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Changes in Monetary Policy and the Variation in Interest Rate Changes Across Credit Markets

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The conduct of monetary policy is most often interpreted in terms of the federal funds target rate set by the Federal Open Market Committee (FOMC), at least until recently when this rate effectively reached its zero bound and additional actions were then implemented. The federal funds rate is the interest rate at which private depository institutions, typically banks, lend balances held with the Federal Reserve to other depository institutions overnight. By targeting a particular value for that rate, the Federal Reserve seeks to adjust the liquidity provided to the banking system through daily operations. Because the federal funds rate applies to overnight transactions between financial institutions, it represents a relatively risk-free rate. As such, it serves to anchor numerous other interest rates that reflect a wide array of credit transactions throughout the U.S. economy, such as deposits, home loans, and corporate loans.

Because the federal funds rate anchors interest rates in many different types of credit transactions, monetary policy actions that move the funds rate in a given direction are expected to move other interest rates in the same general direction. However, the extent to which changes in the federal funds rate affect conditions in different credit markets may vary significantly from market to market. For example, changes in the federal funds rate may be closely linked to changes in the three-month Treasury bill rate, but potentially less so to changes in home loan rates. In that sense, changes in monetary policy,

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as reflected by broad liquidity adjustments through the federal funds market, will be more effective in influencing credit conditions in some markets than others. Thus, this article attempts to assess empirically the extent to which interest rate changes in various credit markets reflect changes in monetary policy. It also explores whether these relationships have changed over time.

As a first step, we construct a panel of 86 time series spanning a diverse set of monthly interest rate changes, including Treasury bill rates, corporate interest rates, repurchase agreement rates, and mortgage rates, among others. The panel of interest rate changes covers the period July 1991–December 2009. The empirical framework then uses principal component analysis to characterize co-movement across these interest rate changes. The basic intuition underlying the exercise is as follows: If changes in monetary policy tend to move a broad array of interest rates in the same general direction, then changes in these interest rates will share some degree of co-movement.

Having characterized the common variation in interest rates using principal components, we ask two questions. First, looking across all interest rate changes, which series tend to be mostly driven by common changes in interest rates rather than idiosyncratic considerations? In particular, idiosyncratic changes in a given interest rate series are orthogonal to the principal components and, therefore, unlikely to reflect a common element such as a change in monetary policy. Therefore, one expects that monetary policy will have only a limited effect on interest rates in which changes are mostly idiosyncratic. Second, recognizing that the common variation across interest rate changes may reflect a broad set of aggregate factors, how closely is the common change component of each interest rate series (which may play a more or less important role in the characterization of different interest rates) related to changes in monetary policy? Furthermore, has this relationship changed over time?

Our results indicate that most of the variation across our sample can be explained by a small number of common components. For most credit markets, including mortgage, repurchase agreement, Treasury, and London Interbank Offered Rate (LIBOR) rates, four components explain approximately 70 percent or more of the variation in interest rate changes. One notable exception is the auto loan market, in which interest rate variation is almost entirely idiosyncratic. For most of the series in our sample, the common variation in interest rate changes is relatively highly correlated with the federal funds rate. This suggests that common movements in interest rates reflect, to a large extent, changes in monetary policy, as defined by the federal funds rate, rather than other aggregate disturbances. That said, there nevertheless remains a moderate number of rates for which the common components, while explaining a significant portion of their variability, are not highly correlated with the federal funds rate. We interpret this finding in mainly two ways. First, these rates, which include corporate bond and mortgage rates, are driven to a greater degree by aggregate factors that may be somewhat disconnected from monetary policy. Second, these rates, to the extent that they include longer term rates, reflect monetary policy more indirectly through changes in expected future short rates. For example, changes in beliefs regarding future productivity will likely affect the perceived path of future federal funds rates.

The rest of this article is organized as follows. In Section 1, we review the relevant literature. Section 2 outlines the principal component methodology and calculations used in our analysis. Section 3 describes the data set used in the empirical work. Section 4 presents our findings, while Section 5 offers concluding remarks.

1. LITERATURE REVIEW

Several recent papers have utilized principal component analysis or similar techniques to explore the behavior of various interest rates and macroeconomic variables over time. Diebold, Rudebusch, and Aruoba (2006) and Bianchi, Mumtaz, and Surico (2009), among others, use a latent factor model to explore the interaction between yield curves and several macroeconomic variables, including a monetary policy instrument. The approach used is similar to using principal components to obtain the factors; however, it differs in that principal component analysis requires factors to be orthogonal to each other, but remains agnostic about the form of the factor loadings. The models used in these and other papers restrict the factor loadings by extending an approach for modeling yield curves from Nelson and Siegel (1987). These papers have also restricted their attention to government bond yields.

Perhaps more closely related to our paper is Knez, Litterman, and Scheinkman (1994). This article investigates the behavior of money market instruments utilizing a factor model that is less restrictive on the loadings than the previous papers discussed. The authors find that much of the total variation in their data set can be explained by three or four factors, and that each factor can be interpreted as a parameter that characterizes systematic movements in the yield curve. It differs from our analysis in that the data set used is much narrower, including only Treasury bills, commercial paper, certificates of deposit, Eurodollar deposits, and bankers' acceptances, all with maturities of less than one year. Additionally, they examine the returns of these securities, whereas we analyze the changes in interest rates across a variety of credit markets.

Finally, Gürkaynak, Sack, and Swanson (2005) and Reinhart and Sack (2005) examine the immediate impact of a variety of forms of FOMC communication on several financial variables, including interest rates, equity prices, and others. They use principal components to extract common components from a set of changes in these variables around FOMC statements, testimonies, and other releases. They find that a small number of factors appears to explain a significant amount of the variation in response to all types of FOMC communication. Our analysis does not limit itself to changes in interest rates around FOMC communication, and explores a broader array of rates than these two articles.

2. PRINCIPAL COMPONENTS

Consider a panel of (demeaned) observations on interest rate changes across N credit markets over T time periods, which we summarize in an $N \times T$ matrix, X. Let X_t denote a column of X (i.e., a set of observations on all interest rate changes at date t). As explained in Malysheva and Sarte (2009), the nature of the principal component problem is to ask how much independence there really is in the set of N variables. To this end, the principal component problem transforms the Xs into a new set of variables that will be pairwise uncorrelated and of which the first will have the maximum possible variance, the second the maximum possible variance among those uncorrelated with the first, and so on.

We denote the jth principal component of X by f_j, where

$$f_j = \lambda_j' X, \tag{1}$$

and λ_j' and f_j are $1 \times N$ and $1 \times T$ vectors, respectively. In other words, different principal components of X simply reflect different linear combinations of interest rate changes across sectors. Moreover, the sum of squares of a given principal component, f_j, is

$$f_j f_j' = \lambda_j' \Sigma_{XX} \lambda_j, \tag{2}$$

where $\Sigma_{XX} = XX'$ represents the variance-covariance matrix (when divided by T) of interest rate changes in the data set.

Let $\Lambda_k = (\lambda_1, ..., \lambda_k)$ denote an $N \times k$ matrix of weights used to construct the first k principal components of X, $f_1, .., f_k$, which we arrange in the $k \times T$ matrix $F_k = (f_1', ..., f_k')'$. Thus, $F_k = \Lambda_k' X$ and the principal component problem is defined as choosing sets of weights, Λ_k, that solve

$$\max_{\Lambda_k} \ \Lambda_k' \Sigma_{XX} \Lambda_k \text{ subject to } \Lambda_k' \Lambda_k = I_k. \tag{3}$$

The solution to the above problem has the property that each set of weights, λ_j, solves[1]

$$\Sigma_{XX} \lambda_j = \mu_j \lambda_j, \tag{4}$$

where $\lambda_j' \lambda_j = 1 \, \forall j$. Put another way, the sets of weights that define the different principal components of X in equation (1) are eigenvectors, λ_j, of the the variance-covariance matrix of interest rate changes, Σ_{XX}, with corresponding eigenvalues given by μ_j. In addition, because the variance-covariance matrix

[1] See the Appendix in Malysheva and Sarte (2009).

of X is symmetric, these eigenvectors are orthogonal to each other, $\lambda_j'\lambda_i = 0$ $\forall i \neq j$.

Combining equations (2) and (4), note that

$$f_j f_j' = \lambda_j' \mu_j \lambda_j = \mu_j. \tag{5}$$

Therefore, the eigenvalue μ_j is the sum of squares of the principal component f_j in (2). Then, given that principal components are ranked by the extent of their variance, the first such component, f_1, is obtained using the weights, λ_1', associated with the largest eigenvalue of Σ_{XX}. The second principal component is obtained using the weights corresponding to the second largest eigenvalue of Σ_{XX}, and so on.

Proceeding in this way for each of the N principal components of X using the weights given by (4), observe that

$$\Lambda_N' \Sigma_{XX} \Lambda_N = \begin{bmatrix} \mu_1 & 0 & ... & 0 \\ 0 & \mu_2 & ... & 0 \\ 0 & 0 & ... & \mu_N \end{bmatrix}. \tag{6}$$

If the rank of Σ_{XX} were $k < N$, there would be $N - k$ zero eigenvalues and the variation in interest rate changes would be completely captured by k independent variables. In fact, even if Σ_{XX} has full rank, some of its eigenvalues may still be close to zero so that a small number of (or the first few) principal components may account for a substantial proportion of the variance of interest rate changes.

The Appendix at the end of the article shows that the principal component problem defined in (3) can be derived as the solution to the least square problem

$$\min_{\{f_1,\ldots,f_k\}_{t=1}^T, \Lambda_k} T^{-1} \sum_{t=1}^{T} e_t' e_t \text{ subject to } \Lambda_k' \Lambda_k = I_k, \tag{7}$$

where

$$X_t = \Lambda_k F_{k,t} + e_t. \tag{8}$$

Hence, it follows that

$$\Sigma_{XX} = \Lambda_k \Sigma_{FF} \Lambda_k' + \Sigma_{ee}, \tag{9}$$

where $\Sigma_{FF} = F_k F_k'$, in which case we can think of the principal components as capturing some portion $\Lambda_k \Sigma_{FF} \Lambda_k'$ of the variation in interest rate changes, Σ_{XX}.

Given the decomposition expressed in (8), each interest rate change in the data set can be written as

$$\Delta r_t^i = \Lambda_k^i F_{k,t} + e_t^i, \tag{10}$$

where Λ_k^i is the ith row of Λ_k. In that sense, $\Lambda_k^i F_{k,t}$ captures the importance of the principal components in driving each individual series. The objective of the article then is to address two key aspects of interest rate changes.

First, having computed a set of principal components, $F_{k,t}$, that account for most of the fraction of the variation in the Xs, we wish to assess the extent to which a given series of interest rate changes, Δr_t^i, is driven by these components rather than its own disturbance term, e_t^i. The important consideration here is that the principal components, $F_{k,t}$, in (10) are common to all interest rate changes (i.e., they do not depend on i) and, therefore, will be directly responsible for co-movement across interest rate changes. In contrast, even if there remains some covariation across the shocks, e_t^i, this covariation will, by construction, play a larger role in explaining idiosyncratic variations in interest rate changes. In that sense, changes in monetary policy will more likely be reflected in the co-movement term $\Lambda_k^i F_{k,t}$ in equation (10) rather than e_t^i.

Formally, we compute how much of the variance of Δr_t^i, denoted $\sigma^2_{\Delta r_{it}}$, is explained by the variance of $\Lambda_k^i F_{k,t}$,

$$R_i^2(F) = \frac{\Lambda_k^i \Sigma_{FF} \Lambda_k^{i\prime}}{\sigma^2_{\Delta r_{it}}}. \tag{11}$$

The series of interest rate changes with $R_i^2(F)$ statistics close to 1 are driven almost entirely by forces that determine mainly the covariation across interest rate changes. In contrast, series of interest rate changes with $R_i^2(F)$ statistics close to zero generally reflect considerations that are likely more idiosyncratic to each series.

Suppose that we were interested in a subgroup of M series—say all mortgage interest rates or all repurchase agreement rates. We can compute an analogous R^2 statistic for that credit market segment by using a $1 \times N$ weight vector, $\mathbf{w}$, that associates positive weights to the series of interest and zeros elsewhere. The implied $R_M^2(F)$ statistic is then given by

$$R_M^2(F) = \frac{\mathbf{w} \Lambda \Sigma_{FF} \Lambda' \mathbf{w}'}{\mathbf{w} \Sigma_{XX} \mathbf{w}'}. \tag{12}$$

As before, $R_M^2(F)$ statistics close to 1 indicate a subgroup of credit markets (defined by the weights, $\mathbf{w}$) that are mostly affected by common forces across interest rates, $\mathbf{w}\Lambda_k F_{k,t}$, rather than conditions specific to that subgroup, $\mathbf{w}e_t$.

Second, because the covariation across interest rate changes reflects not only changes in monetary policy but also other aggregate considerations (including those potentially driven by systemic issues), the next step is to relate changes in each interest rate series captured by principal components to changes in monetary policy. Hence, in each credit market, i, we compute the correlation between $\Lambda_k^i F_{k,t}$ and changes in the effective federal funds rate, Δr_t^{fed},

$$\rho_i = \text{corr}(\Lambda_k^i F_{k,t}, \Delta r_t^{fed}).$$

Evidently, Δr_t^{fed} may not capture all of the relevant aspects of changes in monetary policy and serves here only as an approximate guide. For instance, going forward, we may be more interested in the relationship between $\Lambda_k^i F_{k,t}$ and the interest on reserves. More generally, to the extent that other measurable aspects of changes in monetary policy matter, say represented in a vector Z_t, one could instead compute the projection,

$$\Lambda_k^i F_{k,t} = Z_t \beta + u_t^i,$$

and its associated $R_i^2(Z)$ statistic.

3. THE DATA

Our analysis focuses on a data set that includes 86 time series on interest rate changes, all seasonally adjusted and expressed at an annual rate. These include a wide array of rates with monthly observations spanning back to July 1991. A full list of rates and associated descriptive statistics can be found in the Appendix (Table 5). The data come primarily from Haver Analytics and Bloomberg. While we analyze these rates individually, for ease of presentation we also place them into eight broad categories and investigate the average behavior in each of these credit markets.

The first group includes LIBOR rates based on the U.S. dollar, with maturities ranging from one month to one year. These are reference rates based on the interest rates at which banks are able to borrow unsecured funds from other banks in the London interbank market. We refer to the second group in our data set as the deposit group, which contains averages of dealer offering rates on certificates of deposit with maturities from one to nine months, as well as bid and effective rates on Eurodollar deposits for maturities of overnight to one year. Our third group includes a variety of Treasury bill, note, and bond rates. There are two secondary market rates (three- and six-month), which are the average rates on Treasury bills traded in the secondary market. We also include auction highs on three- and six-month Treasury bills. However, the majority of rates in this group are yields on nominal Treasury securities with maturities ranging from three months to 30 years. These are interpolated by the U.S. Treasury from the daily yield curve for noninflation indexed securities, based on closing market bid yields on actively traded Treasury securities.

Our panel also contains a variety of corporate borrowing rates. We include one-month and three-month rates for nonfinancial and financial commercial paper in this group. These rates are calculated by the Federal Reserve Board using commercial paper trade data from the Depository Trust and Clearing Corporation. Also included are Aaa and Baa Moody's corporate bond yields, which are based on outstanding corporate bonds with remaining maturities of at least 20 years. Finally, Citigroup Global Markets provides corporate bond yields that cover a variety of industries and ratings.

We include two smaller groups, one of which contains three rates for long-term government (state and local) and agency bonds. The other relatively small group in our panel includes two series of interest rate changes for new and used car loans. These are simple unweighted averages of rates commonly charged by commercial banks on auto loans.

The final two groups we utilize are mortgage rates and repurchase agreement rates. The former spans a variety of mortgage rates, including new homes, existing homes, adjustable rate loans, and fixed rate loans. The repurchase agreement group (which also includes reverse repurchase rates) is based on transactions that involve Treasury, mortgage-backed, or agency securities, with maturities ranging from one day to three months.

4. EMPIRICAL FINDINGS

Given the computation of principal components described in Section 1, the next section assesses the extent to which a small number of principal components, out of potentially 86, captures the variation in interest rates across different credit markets. We then gauge the contribution of common changes to individual interest rate variations, as captured by the $R_i^2(F)$ statistic described above. In other words, in each credit market, we assess how much of the variation in its interest rate, Δr_t^i, is explained by its component related to common interest rate movements, $\Lambda_k^i F_{k,t}$. The next subsection then relates the common component of individual interest rate changes, $\Lambda_k^i F_{k,t}$, to changes in the federal funds rate, Δr_t^{fed}, by examining their correlation, $\text{corr}(\Lambda_k^i F_{k,t}, \Delta r_t^{fed})$. Finally, in the last subsection, we examine the robustness of our findings over different sample periods.

Accounting for Interest Rate Variations with a Small Number of Factors

This subsection examines the degree to which a small number of factors potentially captures most of the variation in interest rates across credit markets. We carry out this assessment in mainly two ways. First, we ask how much of the variation in average interest rate changes, $N^{-1}\sum_{i=1}^{N}\Delta r_t^i$, is explained by the first few principal components. Second, following Johnston (1984), we ask how much of the sum of individual variations in the Xs is explained by these components. The total individual variation in interest rate changes is given by

$$\sum_{t=1}^{T}(\Delta r_t^1)^2+\sum_{t=1}^{T}(\Delta r_t^2)^2+...+\sum_{t=1}^{T}(\Delta r_t^N)^2=tr(\Sigma_{XX}). \tag{13}$$

From equation (6), observe that

$$\begin{aligned}\sum_{i=1}^{N} \mu_j &= tr(\Lambda_N' \Sigma_{xx} \Lambda_N) \\ &= tr(\Sigma_{XX} \Lambda_N \Lambda_N') \\ &= tr(\Sigma_{XX}). \end{aligned} \quad (14)$$

In other words, the sum of the eigenvalues of the covariance matrix of interest rate changes, Σ_{XX}, is precisely the sum of individual variations in these changes. It follows that

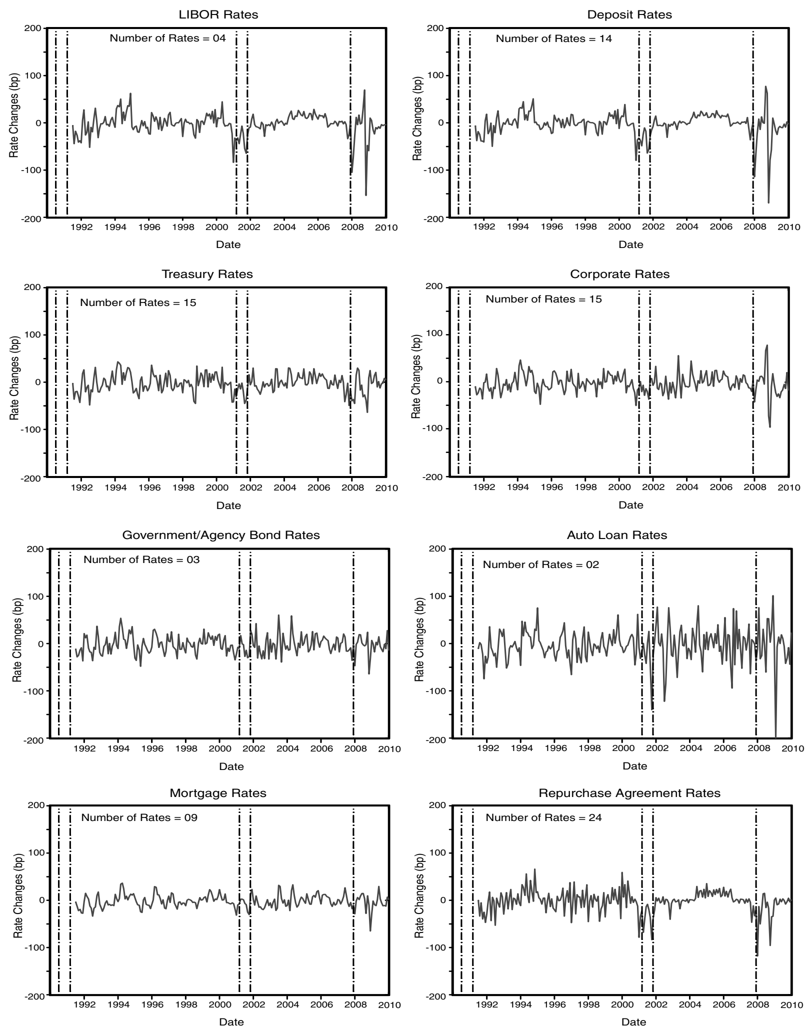
$$\frac{\mu_1}{\sum_{i=1}^{N} \mu_j}, \frac{\mu_2}{\sum_{i=1}^{N} \mu_j}, ..., \frac{\mu_N}{\sum_{i=1}^{N} \mu_j} \quad (15)$$

represent the proportionate contributions of each principal component to the total individual variation in interest rate changes. In addition, since principal components are orthogonal, these proportionate contributions add up to 1.

The analysis reveals that the first four principal components (i.e., $k = 4$) of the panel of interest rate changes constructed for this article explain 99 percent of the variation in average interest rate changes, $N^{-1} \sum_{i=1}^{N} \Delta r_t^i$, and 78 percent of the their total individual variation, $\frac{\sum_{k=1}^{4} \mu_k}{\sum_{i=1}^{N} \mu_j} = 0.78$. In other words, a small number of components effectively accounts for the variation in the data set. The findings discussed in the remainder of the article are based on these first four principal components. However, our conclusions regarding the effects of changes in monetary policy in different credit markets, in particular the qualitative ranking of credit markets most influenced by changes in the federal funds rate, are robust to considering either fewer than four or up to eight principal components.

As discussed in the prior section, we summarize the behavior of our interest rate series into eight main categories. Figure 1 depicts average changes in these eight broad credit markets over time. Recession peaks and troughs are indicated in the figures by vertical dashed lines. The average changes in rates differ in both persistence and volatility across the eight groups. At two extremes, changes in mortgage rates appear to be relatively stable relative to other rates, whereas auto loan rates are considerably more volatile than any other group. Table 1A provides basic summary statistics for each category of credit markets, as well as for the effective federal funds rate. Consistent with Figure 1, Table 1A indicates that auto loan rates are by far the most volatile rates while mortgage rates are least volatile. In addition, many of these interest rate changes, including auto loan, deposit, and mortgage rates, present evidence of kurtosis. That is, much of the variance in these interest rate changes stems from infrequent extreme observations as opposed to relatively common deviations. Some of the series also show evidence of skewness. For

Figure 1 Average Interest Rates in Different Credit Market Segments



example, deposit, auto loan, and LIBOR rates are all left skewed, indicating the presence of large negative changes in the time series.

Table 1B presents analogous summary statistics for individual Treasury bill rates of different maturities. Interestingly, the standard deviations of the rates increase for maturities of three months to three years, and then decrease at higher maturities. In addition, shorter-term rates, namely three months and six months, are left skewed and thus have historically experienced large

Table 1 Changes in Rates by Category

Table 1A: Changes in Rates, by Credit Market

Series	Mean	Std. Dev.	Skewness	Kurtosis	Min.	Max.
Federal Funds	−2.60	19.87	−1.27	6.49	−96	53
LIBOR	−2.68	25.67	−1.62	12.98	−219	94
Deposit	−2.59	27.38	−1.90	17.87	−285	140
Treasury	−2.35	22.71	−0.33	4.08	−111	65
Corporate	−2.24	26.10	0.34	11.54	−179	227
Government/Agency	−2.14	22.72	0.05	3.99	−86	77
Auto	−3.73	48.41	−1.37	15.58	−392	172
Mortgage	−1.94	19.45	0.82	15.03	−110	200
Repurchase Agreements	−2.56	30.03	−0.98	9.13	−225	168

Table 1B: Changes in Treasury Rates, by Maturity

Series	Mean	Std. Dev.	Skewness	Kurtosis	Min.	Max.
Three-Month Bill	−2.55	21.96	−1.06	4.99	−89	49
Six-Month Bill	−2.63	22.16	−0.69	4.11	−77	54
One-Year Bill	−2.70	23.41	−0.43	3.66	−79	60
Two-Year Note	−2.70	36.06	−0.03	2.86	−69	63
Three-Year Note	−2.65	26.85	0.11	2.76	−69	65
Five-Year Note	−2.42	26.06	0.13	2.85	−77	60
Seven-Year Note	−2.22	24.63	0.13	3.28	−93	61
10-Year Note	−2.04	23.43	−0.08	4.35	−111	65
20-Year Bond	−1.74	20.75	−0.18	5.37	−109	58
30-Year Bond	−1.74	19.86	−0.36	6.00	−110	51

Notes: Basis points, monthly at annual rate.

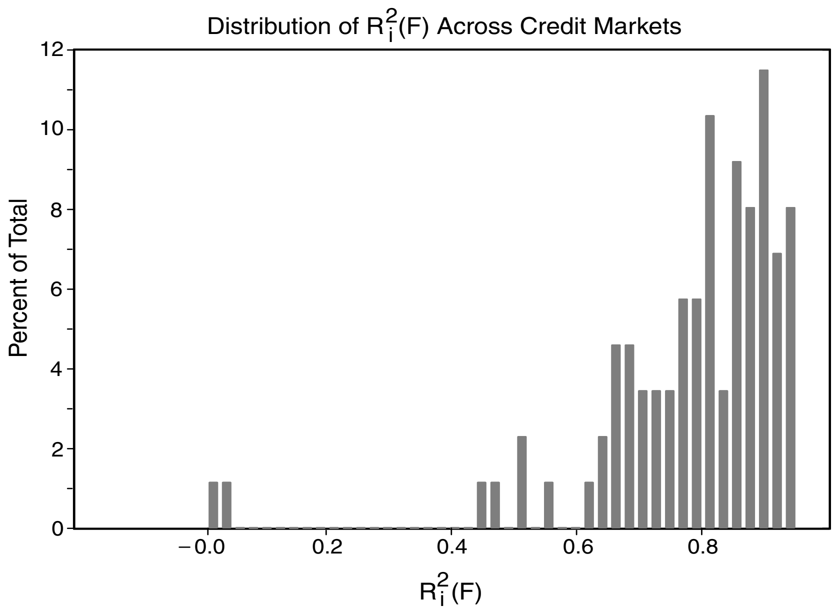
negative changes. Finally, changes in Treasury rates with maturities less than one year and more than 10 years also have relatively large kurtosis statistics.

Contribution of Common Changes to Individual Interest Rate Variations

Figure 2 shows a histogram of the $R_i^2(F)$ statistic discussed in Section 1. This statistic captures the extent to which common movements across interest rates, as summarized by $\Lambda_k^i F_{k,t}$ for each individual interest rate, drive changes in these individual rates. Two main observations stand out. First, changes in interest rates across credit markets tend to reflect factors common to all interest rate changes. In particular, the median $R_i^2(F)$ statistic is 0.814. Second, this first observation notwithstanding, the data also include interest rates in which variations appear almost exclusively driven by idiosyncratic considerations rather than common changes. This is true, for example, of auto loan rates.

Table 2A presents the $R_M^2(F)$ statistics for the eight broad categories of credit markets described earlier. These range from 0.03 for auto loan rates

Figure 2 Importance of Common Changes in Individual Interest Rates



to 0.92 for LIBOR rates.[2] In other words, changes in auto loan rates are explained almost exclusively by idiosyncratic considerations. Put another way, factors that explain co-movement across interest rate changes, one of which is expected to be monetary policy, appear to have little influence over interest rate variations in the auto loan credit market. At the other extreme, changes in LIBOR and deposit rates are almost exclusively driven by forces responsible for the co-movement across interest rates. Somewhere between these two extremes, observe that the common components explain about 68 percent of the variation in government and agency bond rates and mortgage rates.

Table 2B presents the same $R_i^2(F)$ statistics for Treasury bill rates of different maturities. As indicated in the table, the principal components play a large role in explaining the variation in these rates across all maturities. In this case, the $R_i^2(F)$ statistics range from 0.71 to 0.91. Around 78 percent of the variation in 30-year Treasury bill rates is explained by forces common to all interest rates. Interestingly, the common component of the three-month

[2] A listing of all $R_i^2(F)$ statistics can be found in the Appendix (Table 6).

Table 2 Importance of Principal Components in Different Interest Rate Categories

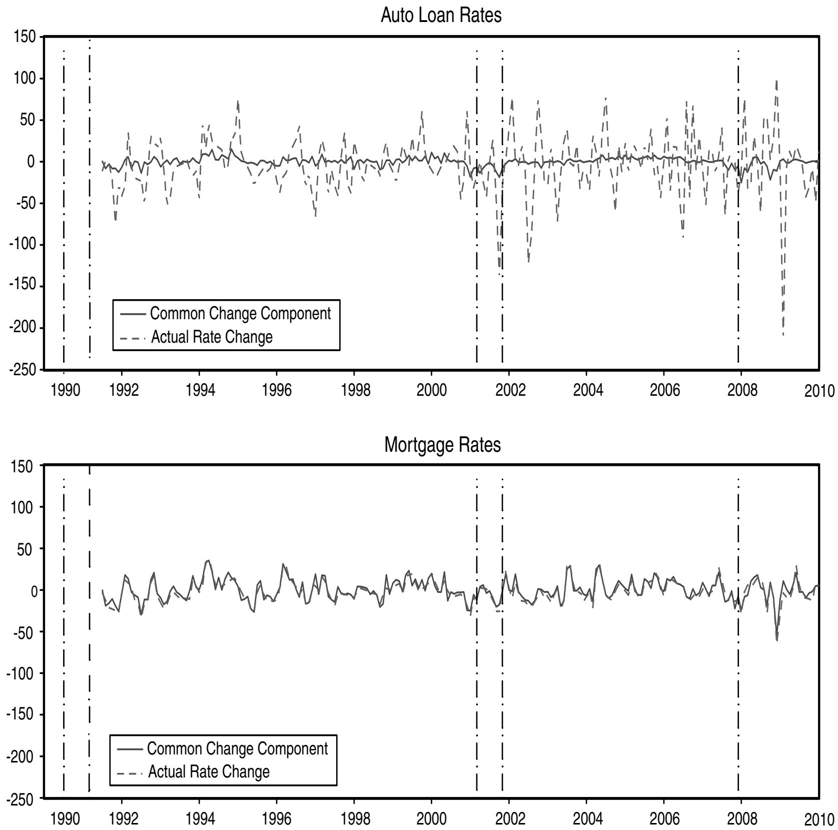
Table 2A: Average $R^2_M(F)$ by Credit Market Segment	
Series	**Average $R^2_i(F)$**
Auto	0.030
Mortgage	0.682
Government/Agency	0.685
Repurchase Agreements	0.754
Treasury	0.835
Corporate	0.839
Deposit	0.860
LIBOR	0.917
Table 2B: Average $R^2_i(F)$ for Treasury Securities	
Series	**Average $R^2_i(F)$**
Three-Month Bill	0.710
Six-Month Bill	0.846
One-Year Bill	0.866
Two-Year Note	0.856
Three-Year Note	0.873
Five-Year Note	0.902
Seven-Year Note	0.913
10-Year Note	0.907
20-Year Bond	0.844
30-Year Bond	0.781

Notes: Monthly rates.

Treasury bill rates explains a lower fraction of the variation in that rate than does the corresponding common component in the 30-year rate. However, since common sources of movement in Treasury bill rates reflect changes not only in monetary policy but also in other aggregate factors, one cannot conclude from Table 2B that changes in the federal funds rate exert a greater influence on the 30-year rate than the three-month rate. For the same reason, it does not follow from Table 2B that changes in monetary policy broadly affect Treasury bill rates to the same degree across all maturities.

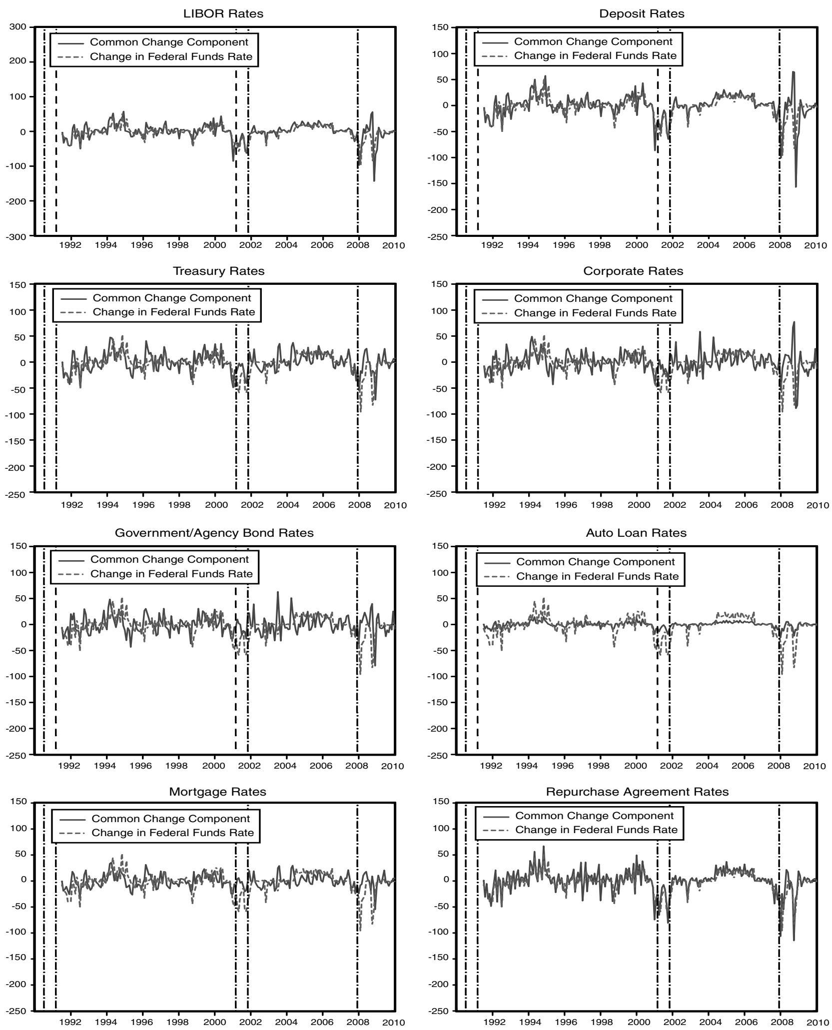
One should recognize that in each credit market category (defined by weights, w), changes in interest rates that stem from sources that are common across all credit markets, $w\Lambda_k F_{k,t}$, will not necessarily correspond to the behavior of average changes in these rates, wX_t. This is shown, for example, in Figure 3 where the difference between the common component of auto loan rate changes and average auto loan rate changes is evident. More important, having extracted the component of each rate change that is related to common sources, Figure 4 plots these common change components against changes in the effective federal funds rate for each of the eight broad credit markets defined above. It is apparent that the different components capturing the effects

Figure 3 Common and Average Rate Variations in Selected Credit Markets



of common forces look different across various credit market segments. However, the volatility of these change components tends to be similar to that of the effective federal funds rate. The question then is: What does the distribution of correlations between the different common change components in interest rates and changes in the effective federal funds rate look like? As mentioned earlier, changes in the effective federal funds rate may constitute only a rough summary of changes in monetary policy. A more general approach might be to examine a projection of common changes across individual interest rates on different aspects of changes in monetary policy, although ultimately not all relevant aspects of monetary policy are easily quantifiable or measured. For now, however, we focus on the effective federal funds rate.

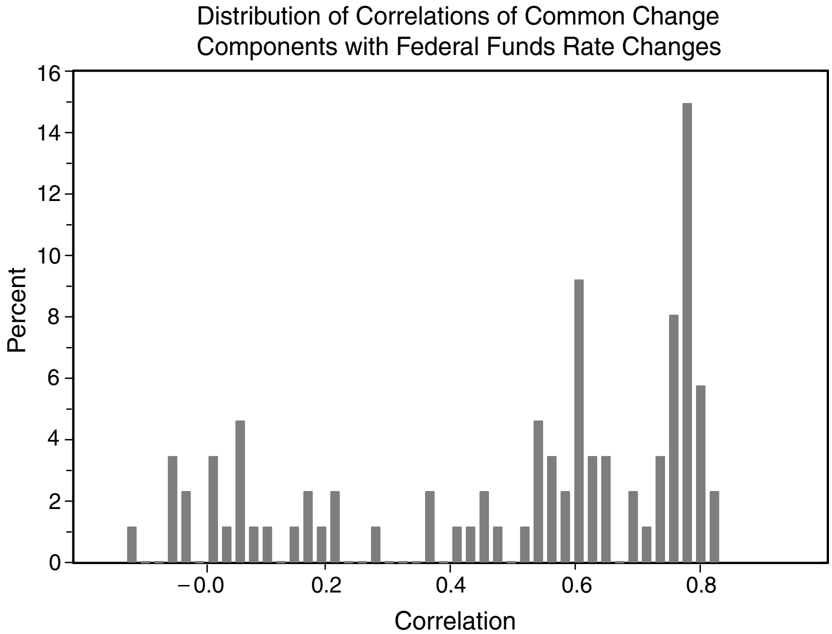
Figure 4 Common Rate Change Components and Federal Funds Rate Changes



Co-movement in Interest Rate Changes and the Federal Funds Rate

Figure 5 shows the histogram of the correlations between common change components in each interest rate, $\Lambda_k^i F_{k,t}$, and changes in the federal funds rate. While some of the common change components in interest rates seem highly correlated with changes in the federal funds rate, there are also many

Figure 5 Changes in the Federal Funds Rate and Common Changes in Interest Rates



other interest rates for which that is not the case. The median correlation in this case is 0.60 while the mean is 0.50. Table 3A provides a ranking of correlations across the eight credit market segments examined in this article.[3]

Interestingly, the common change components least correlated with changes in the federal funds rate are found in the government and agency bond and corporate credit markets. This finding may be interpreted in mainly two ways. First, although the common change components play an important role in driving corporate rates in Table 2A, these components likely reflect aggregate disturbances (or internal co-movement) that are somewhat unrelated to monetary policy. Second, to the extent that these rates include longer-term rates, they reflect monetary policy more indirectly through changes in expected future short rates. For example, changes in beliefs regarding future productivity will likely affect the perceived path of future federal funds rates. In contrast, we also see in Table 3A that the common change components in deposit and LIBOR rates are relatively highly correlated with changes in

[3] A listing of all correlations between $\Lambda_k^i F_{k,t}$ and Δr_t^{fed} can be found in the Appendix (Table 6).

Table 3 Correlation of Changes in Federal Funds Rate with Common Components by Interest Rate Category

Table 3A: Correlation of Common Components for Credit Markets with Changes in Federal Funds Rate

Series	Correlation
Government/Agency	0.131
Corporate	0.212
Mortgage	0.315
Treasury	0.501
Deposit	0.616
LIBOR	0.632
Repurchase Agreements	0.756
Auto	0.769

Table 3B: Correlation of Common Components for Treasury Securities with Changes in Federal Funds Rate

Series	Correlation
Three-Month Bill	0.776
Six-Month Bill	0.730
One-Year Bill	0.640
Two-Year Note	0.485
Three-Year Note	0.400
Five-Year Note	0.290
Seven-Year Note	0.220
10-Year Note	0.155
20-Year Bond	0.066
30-Year Bond	0.070

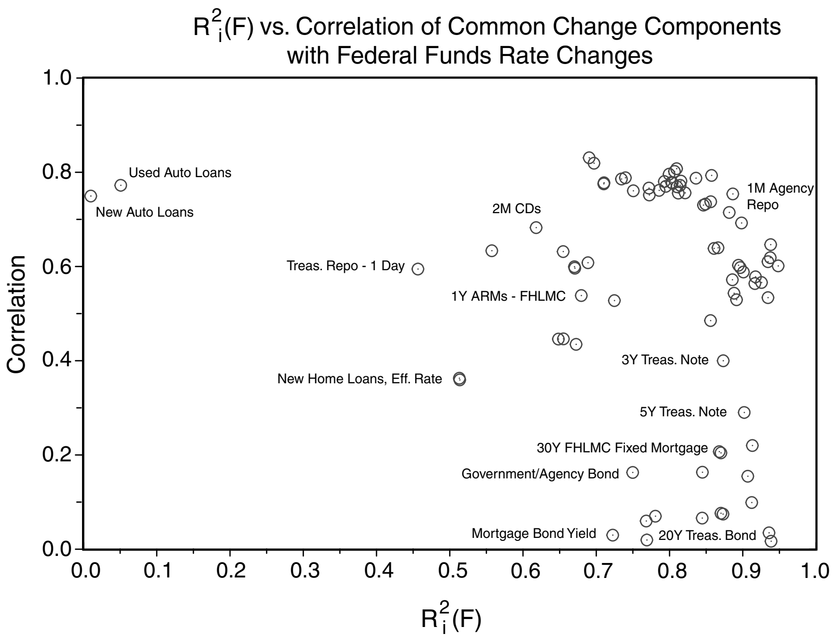
Notes: Monthly rates.

the federal funds rate. Moreover, Table 2A also suggests that the variations in these rates are, for the most part, accounted for by common sources of variations across interest rates. We conclude, therefore, that changes in monetary policy, as captured by changes in the federal funds rate, have played a fundamental role in driving deposit and LIBOR rates.

Table 3B provides the same statistics for Treasury rates of different maturities. As expected, the correlation between the common change component of Treasury bill rates and changes in the federal funds rate is decreasing in maturity, starting at 0.78 for the three-month rate and ending at 0.07 for the 30-year rate. Therefore, even if the common change component of 30-year rates plays a large role in explaining its variations (recall Table 2B), Table 3B is consistent with the conventional view that 30-year rates reflect other more fundamental aggregate changes in the economy rather than contemporaneous changes in policy.

Figure 6 summarizes the results thus far in the form of a scatter plot with $R_i^2(F)$ on the x-axis and $corr(\Lambda_k^i F_{k,t}, \Delta r_t^{\text{fed}})$ on the y-axis. A point near the

Figure 6 Effects of Monetary Policy Across Credit Markets



lower left-hand corner, where both statistics are near zero, would indicate that changes in interest rates are entirely disconnected from changes in the federal funds rate and, in essence, driven by more idiosyncratic considerations. The opposite is true near the top right-hand corner where both statistics are close to 1. Interestingly, the common components for auto loan rates have high correlations with changes in the federal funds rate, so that the common variation in these rates seems related to changes in monetary policy to a nontrivial extent, but also have extremely low $R_i^2(F)$. Put another way, although the common variation in auto loan rates is related to changes in the federal funds rate, their overall variation is ultimately driven by idiosyncratic considerations. There are also several rates in the lower right-hand corner of the plot. Variation in these rates is explained almost entirely by the common variation. However, the common components for these rates appear disconnected from monetary policy, as defined by the federal funds rate. Some of these rates include corporate bonds, fixed-rate mortgages, and long-term Treasury notes and bonds, and all of them have maturities of at least five years. Finally, Figure 6 also includes several rates near the top right-hand corner of the graph, namely several deposit, repurchase agreement, and Treasury bill rates, in which

Table 4 Correlation of Changes in Federal Funds Rate with Common Components by Interest Rate Category Over Different Sample Periods

Table 4A: Correlation of Common Components for Credit Markets with Changes in Federal Funds Rate

	Correlation	
Credit Market Segment	**1991:7–2001:2**	**2001:3–2009:12**
Government/Agency	0.26	0.03
Corporate	0.33	0.14
Mortgage	0.41	0.24
Treasury	0.55	0.47
LIBOR	0.67	0.60
Deposit	0.67	0.58
Repurchase Agreements	0.72	0.79
Auto	0.75	0.79

Table 4B: Correlation of Common Components for Treasury Securities with Changes in Federal Funds Rate

	Correlation	
Treasury Security Maturity	**1991:7–2001:2**	**2001:3–2009:12**
Three-Month Bill	0.76	0.80
Six-Month Bill	0.72	0.75
One-Year Bill	0.65	0.64
Two-Year Note	0.54	0.45
Three-Year Note	0.48	0.34
Five-Year Note	0.40	0.20
Seven-Year Note	0.35	0.12
10-Year Note	0.30	0.04
20-Year Bond	0.22	−0.06
30-Year Bond	0.23	−0.06

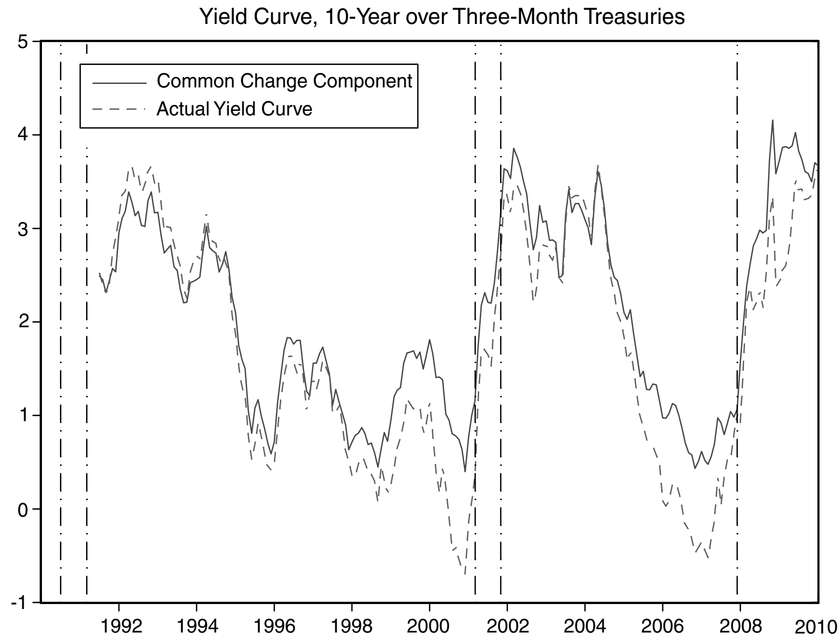
Notes: Monthly rates.

variations therefore appear closely related to changes in contemporaneous monetary policy.

Robustness Across Different Sample Periods

To analyze if this behavior has changed over time, we split the data into two subsamples: July 1991–February 2001 and March 2001–December 2009. We then calculate the correlations of the common components with changes in the effective federal funds rate over these two periods. We chose the breakpoint to be February 2001 to keep the subsamples roughly the same size, and because this is the month prior to the National Bureau of Economic Research peak of the 2001 recession. Table 4A shows the correlations for the eight broad groups

Figure 7 Common Changes in Interest Rates and the Yield Curve



described previously for each subsample. The ordering of the correlations for each credit market is essentially the same across the two periods. The most noticeable differences are seen in the mortgage, corporate, and government and agency bond markets. For these three groups, the correlations are moderately higher in the first subsample, indicating that disturbances less directly related to the contemporaneous federal funds rate have become more important in explaining common variation in these interest rate changes over time. This finding runs somewhat counter to the view in Taylor (2007) that an easy monetary policy kept long-term interest rates too low, thereby contributing to the housing boom. Rather, it is more consistent with the emphasis given by Bernanke (2010) to the role of other factors in keeping long-term interest low during the early 2000s.

The only two groups that saw an increase in correlations over the two periods are auto rates and repurchase agreement rates, though the increases are relatively small. Table 4B shows the analogous correlations for the common components of individual Treasury rates of different maturities. Interestingly, short-term Treasury bill rates have similar correlations across the two periods. However, at longer maturities, correlations between the common components and the federal funds rate have decreased in the later period, with the correlations for 20-year and 30-year Treasury bonds becoming slightly negative in the recent subsample.

As a final examination, we plot the common change component of the yield curve against the yield curve calculated from the raw data. These are shown in Figure 7. We define the yield curve as the 10-year Treasury note yield less the three-month Treasury bill yield. The main periods in which the two series deviate from each other are at their relative peaks and troughs, in particular in 1992, 2000, and 2006. However, overall the two series co-move strongly together, indicating that much of the spreads in rates of different maturities over time resides in how common shocks affect those rates rather than more idiosyncratic considerations.

5. CONCLUDING REMARKS

In this article, we use principal component methods to assess the importance of changes in the federal funds rate in driving interest rate changes across a variety of credit markets. Our findings suggest that most of the variability in interest rate changes across these markets can be explained by a small number of common components. In particular, four components explain approximately 80 percent of the total variation in interest rate changes. One notable exception is the auto loan market, in which interest rate variation is almost entirely idiosyncratic.

For most of our sample, the common variation in interest rate changes is relatively highly correlated with federal funds rate changes. This suggests that common movements in interest rates to a large extent reflect changes in monetary policy rather than other aggregate disturbances. That said, there nevertheless remains a moderate number of rates for which the common components, while explaining a significant portion of their variability, are not highly correlated with the federal funds rate. Therefore, these rates, which include mainly those with longer maturities such as mortgage rates, are driven to a greater extent by aggregate forces other than short-term changes in monetary policy. Finally, the analysis also suggests that movements in the auto loan market are almost entirely driven by idiosyncratic considerations rather than changes in the federal funds rate.

APPENDIX

This appendix shows that the solution to the principal component problem (3) also solves the least square problem described in (7). In particular, combining equations (7) and (8) gives

$$\min_{\{f_1,\ldots,f_k\}_{t=1}^{T},\Lambda_k} T^{-1}\sum_{t=1}^{T}(X_t-\Lambda_k F_{k,t})'(X_t-\Lambda_k F_{k,t}) \text{ subject to } \Lambda_k'\Lambda_k = I_k. \tag{16}$$

Suppose that Λ_k were known. Then the solution for $F_{k,t}$ would simply be given by the standard least square formula,

$$F_{k,t}(\Lambda_k) = (\Lambda_k'\Lambda_k)^{-1}\Lambda_k' X_t.$$

Substituting this solution into (16) yields

$$\min_{\Lambda_k} T^{-1}\sum_{t=1}^{T} X_t'[I_k - \Lambda_k(\Lambda_k'\Lambda_k)\Lambda_k']X_t,$$

or equivalently,

$$\max_{\Lambda_k} T^{-1}\sum_{t=1}^{T} X_t'\Lambda_k(\Lambda_k'\Lambda_k)\Lambda_k' X_t.$$

Now, note that this last expression is a scalar. Hence, we can re-write the problem as

$$\max_{\Lambda_k} tr\left(T^{-1}\sum_{t=1}^{T} X_t'\Lambda_k(\Lambda_k'\Lambda_k)\Lambda_k' X_t\right),$$

or

$$\max_{\Lambda_k} T^{-1}\sum_{t=1}^{T} tr\left(X_t'\Lambda_k(\Lambda_k'\Lambda_k)\Lambda_k' X_t\right).$$

Using the properties of the trace operator, this last expression can also be expressed as

$$\max_{\Lambda_k} T^{-1}\sum_{t=1}^{T} tr\left((\Lambda_k'\Lambda_k)^{-1/2}\Lambda_k'(X_t X_t')\Lambda_k(\Lambda_k'\Lambda_k)^{-1/2}\right),$$

or

$$\max_{\Lambda_k} tr\left((\Lambda_k'\Lambda_k)^{-1/2}\Lambda_k' T^{-1}\sum_{t=1}^{T}(X_t X_t')(\Lambda_k'\Lambda_k)^{-1/2}\Lambda_k(\Lambda_k'\Lambda_k)^{-1/2}\right).$$

Given the notation introduced in the text, one can observe that $T^{-1}\sum_{t=1}^{T}(X_t X_t')$ is simply $XX' = \Sigma_{XX}$. It follows that the least-square problem defined in (16) is equivalent to solving $\max_{\Lambda_k} \ \Lambda_k'\Sigma_{XX}\Lambda_k$ subject to $\Lambda_k'\Lambda_k = I_k$.

Table 5 Monthly Changes (in Basis Points)

Rate	Mean	Std. Dev.	Skewness	Kurtosis	Min	Max
Federal Funds [Effective] Rate	−2.6	19.9	−1.3	6.5	−96	53
One-Month London Interbank Offer Rate: Based on U.S.$	−2.6	28.0	−2.5	19.8	−219	88
Three-Month London Interbank Offer Rate: Based on U.S.$	−2.7	25.2	−1.9	15.2	−178	94
Six-Month London Interbank Offer Rate: Based on U.S.$	−2.7	23.8	−1.2	7.5	−122	65
One-Year London Interbank Offer Rate: Based on U.S.$	−2.7	25.8	−0.5	4.5	−98	74
One-Month Certificates of Deposit, Secondary Market	−2.6	29.2	−2.8	23.7	−241	98
Two-Month Certificate of Deposit	−2.6	29.1	−1.6	12.9	−172	119
Three-Month Certificates of Deposit, Secondary Market	−2.6	26.4	−2.2	17.4	−196	80
Six-Month Certificates of Deposit, Secondary Market	−2.7	25.7	−1.5	9.8	−154	71
Nine-Month Certificate of Deposit	−2.7	29.8	−1.4	11.0	−164	124
One-Month Eurodollar Deposits, London Bid	−2.5	32.3	−3.0	30.6	−285	140
Three-Month Eurodollar Deposits, London Bid	−2.5	28.8	−1.9	20.5	−220	136
Six-Month Eurodollar Deposits, London Bid	−2.6	26.5	−0.9	9.0	−143	109
U.S. Dollar: Eurocurrency Rate, Short-Term	−2.6	20.4	−1.6	8.0	−103	43
U.S. Dollar: Seven-Day Eurocurrency Rate	−2.5	24.9	−3.8	33.2	−229	55
U.S. Dollar: One-Month Eurocurrency Rate	−2.6	29.1	−2.2	19.9	−225	125
U.S. Dollar: Three-Month Eurocurrency Rate	−2.6	26.7	−1.1	11.6	−152	129
U.S. Dollar: Six-Month Eurocurrency Rate	−2.6	26.2	−0.9	8.2	−116	109
U.S. Dollar: One-Year Eurocurrency Rate	−2.7	27.3	−0.5	5.2	−106	98
Three-Month Treasury Bills, Secondary Market	−2.5	21.2	−1.1	5.0	−86	46
Six-Month Treasury Bills, Secondary Market	−2.5	21.0	−0.7	4.2	−73	51
Three-Month Treasury Bills	−2.5	20.8	−1.0	4.6	−83	45
Six-Month Treasury Bills	−2.5	20.8	−0.7	4.2	−75	52
Three-Month Treasury Bill Market Bid Yield at Constant Maturity	−2.6	22.0	−1.1	5.0	−89	49
Six-Month Treasury Bill Market Bid Yield at Constant Maturity	−2.6	22.2	−0.7	4.1	−77	54
One-Year Treasury Bill Yield at Constant Maturity	−2.7	23.4	−0.4	3.7	−79	60

Table 5 (Continued) Monthly Changes (in Basis Points)

Rate	Mean	Std. Dev.	Skewness	Kurtosis	Min	Max
Two-Year Treasury Note Yield at Constant Maturity	−2.7	26.1	0.0	2.9	−69	63
Three-Year Treasury Note Yield at Constant Maturity	−2.7	26.9	0.1	2.8	−69	65
Five-Year Treasury Note Yield at Constant Maturity	−2.5	26.1	0.1	2.9	−77	60
Seven-Year Treasury Note Yield at Constant Maturity	−2.2	24.6	0.1	3.3	−93	61
10-Year Treasury Note Yield at Constant Maturity	−2.0	23.4	−0.1	4.4	−111	65
20-Year Treasury Bond Yield at Constant Maturity	−1.7	20.8	−0.2	5.4	−109	58
30-Year Treasury Bond Yield at Constant Maturity	−1.7	19.9	−0.4	6.0	−110	51
Long-Term Treasury Composite, Over 10 Years	−1.9	20.8	−0.1	5.4	−109	59
One-Month Nonfinancial Commercial Paper	−2.7	22.2	−1.1	6.1	−94	68
Three-Month Nonfinancial Commercial Paper	−2.7	21.2	−1.0	6.1	−98	56
One-Month Financial Commercial Paper	−2.6	23.3	−1.7	10.8	−148	64
Three-Month Financial Commercial Paper	−2.6	23.1	−2.2	15.4	−165	61
Moody’s Seasoned Aaa Corporate Bond Yield	−1.7	18.4	−0.3	7.6	−107	63
Moody’s Seasoned Baa Corporate Bond Yield	−1.7	21.7	1.6	15.0	−76	157
Citigroup Global Markets: U.S. Broad Investment Grade Bond Yield	−2.4	28.6	0.3	4.6	−89	118
Citigroup Global Markets: Credit (Corporate) Bond Yield	−2.3	27.6	0.5	6.7	−116	124
Citigroup Global Markets: Credit (Corporate) Bond Yield: AAA/AA	−2.8	28.6	−0.7	9.7	−179	112
Citigroup Global Markets: Credit (Corporate) Bond Yield: AAA/AA 10+ Years	−1.6	23.8	−0.1	7.0	−115	90
Citigroup Global Markets: Credit (Corporate) Bond Yield: A	−2.3	28.1	0.4	6.8	−127	133
Citigroup Global Markets: Credit (Corporate) Bond Yield: BBB	−2.1	30.1	1.8	16.0	−80	222
Citigroup Global Markets: Credit (Corporate) Bond Yield: Finance	−1.9	33.6	1.1	12.9	−130	227
Citigroup Global Markets: Credit (Corporate) Bond Yield: Utility	−2.2	30.1	0.7	12.0	−147	188
Citigroup Global Markets: Credit (Corporate) Bond Yield: Industrial	−2.3	27.3	1.3	11.3	−80	181
Citigroup Global Markets: Gov’t Sponsored Bond Yield, U.S. Agency/Supranational	−2.7	24.7	−0.1	3.8	−86	77
Citigroup Global Markets: Gov’t Agency Bond Yield	−2.5	26.2	0.0	3.2	−85	69
Bond Buyer Index: State/Local Bonds, 20-Year, Genl Obligation	−1.3	16.0	0.7	4.6	−49	64
Auto Finance Company Interest Rates: New Car Loans	−4.2	65.2	−1.1	9.4	−392	172
Auto Finance Company Interest Rates: Used Car Loans	−3.3	21.2	0.3	3.8	−59	74
Citigroup Global Markets: Mortgage Bond Yield	−2.5	37.9	0.9	8.3	−110	200
Home Mortgage Loans: Effective Rate, All Loans Closed	−1.9	13.2	−0.3	4.7	−63	34

Table 5 (Continued) Monthly Changes (in Basis Points)

Rate	Mean	Std. Dev.	Skewness	Kurtosis	Min	Max
Purchase of Newly Built Homes: Effective Rate, All Loans	−2.0	14.2	−0.3	4.2	−56	35
Purchase of Previously Occupied Homes: Effective Rate, All Loans	−1.9	13.7	−0.3	4.8	−67	35
Contract Rates on Commitments:						
Conventional 30-Year Mortgages, FHLMC	−2.1	20.6	0.5	4.0	−76	64
Purchase of New Single-Family Home: Contract Interest Rate	−1.9	13.7	−0.3	4.3	−55	35
Purchase of Existing Single-Family Home: Contract Interest Rate	−1.8	13.3	−0.4	5.2	−67	36
FHLMC: 30-Year Fixed-Rate Mortgages: U.S.	−2.1	20.6	0.6	4.0	−76	64
FHLMC: 1-Year Adjustable Rate Mortgages: U.S.	−1.3	14.5	0.6	4.3	−39	56
Treasury Repo - One Day	−2.5	43.1	−0.5	5.6	−165	168
Treasury Repo - One Week	−2.6	25.2	−1.5	9.7	−140	69
Treasury Repo - One Month	−2.6	23.3	−2.4	13.2	−140	59
Treasury Repo - Three Months	−2.6	23.6	−2.2	12.0	−135	48
Treasury Reverse Repo - One Day	−2.5	43.3	−0.4	5.6	−180	168
Treasury Reverse Repo - One Week	−2.6	27.1	−1.1	7.7	−130	82
Treasury Reverse Repo - One Month	−2.6	23.4	−2.2	11.8	−135	58
Treasury Reverse Repo - Three Months	−2.6	22.8	−1.9	10.3	−125	48
MBS Repo - One Day	−2.6	43.0	−0.3	5.1	−140	168
MBS Repo - One Week	−2.6	25.5	−0.8	6.5	−110	85
MBS Repo - One Month	−2.6	22.9	−1.9	9.7	−117	62
MBS Repo - Three Months	−2.6	22.8	−1.9	10.3	−116	62
MBS Reverse Repo - One Day	−2.5	44.2	−0.4	5.1	−153	168
MBS Reverse Repo - One Week	−2.7	29.1	−1.0	6.9	−120	90
MBS Reverse Repo - One Month	−2.6	23.5	−1.8	9.4	−120	60
MBS Reverse Repo - Three Months	−2.6	23.0	−1.9	10.3	−120	56
Agency Repo - One Day	−2.5	39.8	−0.3	6.0	−145	168
Agency Repo - One Week	−2.6	24.6	−1.1	6.9	−115	72
Agency Repo - One Month	−2.6	22.9	−2.2	11.6	−130	59
Agency Repo - Three Months	−2.6	23.4	−2.2	11.3	−125	43
Agency Reverse Repo - One Day	−2.5	43.5	−0.7	7.3	−225	168
Agency Reverse Repo - One Week	−2.6	27.0	−1.0	6.8	−115	82
Agency Reverse Repo - One Month	−2.6	24.0	−2.2	11.8	−130	58
Agency Reverse Repo - Three Months	−2.6	23.9	−2.2	10.8	−125	41

Table 6 R-Squared and Correlation of Factor Components with Federal Funds Rate (Monthly Data)

Rate	R^2	Correlation
Auto Finance Company Interest Rates: New Car Loans	0.010	0.750
Auto Finance Company Interest Rates: Used Car Loans	0.051	0.772
Treasury Repo - One Day	0.457	0.595
Bond Buyer Index: State/Local Bonds, 20-Year, Genl Obligation	0.459	−0.027
Purchase of New Single-Family Home: Contract Interest Rate	0.513	0.363
Purchase of Newly Built Homes: Effective Rate, All Loans	0.514	0.359
Treasury Reverse Repo - One Day	0.558	0.634
Two-Month Certificate of Deposit	0.618	0.683
Moody's Seasoned Baa Corporate Bond Yield	0.643	−0.118
Purchase of Existing Single-Family Home: Contract Interest Rate	0.648	0.446
Agency Repo - One Day	0.655	0.632
Purchase of Previously Occupied Homes: Effective Rate, All Loans	0.655	0.447
MBS Repo - One Day	0.670	0.600
MBS Reverse Repo - One Day	0.671	0.597
Home Mortgage Loans: Effective Rate, All Loans Closed	0.672	0.435
FHLMC: One-Year Adjustable Rate Mortgages: U.S.	0.680	0.538
Agency Reverse Repo - One Day	0.689	0.608
U.S. Dollar: Eurocurrency Rate, Short-Term	0.697	0.819
Three-Month Treasury Bill Market Bid Yield at Constant Maturity	0.710	0.776
Three-Month Treasury Bills, Secondary Market	0.711	0.778
Citigroup Global Markets: Mortgage Bond Yield	0.722	0.030
Nine-Month Certificate of Deposit	0.725	0.528
Three-Month Treasury Bills	0.734	0.786
Agency Repo - One Week	0.740	0.789
Citigroup Global Markets: Gov't Agency Bond Yield	0.750	0.163

Table 6 (Continued) R-Squared and Correlation of Factor Components with Federal Funds Rate (Monthly Data)

Rate	R^2	Correlation
MBS Reverse Repo - One Week	0.751	0.761
Citigroup Global Markets: Credit (Corporate) Bond Yield: Utility	0.764	−0.037
Citigroup Global Markets: Credit (Corporate) Bond Yield: Finance	0.768	0.060
Moody's Seasoned Aaa Corporate Bond Yield	0.769	0.020
Treasury Repo - Three Months	0.772	0.766
Treasury Reverse Repo - One Week	0.772	0.752
30-Year Treasury Bond Yield at Constant Maturity	0.781	0.070
Agency Reverse Repo - One Week	0.786	0.762
MBS Repo - One Week	0.793	0.781
Citigroup Global Markets: Credit (Corporate) Bond Yield: BBB	0.793	−0.053
Treasury Reverse Repo - Three Months	0.795	0.770
One-Month Nonfinancial Commercial Paper	0.799	0.796
Agency Repo - Three Months	0.803	0.779
Treasury Repo - One Month	0.804	0.777
MBS Reverse Repo - One Month	0.807	0.802
MBS Repo - One Month	0.810	0.808
Agency Reverse Repo - Three Months	0.810	0.769
MBS Reverse Repo - Three Months	0.812	0.756
MBS Repo - Three Months	0.815	0.772
Treasury Reverse Repo - One Month	0.815	0.781
Treasury Repo - One Week	0.821	0.756
Citigroup Global Markets: Credit (Corporate) Bond Yield: AAA/AA 10+ Years	0.833	−0.042
Agency Reverse Repo - One Month	0.836	0.788
20-Year Treasury Bond Yield at Constant Maturity	0.844	0.066
Citigroup Global Markets: Gov't Sponsored Bond Yield: U.S. Agency/Supranational	0.845	0.163
Six-Month Treasury Bill Market Bid Yield at Constant Maturity	0.846	0.730
Six-Month Treasury Bills, Secondary Market	0.849	0.733
Two-Year Treasury Note Yield at Constant Maturity	0.856	0.485
Six-Month Treasury Bills	0.856	0.738
Agency Repo - One Month	0.857	0.793
U.S. Dollar: Seven-Day Eurocurrency Rate	0.861	0.638

Table 6 (Continued) R-Squared and Correlation of Factor Components with Federal Funds Rate (Monthly Data)

Rate	R^2	Correlation
One-Year Treasury Bill Yield at Constant Maturity	0.866	0.640
FHLMC: 30-Year Fixed-Rate Mortgages: U.S.	0.868	0.207
Long-Term Treasury Composite, Over 10 Years	0.870	0.076
Contract Rates on Commitments: Conventional 30-Yr Mortgages, FHLMC	0.870	0.204
Citigroup Global Markets: U.S. Broad Investment Grade Bond Yield	0.873	0.074
Three-Year Treasury Note Yield at Constant Maturity	0.873	0.400
One-Month Financial Commercial Paper	0.882	0.715
U.S. Dollar: One-Month Eurocurrency Rate	0.886	0.572
Three-Month Nonfinancial Paper	0.886	0.754
One-Month Eurodollar Deposits, London Bid	0.888	0.543
Citigroup Global Markets: Credit (Corporate) Bond Yield: Industrial	0.889	−0.016
U.S. Dollar: One-Year Eurocurrency Rate	0.892	0.529
One-Month London Interbank Offer Rate: Based on U.S.$	0.894	0.603
One-Month Certificates of Deposit, Secondary Market	0.897	0.598
Three-Month Financial Commercial Paper	0.898	0.693
One-Year London Interbank Offer Rate: Based on U.S.$	0.901	0.588
Five-Year Treasury Note Yield at Constant Maturity	0.902	0.290
10-Year Treasury Note Yield at Constant Maturity	0.907	0.155
Citigroup Global Markets: Credit (Corporate) Bond Yield: AAA/AA	0.912	0.099
Seven-Year Treasury Note Yield at Constant Maturity	0.913	0.220
U.S. Dollar: Three-Month Eurocurrency Rate	0.916	0.564
U.S. Dollar: Six-Month Eurocurrency Rate	0.917	0.578
Six-Month Eurodollar Deposits, London Bid	0.926	0.566
Three-Month London Interbank Offer Rate: Based on U.S.$	0.934	0.610
Three-Month Eurodollar Deposits, London Bid	0.934	0.534
Citigroup Global Markets: Credit (Corporate) Bond Yield: A	0.936	0.035
Six-Month Certificates of Deposit, Secondary Market	0.937	0.619
Six-Month London Interbank Offer Rate: Based on U.S.$	0.938	0.646
Citigroup Global Markets: Credit (Corporate) Bond Yield	0.939	0.017
Three-Month Certificates of Deposit, Secondary Market	0.948	0.601

REFERENCES

Bernanke, Ben. 2010. “Monetary Policy and the Housing Bubble.” Speech at the Annual Meeting of the American Economic Association, Atlanta (January 3).

Bianchi, Francesco, Haroon Mumtaz, and Paolo Surico. 2009. “The Great Moderation of the Term Structure of UK Interest Rates.” *Journal of Monetary Economics* 56 (September): 856–71.

Diebold, Francis X., Glenn D. Rudebusch, and S. Boragan Aruoba. 2006. “The Macroeconomy and the Yield Curve: A Dynamic Latent Factor Approach.” *Journal of Econometrics* 131: 309–38.

Gürkaynak, Refet S., Brian Sack, and Eric T. Swanson. 2005. “Do Actions Speak Louder than Words? The Response of Asset Prices to Monetary Policy Actions and Statements.” *International Journal of Central Banking* 1 (May): 55–93.

Johnston, Jack. 1984. *Econometric Methods*, third edition. New York: McGraw Hill.

Knez, Peter J., Robert Litterman, and Jose Scheinkman. 1994. “Explorations into Factors Explaining Money Market Returns.” *The Journal of Finance* 49 (December): 1,861–82.

Malysheva, Nadezhda, and Pierre-Daniel G. Sarte. 2009. “Heterogeneity in Sectoral Employment and the Business Cycle.” Federal Reserve Bank of Richmond *Economic Quarterly* 95 (Fall): 335–55.

Nelson, Charles R., and Andrew F. Siegel. 1987. “Parsimonious Modeling of Yield Curves.” *The Journal of Business* 60 (October): 473–89.

Reinhart, Vincent, and Brian Sack. 2005. “Grading the Federal Open Market Committee’s Communications.” Unpublished manuscript.

Taylor, John B. 2007. “Housing and Monetary Policy.” Paper presented at Federal Reserve Bank of Kansas City Economic Symposium on Housing, Housing Finance, and Monetary Policy, Jackson Hole, Wyoming (August 30–September 1).