Mar-94	X	16-Nov-99	10-Nov-99	10-Nov-99		3-May-05	28-Apr-05	10-Apr-05		14-Dec-10	8-Dec-10	10-Dec-10	
17-May-94	13-May-94	10-May-94		21-Dec-99	15-Dec-99	10-Dec-99		30-Jun-05	22-Jun-05	10-Jun-05		26-Jan-11	19-Jan-11	10-Jan-11	
6-Jul-94	30-Jun-94	10-Jun-94		2-Feb-00	27-Jan-00	10-Jan-00		9-Aug-05	4-Aug-05	10-Jul-05		15-Mar-11	9-Mar-11	10-Mar-11	
16-Aug-94	12-Aug-94	10-Aug-94		21-Mar-00	15-Mar-00	10-Mar-00		20-Sep-05	14-Sep-05	10-Sep-05		27-Apr-11	20-Apr-11	10-Apr-11	
27-Sep-94	21-Sep-94	10-Sep-94		16-May-00	11-May-00	10-May-00		1-Nov-05	26-Oct-05	10-Oct-05		22-Jun-11	15-Jun-11	10-Jun-11	
15-Nov-94	9-Nov-94	10-Nov-94		28-Jun-00	21-Jun-00	10-Jun-00		13-Dec-05	7-Dec-05	10-Dec-05		9-Aug-11	3-Aug-11	10-Jul-11	
20-Dec-94	14-Dec-94	10-Dec-94		22-Aug-00	16-Aug-00	10-Aug-00		31-Jan-06	25-Jan-06	10-Jan-06		21-Sep-11	14-Sep-11	10-Sep-11	
1-Feb-95	25-Jan-95	10-Jan-95		3-Oct-00	27-Sep-00	10-Sep-00		28-Mar-06	22-Mar-06	10-Mar-06		2-Nov-11	26-Oct-11	10-Oct-11	
28-Mar-95	22-Mar-95	10-Mar-95		15-Nov-00	8-Nov-00	10-Nov-00		10-May-06	3-May-06	10-May-06		13-Dec-11	7-Dec-11	10-Dec-11	

This table reports all FOMC dates from 1991-2011 and the corresponding Greenbook and Blue Chip forecast dates used to construct private information variables. Unscheduled FOMC decisions are denoted with an X and turning point decisions are denoted with TP.

Table 2.2: Summary Statistics - Monetary Policy Surprise and S&P 500

	All FOMC days		Turning points		Unscheduled	
	30 Minute	Daily	30 Minute	Daily	30 Minute	Daily
Monetary Policy Surprise						
Mean	0.00	0.00	-0.04	-0.03	-0.10	-0.14
Median	0.01	0.01	-0.03	-0.08	-0.10	-0.14
Standard Deviation	0.07	0.09	0.13	0.12	0.12	0.15
Min	-0.34	-0.44	-0.19	-0.17	-0.34	-0.44
Max	0.15	0.24	0.15	0.16	0.13	0.22
Correlation	0.81		0.95		0.82	
Observations	183		8		17	
S&P 500 Return						
Mean	-0.24	0.34	0.69	1.08	0.53	0.60
Median	-0.06	0.24	0.30	0.82	0.03	0.38
Standard Deviation	0.63	1.23	1.64	2.19	1.25	1.69
Min	-1.88	-2.94	-0.75	-2.27	-0.92	-1.13
Max	4.08	5.14	4.08	5.01	4.08	5.01
Correlation	0.47		0.93		0.90	
Observations	183		8		17	

This table reports the summary statistics calculated using a tight 30 minute window and a broad daily window. The monetary policy surprise measure reported in percentage points is constructed using a principal component analysis of futures data, see section 2.3.1 for details. The S&P 500 return is also reported in percentage points.

Table 2.3: Stock Market Response to Monetary Policy Surprise - 30 Minute Window

VARIABLES	S&P 500 (30 Minute Window)			
	(1)	(2)	(3)	(4)
MP Surprise	-5.14	-4.24	-4.62	-4.34
	(0.93)	(0.98)	(0.84)	(0.83)
Unscheduled/Turning Point Dummy		0.05		
		(0.13)		
MP Surprise x Unscheduled/Turning Point		-1.37		
		(1.60)		
Unscheduled FOMC Dummy			-0.01	
			(0.17)	
MP Surprise x Unscheduled			-1.15	
			(1.74)	
Turning Point Dummy				0.38
				(0.28)
MP Surprise x Turning Point				-4.70
				(3.81)
Constant	-0.02	-0.04	-0.03	-0.05
	(0.04)	(0.04)	(0.04)	(0.03)
Observations	183	183	183	183
R-squared	0.32	0.33	0.32	0.38
Adjusted R-squared	0.32	0.32	0.31	0.37

The table reports the regression of the change in the S&P 500 index on the monetary policy surprise, both measured in a 30 minute window around FOMC announcements. The Unscheduled dummy is set to 1 for FOMC meetings occurring outside the regularly scheduled dates. The Turning Point dummy is set to 1 if the policy decision changed the fed funds rate in the opposite direction of the previous change. The Unscheduled/Turning Point dummy is set to 1 for either occurrence. Robust standard errors are in the parentheses.

Table 2.4: Stock Market Response to Monetary Policy Surprise - Daily Window

VARIABLES	S&P 500 (Daily Window)			
	(1)	(2)	(3)	(4)
MP Surprise	-2.42	-1.55	-2.68	-1.57
	(1.45)	(2.27)	(2.10)	(1.45)
Unscheduled/Turning Point Dummy		-0.15		
		(0.34)		
MP Surprise x Unscheduled/Turning Point		-2.21		
		(3.23)		
Unscheduled FOMC Dummy			-0.08	
			(0.47)	
MP Surprise x Unscheduled			0.30	
			(3.25)	
Turning Point Dummy				0.31
				(0.42)
MP Surprise x Turning Point				-12.16
				(3.84)
Constant	0.34	0.33	0.35	0.31
	(0.09)	(0.10)	(0.10)	(0.09)
Observations	183	183	183	183
R-squared	0.03	0.04	0.03	0.10
Adjusted R-squared	0.02	0.02	0.02	0.08

The table reports the regression of the change in the S&P 500 index on the monetary policy surprise, both measured using a daily window around FOMC announcements. The Unscheduled dummy is set to 1 for FOMC meetings occurring outside the regularly scheduled dates. The Turning Point dummy is set to 1 if the policy decision changed the fed funds rate in the opposite direction of the previous change. The Unscheduled/Turning Point dummy is set to 1 for either occurrence. Robust standard errors are in the parentheses.

Table 2.5: 1st Step - Monetary Policy Surprise on Private Information

VARIABLES	MP Surprise
CPI0Q	0.008
	(0.004)
U0Q	-0.005
	(0.051)
GDP0Q	0.018
	(0.009)
IP0Q	0.003
	(0.003)
CPI4Q	0.013
	(0.020)
U4Q	0.025
	(0.028)
GDP4Q	0.014
	(0.016)
IP4Q	0.006
	(0.011)
CPI0Q Lag	-0.003
	(0.007)
U0Q Lag	0.030
	(0.044)
GDP0Q Lag	-0.007
	(0.009)
IP0Q Lag	0.002
	(0.003)
CPI4Q Lag	0.002
	(0.020)
U4Q Lag	-0.048
	(0.027)
GDP4Q Lag	0.014
	(0.017)
IP4Q Lag	-0.018
	(0.010)
Constant	0.012
	(0.009)
Observations	182
R-squared	0.16
Adjusted R-squared	0.08
P-Value	0.01

The table reports the regression of the monetary policy surprise on the private information variables (constructed as the difference between the Greenbook forecasts and Blue Chip forecasts). “0Q" and “4Q" refer to the nowcast and 4 quarter ahead forecast, see the main text for more details. The p-value is for the test of joint significance of all the private info variables in the regression. Robust standard errors are in parentheses.

Table 2.6: Summary Statistics - Exogenous and Delphic Shocks

	All	Unscheduled/TP	Pre-ZLB	Post-1994	No Report
Exogenous Shock					
Mean	0.00	-0.07	0.00	0.00	0.00
Median	0.01	-0.04	0.01	0.00	0.01
Standard Deviation	0.06	0.11	0.06	0.06	0.06
Min	-0.30	-0.30	-0.30	-0.30	-0.30
Max	0.16	0.11	0.16	0.16	0.16
Correlation with MP surprise	0.92	0.98	0.92	0.90	0.91
Observations	182	23	159	139	175
Delphic Shock					
Mean	0.00	-0.01	0.00	0.00	0.00
Median	0.00	-0.01	0.00	0.01	0.01
Standard Deviation	0.03	0.03	0.03	0.03	0.03
Min	-0.09	-0.06	-0.09	-0.09	-0.09
Max	0.08	0.05	0.08	0.08	0.08
Correlation with MP surprise	0.40	0.61	0.40	0.41	0.39
Observations	182	23	159	139	175

This table reports the summary statistics calculated using a tight 30 minute window. Both shocks, reported in percentage points, are retrieved from the regression of monetary policy surprises on Fed private information. The exogenous monetary policy (MP) shock is the residual and the Delphic shock is the fitted value, see section 2.4.2 for details. The first column includes all FOMC dates in our sample, the second includes only unscheduled and turning point dates, the third includes all dates prior to the fed funds rate hitting the zero lower bound, the fourth column includes all dates following 1994, and the fifth includes all dates that did not coincide with the release of an unemployment report.

Table 2.7: 2nd Step - Response of Stock Prices to Exogenous and Delphic Shocks

VARIABLES	S&P 500 (30 minute window)			
	(1)	(2)	(3)	(4)
Exogenous Shock	-5.72	-4.62	-5.19	-4.74
	(0.99)	(0.90)	(0.86)	(0.84)
Delphic Shock	-2.12	-2.93	-2.49	-2.13
	(1.87)	(1.97)	(1.80)	(1.91)
Unscheduled/Turning Point Dummy		-0.01		
		(0.18)		
Exogenous x Unscheduled/Turning Point		-3.59		
		(2.16)		
Delphic x Unscheduled/Turning Point		14.62		
		(7.08)		
Unscheduled FOMC Dummy			0.15	
			(0.29)	
Exogenous x Unscheduled			-2.48	
			(2.84)	
Delphic x Unscheduled			18.4	
			(14.85)	
Turning Point Dummy				0.06
				(1.59)
Exogenous x Turning Point				-8.67
				(12.57)
Delphic x Turning Point				10.47
				(59.07)
Constant	-0.03	-0.04	-0.03	-0.05
	(0.04)	(0.04)	(0.04)	(0.04)
Observations	182	182	182	182
R-squared	0.34	0.39	0.37	0.42
Adjusted R-squared	0.33	0.37	0.35	0.40

The table reports the regression of the change in the S&P 500 index on the residual and fitted value of the policy surprise from the first step, both measured in a 30 minute window around FOMC announcements. The Unscheduled dummy is set to 1 for FOMC meetings occurring outside the regularly scheduled dates. The Turning Point dummy is set to 1 if the policy decision changed the fed funds rate in the opposite direction of the previous change. The Unscheduled/Turning Point dummy is set to 1 for either occurrence. Bootstrapped standard errors are in the parentheses.

Table 2.8: 2nd Step - Subsamples

VARIABLES	Pre-ZLB		Post-1994		No Employment Report	
	(1a)	(1b)	(2a)	(2b)	(3a)	(3b)
Exogenous Shock	-5.87	-4.11	-6.87	-5.25	-5.74	-4.56
	(1.09)	(1.03)	(1.17)	(0.93)	(1.05)	(0.90)
Delphic Shock	-1.27	-1.71	-2.24	-2.33	-2.31	-3.14
	(1.83)	(1.97)	(1.98)	(2.09)	(1.87)	(2.01)
Unscheduled/Turning Point Dummy		-0.03		-0.11		-0.13
		(0.18)		(0.44)		(0.24)
Exogenous x Unscheduled/Turning Point		-4.70		-4.46		-5.10
		(2.34)		(4.45)		(2.54)
Delphic x Unscheduled/Turning Point		11.83		8.67		20.85
		(6.00)		(11.78)		(9.61)
Constant	-0.04	-0.07	-0.04	-0.06	-0.03	-0.04
	(0.05)	(0.04)	(0.05)	(0.05)	(0.04)	(0.04)
Observations	159	159	148	148	175	175
R-squared	0.35	0.41	0.38	0.41	0.34	0.41
Adjusted R-squared	0.34	0.39	0.37	0.39	0.33	0.39

The table reports the regression of the change in the S&P 500 index on the residual and fitted value of the policy surprise from the first step, both measured in a 30 minute window around FOMC announcements. The Unscheduled dummy is set to 1 for FOMC meetings occurring outside the regularly scheduled dates. The Turning Point dummy is set to 1 if the policy decision changed the fed funds rate in the opposite direction of the previous change. The Unscheduled/Turning Point dummy is set to 1 for either occurrence. Bootstrapped standard errors are in the parentheses.

Table 2.9: Excess Stock Return Variance Decomposition

	BK 1989 - 2002		1991 - 2011	
	Total	Share (%)	Total	Share (%)
Var(Excess Return)	19.00		19.59	
Var(Dividends)	6.10	31.90	8.31	42.43
Var(Real Rate)	0.10	0.60	0.29	1.50
Var(Future Returns)	7.20	38.00	5.45	27.82
-2*Cov(Dividends, Real Rate)	-0.60	-3.20	0.55	2.80
-2*Cov(Dividends, Future Excess Returns)	7.20	37.70	4.85	24.77
2*Cov(Future Excess Returns, Real Rate)	1.00	5.10	0.13	0.68

The table reports the variance decomposition of current excess equity returns into the variances of revisions in expectations of dividends, real interest rates, future excess returns, and the covariances between them.

Table 2.10: Response of Excess Returns to Exogenous & Delphic Shocks

	BK 1989 - 2002	MP Surprise	Exog Shock	Delphic Shock
Current Excess Ret.	-11.01	-16.65	-17.45	-12.07
	(3.72)	(5.09)	(5.47)	(12.52)
Future Excess Ret.	3.29	3.61	4.02	1.24
	(1.10)	(2.75)	(2.94)	(4.63)
Real Interest Rate	0.77	1.72	1.82	1.10
	(1.87)	(0.63)	(0.68)	(1.54)
Dividends	-6.96	-11.32	-11.60	-9.73
	(2.35)	(4.93)	(5.42)	(11.47)

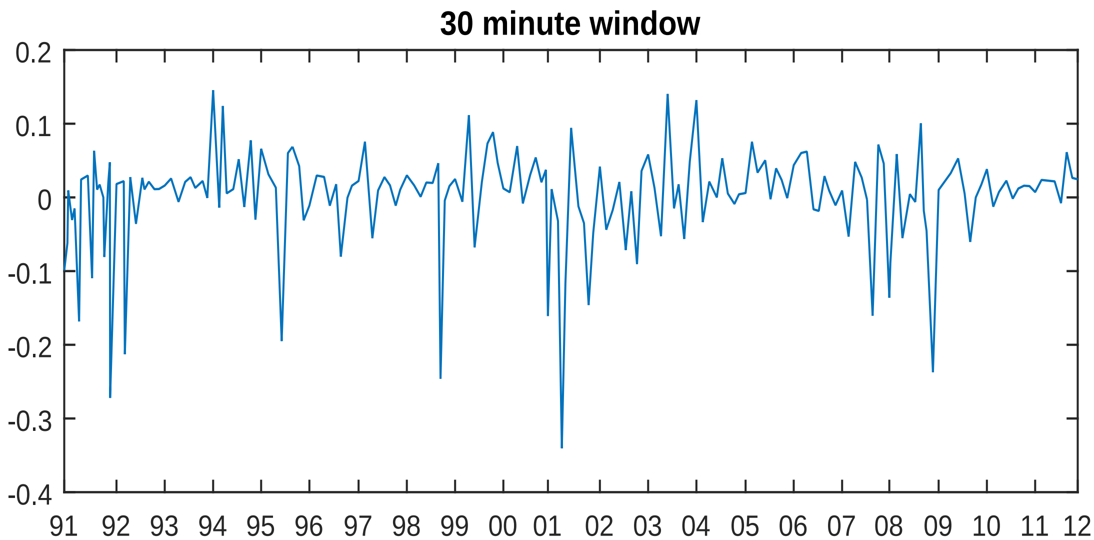
This table reports the response of current excess equity returns and its components to monetary policy shocks. The first column reproduces the BK results estimated on the sample 5/1989 to 12/2002. The remaining three columns use the baseline data sample of 2/1991 to 12/2011. Delta method standard errors are in parentheses.

Table 2.11: Response of Excess Returns on Unscheduled/Turning Point Meetings

	Exog	Delphic	Unsch/TP Dum	Exog x Unsch/TP	Delphic x Unsch/TP
	$\widetilde{\phi}_1$	$\widetilde{\phi}_2$	$\widetilde{\phi}_3$	$\widetilde{\phi}_4$	$\widetilde{\phi}_5$
Current Excess Ret.	-19.05	-21.13	0.35	3.61	34.67
	(6.13)	(14.19)	(1.09)	(14.02)	(27.94)
Future Excess Ret.	5.35	9.66	-0.01	-1.89	-31.14
	(2.98)	(5.15)	(0.34)	(4.47)	(8.72)
Real Interest Rate	1.17	0.44	0.12	3.21	1.70
	(0.74)	(1.73)	(0.13)	(1.65)	(3.29)
Dividends	-12.52	-11.03	0.45	4.93	5.23
	(5.98)	(13.00)	(1.01)	(13.06)	(25.83)

This table reports the response of current excess equity returns and its components to monetary policy shocks interacted with the unscheduled/turning point dummy. The dummy equals 1 on dates for which the FOMC decision was unscheduled or reversed the previous direction of policy. Delta method standard errors are in parentheses.

Figure 2.1: Monetary Policy Surprise



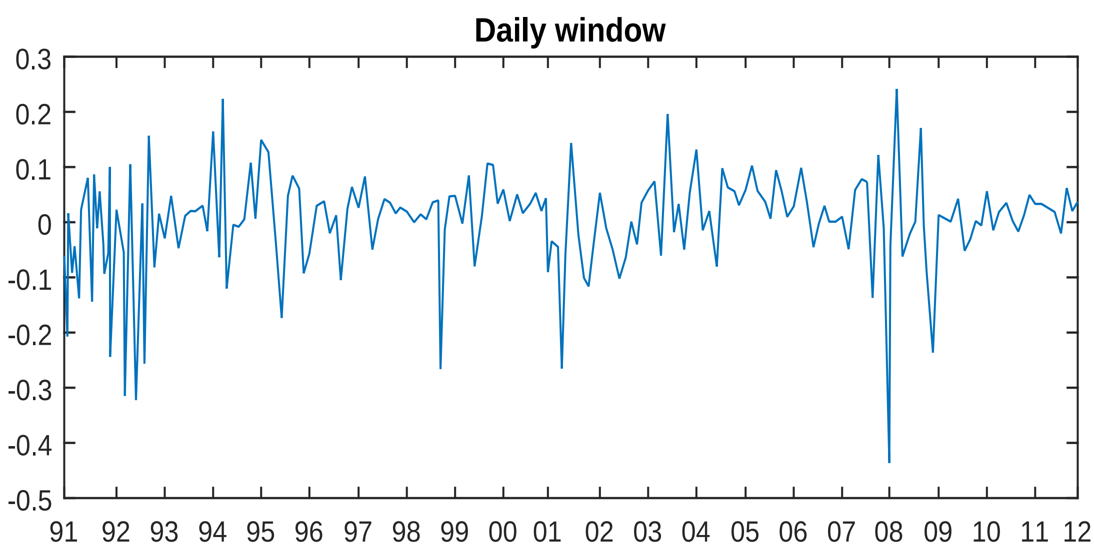


Figure 2.2: Private Information Variables

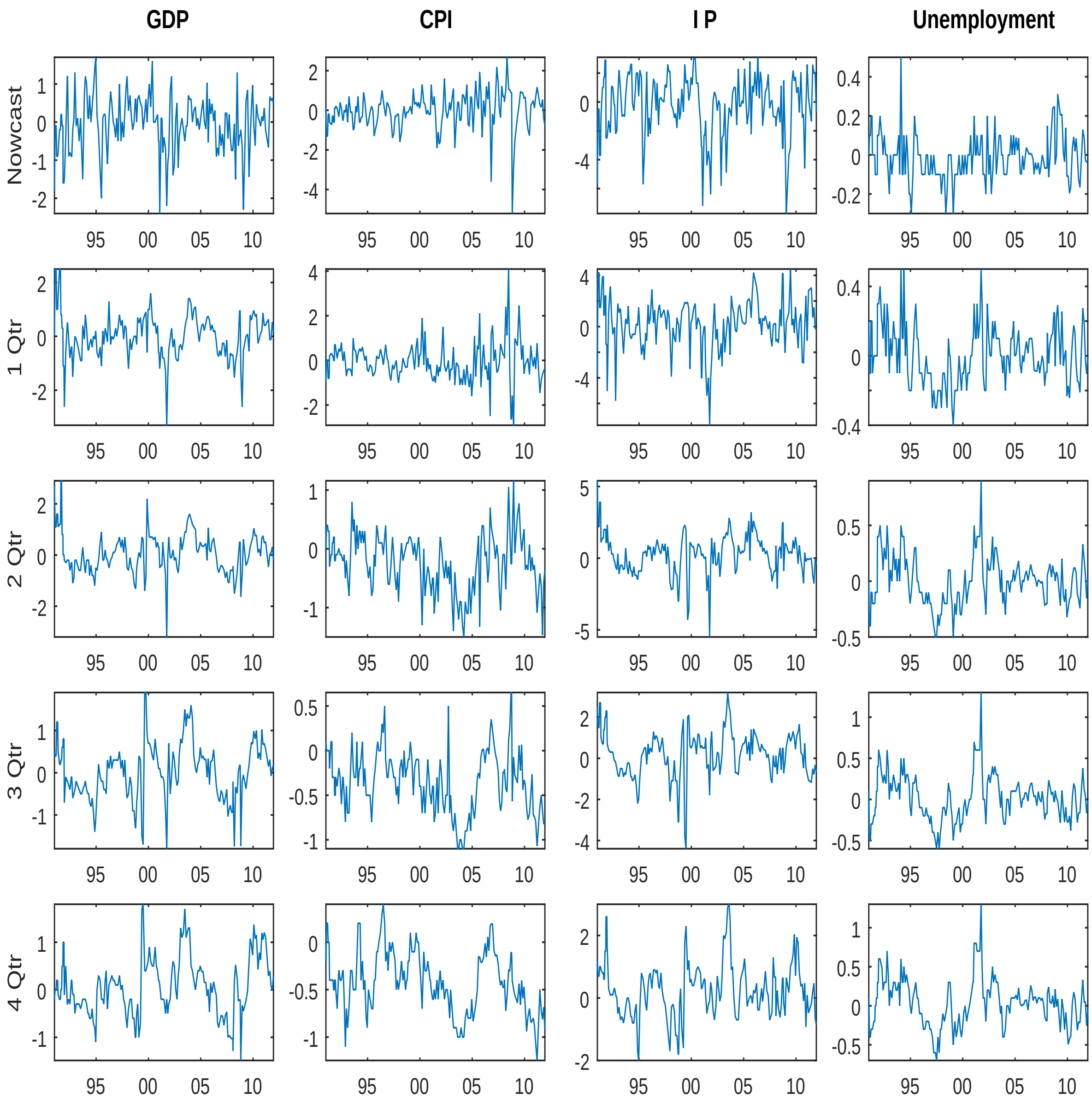


Figure 2.3: Stock Returns vs Monetary Policy Surprises

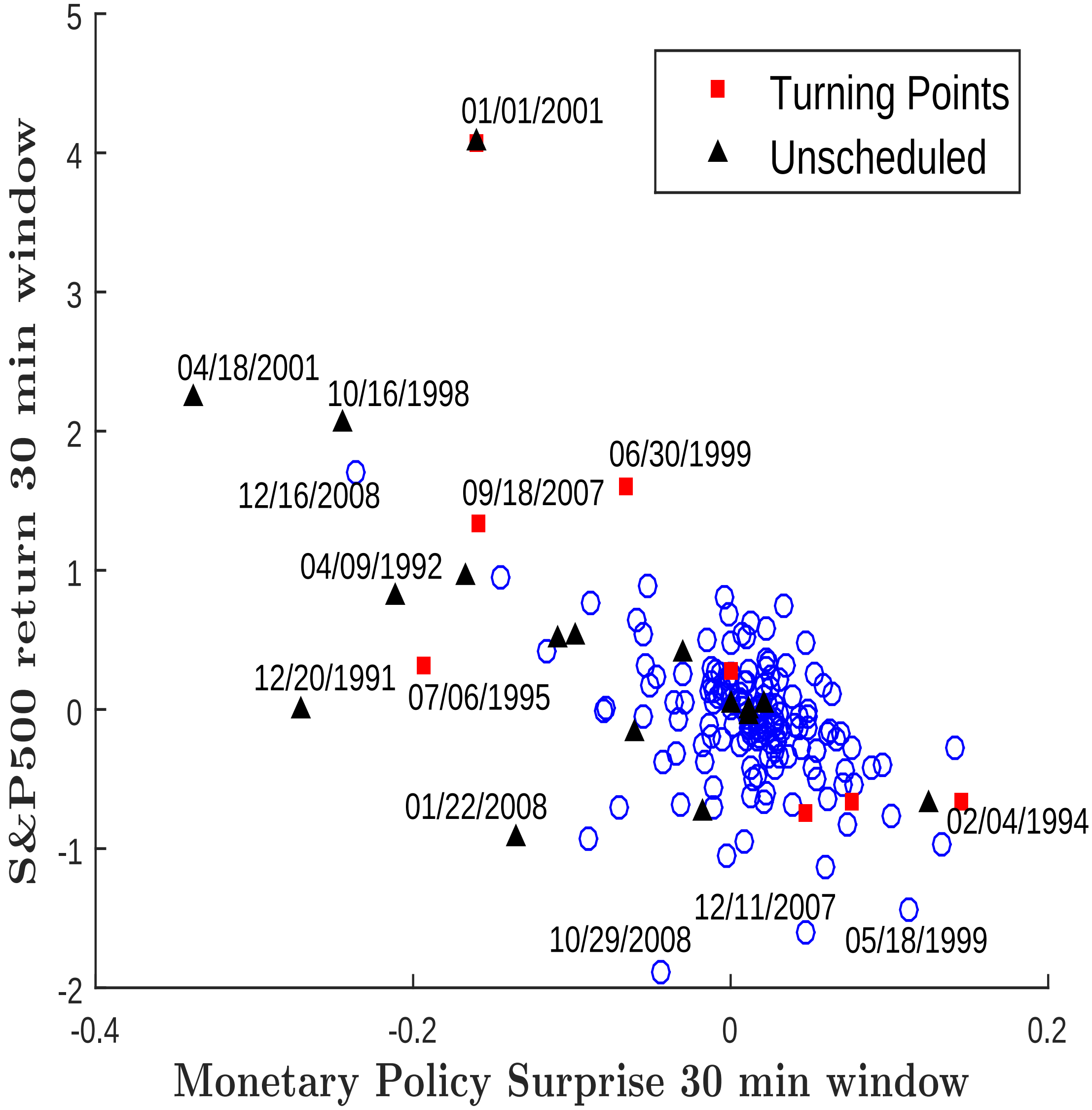
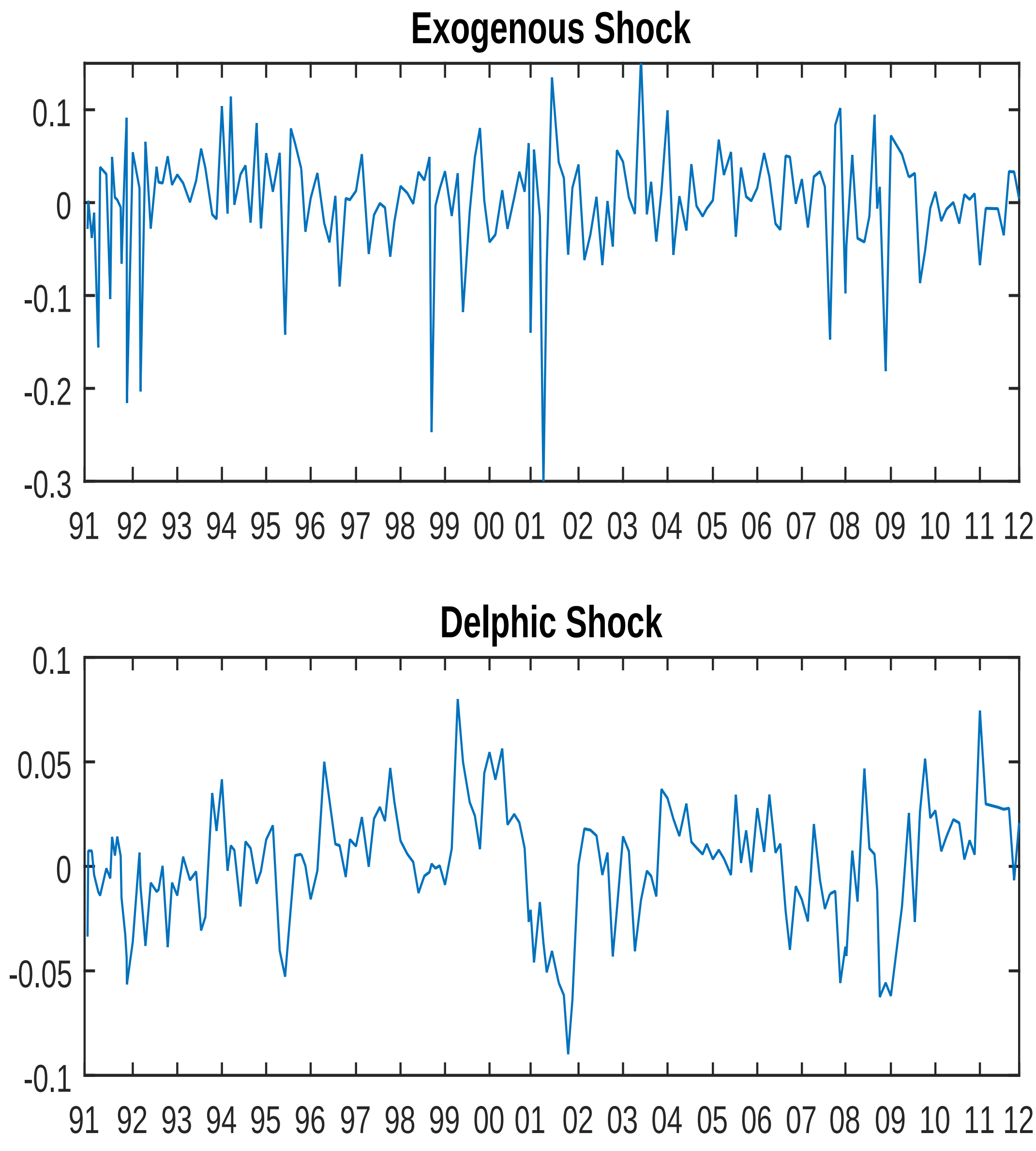


Figure 2.4: Exogenous and Delphic Shocks



CHAPTER 3

REGIONAL RESPONSES TO MONETARY POLICY OVER TIME

3.1 Introduction

The US is a large country with significant geographical diversity. This diversity includes economic activities and conditions. Accounting for and understanding these differences is important for policymakers looking to optimize policy at the national level. Since monetary policy in particular is applied in a one-size-fits-all approach, understanding how each region responds to monetary policy is a significant consideration.

Carlino and DeFina (1998) wrote the seminal paper on differential regional responses to monetary policy shocks in the United States. Their analysis showed that real personal income in five of the eight BEA regions do not have a statistically different response to policy shocks than aggregate US real personal income does. On the other hand, three regions were shown to have significantly different responses. The sample used in Carlino and DeFina (1998) ended in 1992, highlighting a need to update their results. Additionally, evidence that the effects of monetary policy have changed over time, as presented in Boivin, Kiley, and Mishkin (2010) among others, makes this task especially imperative. Beyond updating the data used, it is also possible to update the empirical method.

Carlino and DeFina (1998) estimate a ten variable VAR through recursive identification. Recent papers such as Faust, Swanson, and Wright (2004b) have called into question the legitimacy of VAR identification schemes which impose zero contemporaneous effect restrictions. Additionally, the somewhat arbitrary ordering of the variables in a recursive VAR can have a significant effect on the resulting impulse responses. These issues can both be overcome through external instrument identification.

The role of various channels in transmitting monetary policy at the regional level is investigated as well. Carlino and DeFina (1998) along with other papers in the literature have consistently found evidence of a regional interest rate channel. Taking a similar approach, we analyze whether evidence for this channel holds for a more recent period of time. Additionally we explore whether evidence for a credit channel, broad or narrow, can be found. Further, we examine the relationship between state-level effects of monetary policy and state-level industry shares of nonfarm employment.

3.2 Previous Literature

As noted in the introduction, Carlino and DeFina (1998) is the original paper in this literature. Their sample period is 1958-1992 and they investigate the response of regional real personal income to a monetary policy shock. Their regions are defined by the Bureau of Economic Analysis categorization. The main finding is that five "core" regions – New England, Mideast, Plains, Southeast, and Far West – respond to monetary policy shocks in a statistically equivalent manner to the US aggregate response. Of the three non-core regions, the Great Lakes is significantly more sensitive to a shock while the Southwest and Rocky Mountains are less sensitive.

A ten variable quarterly VAR is used including the fed funds rate, the eight regional measures of real personal income growth, and a measure of the relative price of energy to control for aggregate supply shocks. The same VAR specification is used here, with the only difference being the identification approach. Carlino and DeFina (1998) also attempt to investigate the role of various monetary policy channels in explaining the differential regional responses. They estimate 48 state-level VARs with state real personal income replacing the regional measure. The state personal income responses are regressed upon proxies for the interest rate channel, broad credit channel, and narrow credit channel. The results provide strong evidence of a regional interest rate channel, along with weaker evidence of a broad and narrow credit channel - although the coefficient on the narrow credit channel is the opposite sign than expected.

Owyang and Wall (2003) perform a similar analysis using the BEA measures of regional personal income. They estimate the responses of real regional personal income to a monetary policy shock in a 12 variable VAR including the fed funds rate, CPI, the 10 year treasury rate, a commodity price index, and the eight regional personal income measures, with recursive identification. Their full sample results (1960-2002) show that the Great Lakes region suffers the largest total loss in personal income following a contractionary monetary shock while New England, the Plains, and the Mideast have the smallest responses.

They also split their sample into a pre-Volcker era (1960-1978) and a Volcker-Greenspan era (1983-2002). Total personal income losses are larger in the pre-Volcker era compared to the full sample. On the other hand, personal income losses are much smaller in the Volcker-Greenspan era, with five regions actually seeing total personal income gains over the period. This is in line with Boivin, Kiley, and Mishkin (2010) who find that monetary policy shocks have a weaker effect on real activity at the national level post-1980. Schunk (2005) conducts a similar study to Owyang and Wall (2003) and also reports that the magnitude and differences in state-level responses to monetary shocks have decreased over time.

Owyang and Wall (2003) investigate the roles of the interest rate channel, broad credit channel, and narrow credit channel in explaining the differential regional responses as well. They construct 19 sub-regions from the eight BEA regions and re-estimate their VAR at this sub-regional level. Total personal income loss from each sub-region is regressed on proxies for the three monetary channels as in Carlino and DeFina (1998). For the full sample, all three channels are found to significantly impact the personal income losses resulting from a monetary tightening, although the sign on the narrow credit channel is the opposite of what was expected (indicating regions with a greater share of large banks experience greater personal income losses). For the Volcker-Greenspan era only the interest rate channel is significant in determining personal income loss following a monetary tightening.

Two other related studies are Kouparitsas (2001) and Crone (2005). Kouparitsas (2001) estimates a ten variable VAR similar to Carlino and DeFina (1998), albeit with different identifying restrictions, which includes real personal income from the eight BEA regions, the fed funds rate, and oil prices for the sample 1969-2001. His results show the Great Lakes, Plains, and Rocky Mountains to be the region's most sensitive to monetary policy shocks while the Southwest is reported as the least sensitive.

Crone (2005) estimates a VAR for the sample 1959-1993 that is identical to Carlino and DeFina (1998) other than the definitions of regions used. He constructs a new set of regions based on state business cycle patterns. His results show that his Great Lakes region (which is similar to the BEA Great Lakes region) is the most sensitive to monetary policy shocks while what he calls the Energy Belt (which is made up of portions of the BEA's Southwest and Rocky Mountains regions) is the least sensitive.

Beckworth (2010) estimates a state-level VAR which includes a national coincident indicator (a measure of real economic activity published by the Philadelphia Fed), CPI, PPI, and 48 state national coincident indicators for the sample 1983-2008. Using state coincident indicators rather than state personal income allows for differential regional prices to be accounted for, since personal income can only be deflated by national CPI. Overidentifying restrictions are used to surmount the degrees of freedom problem. The results are quite similar to Crone (2005) as the states least sensitive to monetary policy shocks tend to be from the so-called Energy Belt (mostly Southwest and Rocky Mountains) while the most sensitive states tend to be from the so-called Rust Belt (mostly Great Lakes).

Crone et al. (2007) provides a nice summary of the relevant studies: "the area around the Great Lakes is one of the regions most affected by shocks to monetary policy. Regions with a large proportion of their economic activity derived from energy are among the least affected, whether this is the Southwest as in the traditional BEA definition of regions or the Energy Belt as I have defined it." Additionally, as far as investigations into the role of monetary policy channels have gone, "differences in industry mix (interest rate channel) are the only explanation that has found consistent support in economic studies of regional differences in the effects of monetary policy."

3.3 Estimation

As the previous section discusses, other researchers have attempted updating Carlino and DeFina (1998). The fact that these investigations have yielded relatively consistent results is encouraging. Here we will attempt to improve on the past literature by re-estimating the baseline

VAR from Carlino and DeFina (1998) using the longest available sample (1958:Q1 – 2015:Q2) and an external instruments identification strategy.

The previous studies in this literature all rely on recursive identification assumptions. As is well known, impulse responses produced by recursive VARs can be sensitive to the somewhat arbitrary choice of how the endogenous variables are ordered within the system. Additionally, the most common recursive structure orders the federal funds rate last, which in the context of a quarterly VAR has the interpretation that a shock to the fed funds rate will not impact the real variables in the system until a full three months has passed. The validity of such an assumption has been questioned in recent years in papers such as Faust, Swanson, and Wright (2004b).

The external instruments approach can alleviate the problems associated with arbitrary variable ordering and zero contemporaneous effect assumptions. Developed by Stock and Watson (2012) and Mertens and Ravn (2013), the approach has been applied in a similar monetary context by Gertler and Karadi (2015b). Rather than relying on a recursive ordering of the endogenous variables, it achieves identification by exploiting the information contained in a series of exogenous monetary policy shocks. For a detailed, yet accessible explanation of the method see Mertens and Ravn (2013). The measure of exogenous monetary policy shocks used here will be the Romer and Romer (2004) (R&R) shock series. This series identifies monetary policy shocks as innovations to the fed funds rate which are uncorrelated with the Greenbook forecasts made prior to each FOMC meeting (see Romer and Romer (2004)).

We use the same ten variable VAR as Carlino and DeFina (1998) which includes: the effective fed funds rate, real personal income growth in each of the eight BEA regions, and a measure of relative energy prices (the PPI for fuels and related products relative to total PPI). The R&R shock measure is used as an instrument to identify unanticipated innovations to the fed funds rate. We first estimate cumulative impulse responses for the entire 226 quarter sample. Next, we split the sample with the early period being 1958:Q1 – 1992:Q4 and the recent period being 1993:Q1 – 2015:Q2. This will be instructive for two reasons. First, comparing our early period results with those of Carlino and DeFina (1998) will allow us to see whether any differences arise from using the external instruments approach rather than a recursive one. Second, comparing our early period and recent period results will allow us to see how regional responses to monetary policy have changed over time.

3.4 Results

3.4.1 Full Sample

Figure 3.1 displays the cumulative impulse response functions for the full sample. Statistical equivalence of each regional response with the national response is tested using a two sample t-test. Five regions – the Far West, Plains, Rocky Mountains, Southeast, and Southwest – are found to respond to monetary policy shocks in essentially the same manner as the nation as a whole. Three regions – the Great Lakes, Mideast, and New England – are found to have significantly different responses than the national. The Great Lakes response is the most severe of all the regions while the Mideast and New England have the mildest responses. The F-statistic from the first stage regression of the fed funds rate residual on the R&R shocks is 11.01, which is above the common cut off point of 10 and therefore indicates that we needn't be concerned with relevancy issues.

There are interesting comparisons here to Carlino and DeFina (1998). Three regions have responses significantly different from the national in both, with the Great Lakes being the only region to have a more severe response. The two regions having weaker responses are different between the two sets of results, as it's the Southwest and Rocky Mountains in Carlino and DeFina (1998) versus the Mideast and New England here. It is interesting to note that the Rocky Mountains have the second most severe response after 5 years in our results. The Southeast, Far West, and Plains have responses equivalent to the national in both. The magnitude of personal income lost is very similar for both sets of results as well. After five years national personal income loss is about 0.8% lower in Carlino and DeFina (1998) compared to 1.1% lower here, while the Great Lakes loss is about 1.3% in each.

3.4.2 Early Sample

Figure 3.2 presents the cumulative impulse response functions for the early sample, 1958:Q2 – 1992:Q4. This is the sample originally estimated in Carlino and DeFina (1998). The F-statistic here is 50.13, indicating that the R&R shocks are very strong instruments for this time period. Once again, three regions have responses significantly different from the national with the Great Lakes having the strongest. The Southeast response is also significantly stronger than the national in this period while the Southwest is the only region to have a significantly weaker reaction.

These results are qualitatively similar to Carlino and DeFina (1998), as the Great Lakes has the most sensitive response and the Southwest has the least sensitive response in each. The reactions of the Plains, Mideast, New England, and Far West are equivalent to the national response in each as well. The results here show a much larger magnitude of personal income lost however. The total loss after 5 years for the Great Lakes region is 2.6% - which is twice as large as Carlino and DeFina's estimate. In fact, the cumulative loss is at least double for every region (and nationally) except for New England, which increases from 0.8% in Carlino and DeFina (1998) to about 1.3% here.

3.4.3 Recent Sample

Figure 3.3 displays the cumulative impulse response functions for the recent period, 1993:Q1 – 2015:Q2. The results here are novel, as no paper measuring regional responses to monetary policy shocks has used a sample going past 2002. We now see a much different pattern in the responses. All regions show an initial negative reaction to an unanticipated monetary tightening with personal income loss hitting a trough after two quarters. After one year each region's response begins rebounding though, with a few even returning to positive gains at that point. After two years none of the regions have a negative total personal income loss, although after five years there is a small total loss for the Far West, Great Lakes, and Southwest.

The magnitude of real personal income lost or gained after five years is small, with the Far West suffering the biggest loss of -0.45% and New England seeing the largest gain at 0.44%. The national response is only negative for the first three quarters and after five years sees a slight gain of about 0.35%. The only regions which have a statistically equivalent response are the Mideast and New England. Importantly, none of the responses - regional or national - are statistically different from zero. These results are in line with Owyang and Wall (2003) who report smaller effects of monetary policy shocks on regional real personal income over time. This is also consistent with Boivin, Kiley, and Mishkin (2010) who find smaller effects of monetary policy on national real activity in the post-1984 period.

One concern with the results for this sample is the F-statistic of 9.16 from the first stage regression, which is slightly below the standard cutoff of 10. This indicates we may have a weak instrument problem. A possible cause of this low F-statistic is the unusual monetary policy environment of the post-2008 United States, where the fed funds rate has been stuck at the zero lower bound. We therefore re-estimate the recent sample from 1984-2008 as a robustness check. These results are presented in Figure 3.4. The general pattern of the results is quite similar and once again each region's response is not statistically different from zero. The F-statistic here increases to a safe 15.32, which reassures that our results are not distorted by a weak instrument.

3.5 Regional Monetary Channels

There is a consensus in the previous literature that manufacturing-intensive states are more responsive to monetary policy shocks on average, indicating that there is an interest rate channel of monetary policy at the regional level. Here we attempt a similar analysis using our more recent dataset. While many channels of monetary policy have been proposed (see Boivin, Kiley, and Mishkin (2010)) the papers in this literature have looked at just three: the interest rate channel, the broad credit channel, and the narrow credit channel.

An interest rate channel works as follows: monetary tightening increases interest rates, which increases the user cost of capital, reduces investment and thus reduces aggregate demand. As a proxy for this channel we will use a state's manufacturing share of total nonfarm employment, since the manufacturing sector tends to be the most interest rate sensitive. A broad credit or balance sheet channel states that monetary tightening should increase the cost of raising external funds, thus decreasing investment and aggregate demand. Since smaller firms tend to face higher borrowing costs than large entities they should be more adversely affected by a monetary tightening. We therefore use a state's share of total employment in firms with less than 100 employees as a proxy. A narrow credit or bank lending channel states that a monetary tightening will decrease the supply of loanable funds available from banks and thus firms reliant on bank credit will either be unable to borrow or may only be able to borrow at a higher cost. This leads to a reduction in investment spending and lowers aggregate demand. Small banks have less access to alternative sources of funding than large banks do so they should be more intensely affected by a monetary tightening working through this channel. Therefore as a proxy we will use a state's share of total bank assets in banks with less than $1 billion in assets.

Due to the consensus in the previous literature for earlier time periods and limitations on the data available for our proxy variables we will only analyze the period 1990-2008 in this section. This is of special interest because, as seen in the previous section, the response of regional personal income to monetary policy shocks over this time has changed significantly from past decades. Thus it will be of interest to see if there are changes in how monetary policy has been transmitted over this period as well.

To achieve sufficient cross-sectional variation we run 48 state-level VARs (leaving out Alaska and Hawaii). Each VAR will include the fed funds rate, the relative energy measure, state real personal income growth, regional real personal income growth for that state's region minus the contribution of the state itself, and national real personal income growth minus the previous variable. This is equivalent to the state-level VARs used in Carlino and DeFina (1998) except we use national personal income growth rather than including personal income growth for each of the seven other regions separately. Once again, we will implement external instrument identification with the R&R shocks as our instrument for fed funds rate innovations.

The state-level cumulative impulse responses are similar to the regional responses analyzed in the previous section, with most states hitting a trough in the second quarter following an unanticipated monetary tightening. Therefore the dependent variable here will be the second quarter cumulative decline in real personal income growth for each state. The three independent variables will be the channel proxies discussed above. The variables are constructed as an average of the annual observations available from 1990-2008 for each. State manufacturing share is available for each of those years, small business share is available for 1992 and then every year of 1997-2008, and small bank share is available for 2000, 2004, and 2008. We run the following regression with our 48 observations:

$$PIresponse_i = \beta_1 + \beta_2 MANUF_i + \beta_3 SMALLBUS_i + \beta_4 SMALLBANK_i + \epsilon_i \tag{3.1}$$

The results are shown in table 3.1. We find that state share of small businesses is the only variable to have any statistical significance, at the 10% level, providing evidence that a regional broad credit channel may exist. The coefficient on small business share tells us that a doubling of a state's share of small firms is associated with an additional 1.5% loss in real personal income growth at the trough following a surprise monetary tightening.

State manufacturing share and small bank share both appear to be insignificant for determining losses to real personal income growth following a shock. Surprisingly, the coefficient on manufacturing share is the opposite of what would be expected. The past literature has found that states with larger manufacturing sectors have significantly larger personal income losses following a monetary tightening, indicating that the coefficient should be negative. The fact that it is positive and insignificant here indicates that the interest rate channel may no longer be operative at the regional level. The coefficient on the small bank share variable is very insignificant, both quantitatively and statistically. This perhaps is not surprising given the increasing centralization of the financial sector over time.

These results are interesting as they suggest that the change in regional responses to monetary policy over time may be attributable to a change in how monetary policy is transmitted. In the past, the interest rate sensitivity of a region's economy is thought to have been the driving factor in differential regional responses, while in the modern era this no longer seems to be the case

3.6 Regional Industry Composition

Another possible explanation as to why regional responses to monetary policy have diminished over time is simply that differences in regional economies have diminished over time. As noted in section 2, Crone et al. (2007) summary of the literature states that, "differences in industry mix are the only explanation that has found consistent support in economic studies of regional differences in the effects of monetary policy." The previous literature, as in our previous section, has only looked at differences in state manufacturing sectors however.

In this section we will investigate the relationship between state-level responses to positive monetary policy shocks and state-level industry shares of total nonfarm employment for seven NAICS/SIC industries. Industry codes changed in 1990 from the old SIC system to the current NAICS codes. This matches up roughly with our two sample periods, and will give us enough observations for the recent period to leave the post-2008 years out. Thus in this section our early sample will be 1958-1989 and our recent sample will be 1990-2008.

We use the same 48 state-level VARs from section 5, this time including the early sample as well. As in section 5, for the recent sample our dependent variable will be the second quarter cumulative decline in real personal income for each state, since that is the trough of the response in most cases. For the early sample the trough does not occur till the twentieth quarter for most states; the decline in real personal income does begin to flatten out after the eighth quarter though, so we will use the eighth quarter response as the dependent variable there.

Using data from the BLS state and metro area employment, hours, and earnings database we construct average share of state nonfarm employment measures for each of the following industries over the respective samples: mining and logging, construction, manufacturing, trade transport and public utilities, financial activities, services, and government. Under the newer NAICS codes an information industry exists that has no close analogue under the old SIC codes. Including the information sector in our recent sample regressions does little to change the results as it is never significant, therefore we leave it out of our main specification to facilitate the comparison. We run the following regression for each sample period:

$$\begin{aligned} PIresponse_i = \beta_1 + \beta_2 MINING_i + \beta_3 CONSTR_i + \beta_4 MANUF_i + \beta_5 TTPU_i + \beta_6 FIN_i \\ + \beta_7 SERV_i + \beta_8 GOV_i + \epsilon_i \end{aligned} \tag{3.2}$$

The results are presented in Table 3.2. In the early sample three industry shares are significantly associated with the eighth quarter cumulative loss of real personal income. A more severe loss is associated with a larger share of nonfarm employment in the manufacturing and service industries. On the other hand, a weaker response is associated with a larger share of employment in the financial sector. The coefficients can be interpreted as follows: a doubling of a state's share of nonfarm employment in, say manufacturing is associated with an additional 2.38% loss in real personal income growth eight quarters after a positive monetary policy shock.

In the recent sample no industry shares are significantly associated with the real personal income loss following a shock. Standard errors are quite large and the closest sector to being statistically significant is mining and logging, however the p-value there is still just 0.18. These results suggest that differential state responses to monetary policy can no longer be explained by industry composition of the states.

One reason for this, as explored in section 5, is that monetary policy has been transmitted to the real economy differently in the recent sample than in the early sample. Another possible explanation however is that there is fewer differences in state-level industry composition in recent decades. Table 3.3 shows the standard deviation of the average industry shares across 48 states over the two samples. As can be seen, the variance in industry employment share of nonfarm labor has declined in six of the seven industries, with finance being the only exception. This means that states have become more similar to one another in industry composition over time.

Differences in the effects of monetary policy at the state level were, but no longer are associated with differences in industry mix. Differences in industry mix have diminished over time as well. A natural implication therefore is that the decrease in differential regional responses to monetary policy over time has been driven by greater similarities in regional industry composition.

To determine which of these explanations holds more power - a change in the transmission mechanism or a change in industry mix - it would be instructive to examine how differential industry responses to monetary policy shocks have evolved over time. If industry responses have not changed drastically over these two samples it would imply that the decrease in differential regional responses is primarily due to a homogenization of state economies. On the other hand, if industry responses have changed significantly it may imply that the monetary policy transmission mechanism has changed over time – in which case such changes may be partially driving the diminishing regional differences. This is an interesting avenue for further study.

3.7 Conclusion

Investigations into US regional responses to monetary policy shocks have produced an interesting literature over the past two decades. This paper has updated the seminal contribution of Carlino and DeFina (1998) by adding over 20 years of additional data and employing a cutting edge identification strategy. Our results for the early sample are consistent with the past literature, as we find real personal income growth in the Great Lakes region to respond most sensitively to monetary policy shocks while real personal income growth in the Southwest region responds least sensitively.

Our most interesting results are from the recent sample. The estimated responses show very little reaction to a monetary policy shock for any region. Additionally, the differences among the regional responses are negligible as none are statistically different from zero over 20 quarters. This result is consistent with Boivin, Kiley, and Mishkin (2010) which finds that the impact of monetary policy on real variables at the national level has been declining over time. Additionally, it supports the argument from **?** that choice of sample period is important for estimating regional responses to monetary policy. Just looking at our full sample results could lead to very inaccurate conclusions if one is concerned with the impact of monetary policy on regional personal income today.

Our results have a policy implication as well. Monetary policy shocks appear to have little to no effect on regional real personal income in the present era. Thus Federal Reserve officials may be able to disregard regional level effects when making policy decisions. It is unclear whether officials have actually given weight to such regional effects in the past - nonetheless knowledge of the existence of such differences was surely valuable. For the last two decades however it appears that these differences, in real personal income at least, have largely vanished.

We explore the role of three different monetary policy channels in explaining the regional responses. We find some evidence of a broad credit channel operating at the regional level. Just as importantly, we find no evidence of an interest rate channel, which contradicts the results of past papers studying earlier periods. This suggests that the reduction in magnitudes and differences among regional responses over time may be due to a change in the way monetary policy is transmitted to the real economy. Alternatively, we also find evidence that the diminished regional differences may be driven by a homogenization of industry composition across the regions. Disentangling these two causes is a promising avenue for future research.

APPENDIX

Table 3.1: State-Level Monetary Policy Channels

Variable	
Intercept	0.17
	(0.31)
State Manufacturing Share	0.96
	(0.72)
State Small Business Share	-1.52*
	(0.83)
State Small Bank Share	0.00
	(0.31)
R-Squared	0.16

The dependent variable is the 2nd quarter cumulative response of state real personal income growth to a contractionary monetary policy shock. Robust standard errors are in parentheses. * indicates statistical significance at the 10% level.

Table 3.2: State-Level Monetary Policy Response and Industry Shares

Variable	**Early Sample (1958-1989)**	**Recent Sample (1990-2008)**
Mining & Logging	6.00	-8.49
	(4.20)	(6.28)
Construction	1.32	0.72
	(5.93)	(8.99)
Manufacturing	-2.38**	-5.48
	(1.12)	(7.99)
Trade, Transportation & Utilities	-0.01	-9.33
	(2.10)	(8.93)
Financial Activities	14.91**	-7.50
	(6.53)	(10.63)
Services	-2.31***	-7.35
	(0.77)	(8.77)
Government	-2.73	-10.61
	(1.87)	(9.86)
Intercept	-0.32	7.38
	(1.20)	(8.54)
R-Squared	0.41	0.34

Robust standard errors in parantheses. ** indicates statistical significance at the 5% level. *** indicates statistical significance at the 1% level.

Table 3.3: State Industry Share Standard Deviations

Industry	**M&L**	**Const**	**Manuf**	**TTPU**	**Finance**	**Services**	**Govt**
Early Sample	0.02	0.01	0.47	0.03	0.01	0.05	0.04
Recent Sample	0.01	0.01	0.04	0.01	0.01	0.04	0.03

This table shows the standard deviation of employment share in each of the major sectors across states for the early and recent samples.

Figure 3.1: Cumulative Response to Monetary Policy Shock (1958.Q1-2015.Q2)

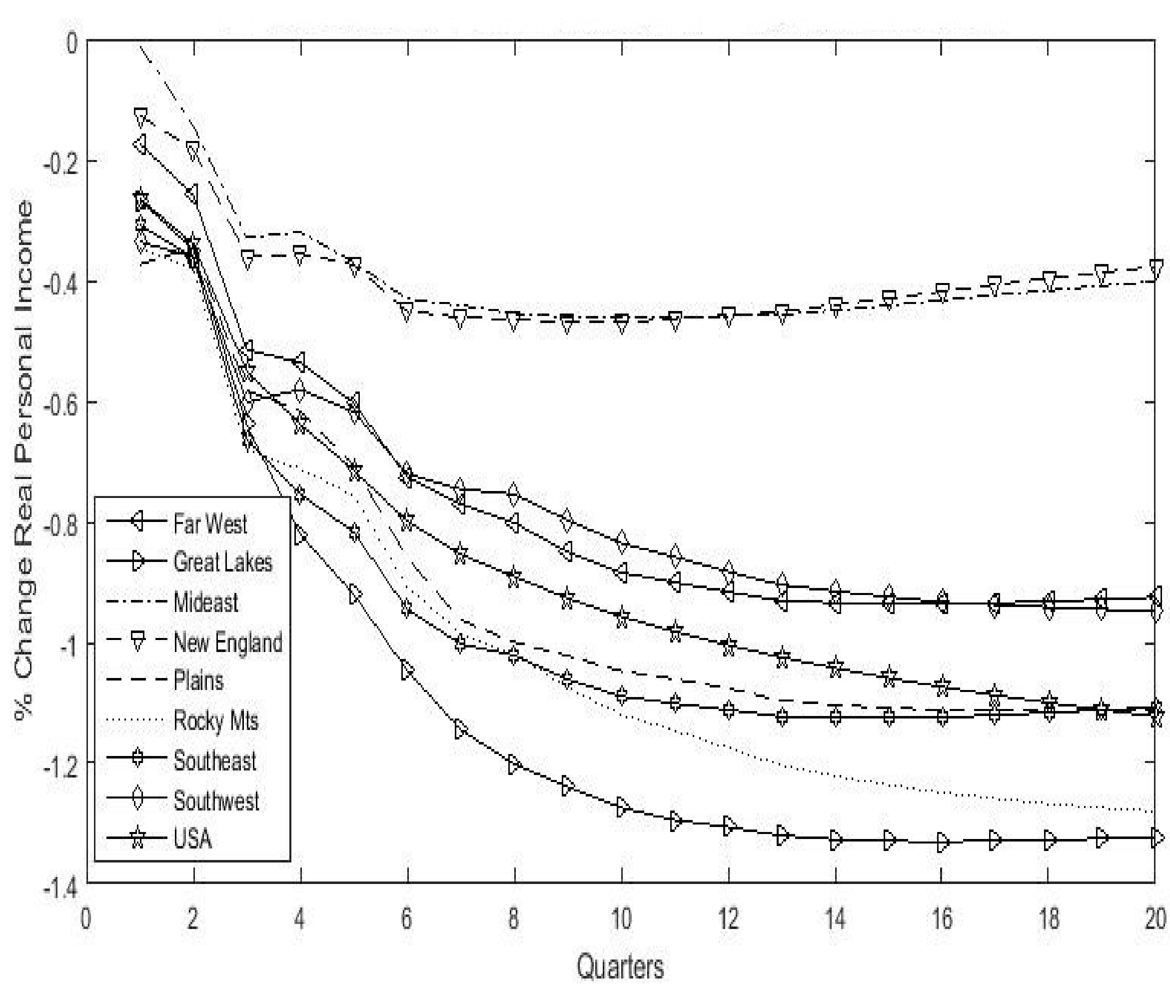


Figure 3.2: Cumulative Response to Monetary Policy Shock (1958.Q1-1992.Q4)

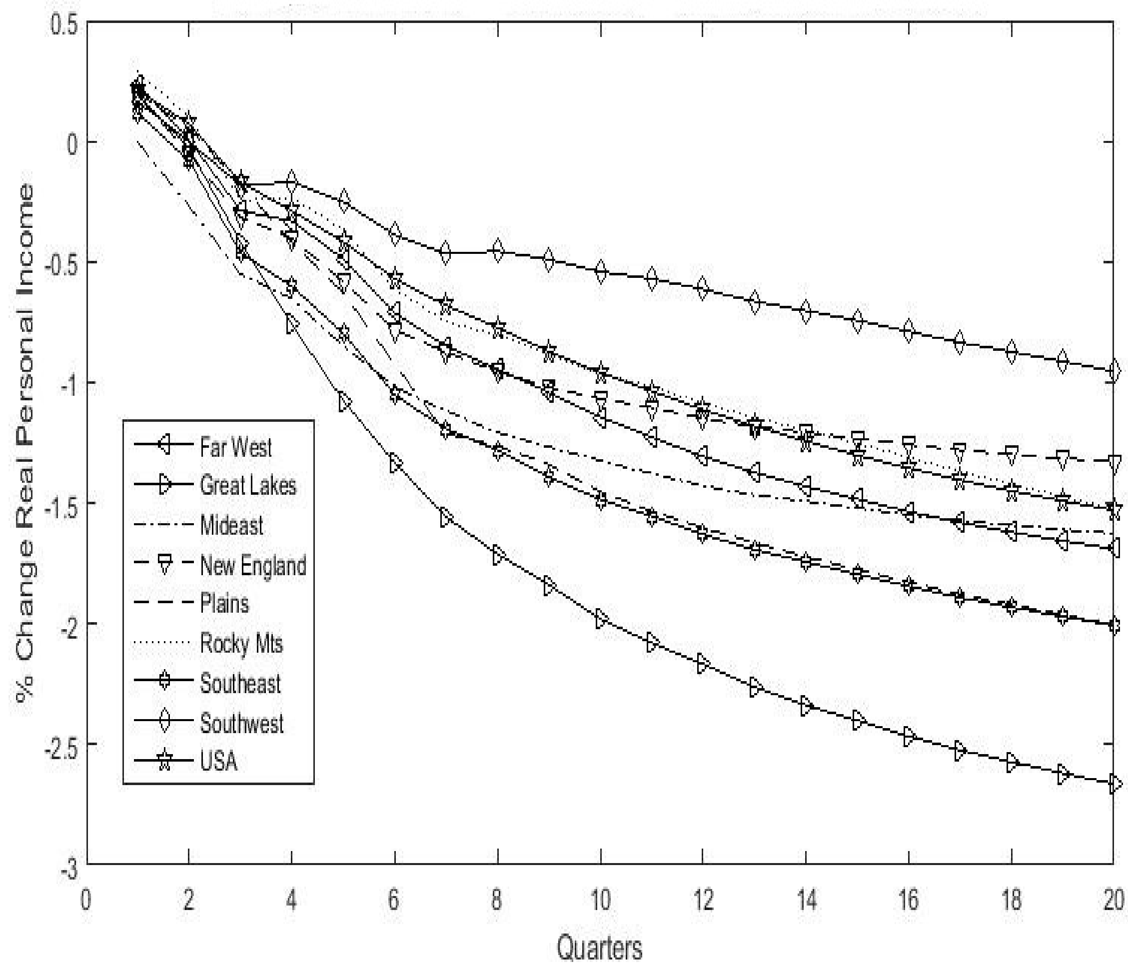


Figure 3.3: Cumulative Response to Monetary Policy Shock (1993.Q1-2015.Q2)

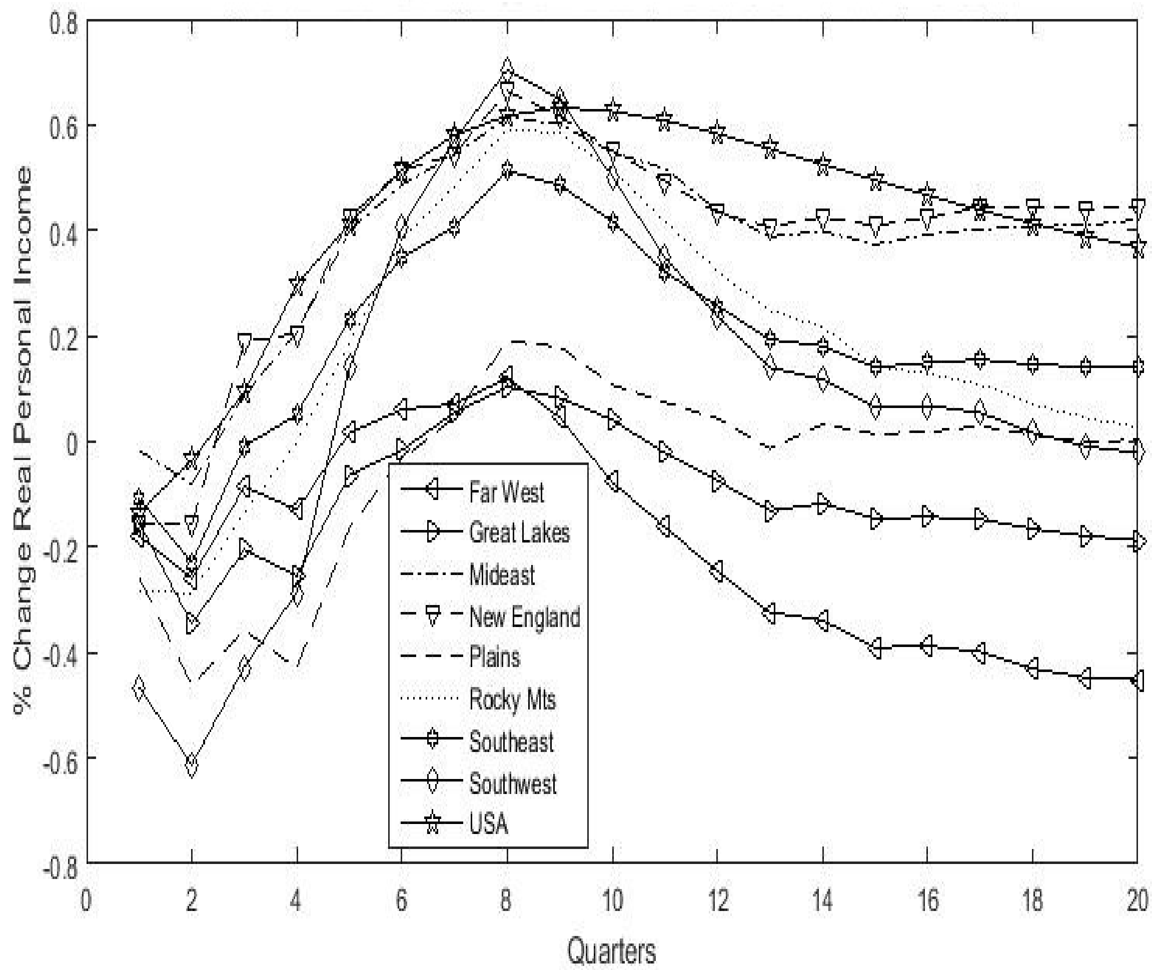
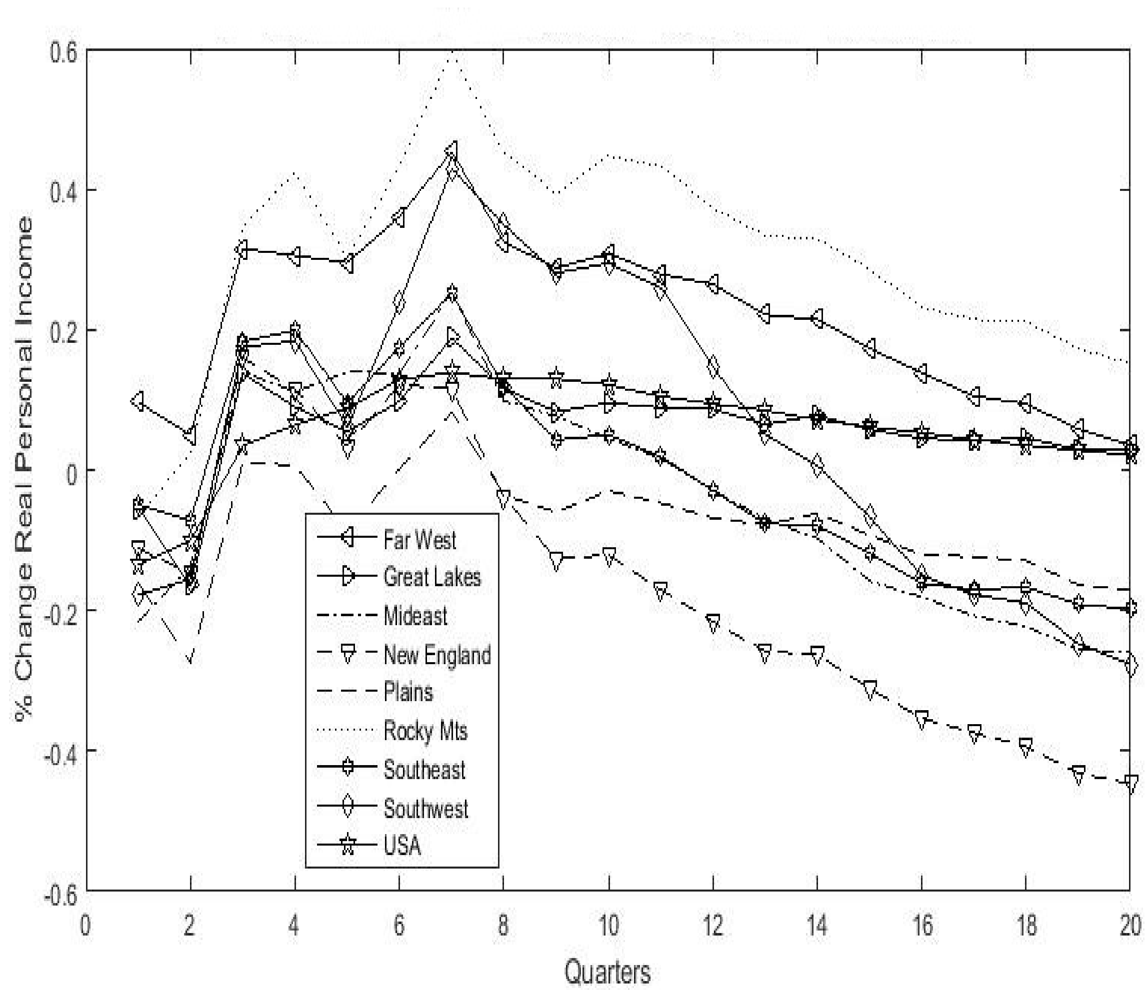


Figure 3.4: Cumulative Response to Monetary Policy Shock (1984.Q1-2008.Q4)



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