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# Monetary Policy Uncertainty

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# MONETARY POLICY UNCERTAINTY

by

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A Research Paper
Submitted in Partial Fulfillment of the Requirements for the
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## 1. Introduction

By definition, monetary policy uncertainty is the increased volatility of the expected outcome resulting from changes in monetary policy, which is unforecastable from the perspective of economic agents. Following the financial crisis of 2007-2008, the US Federal Reserve shouldered most of the burden of providing economic stimulus. They did so by slashing their benchmark interest rate, and by buying longer-term bonds and mortgage-backed securities. However, the Federal Reserve has a dual mandate, and it is not specific to the extent it targets employment versus price stability. Therefore, economic agents must depend on precedent to form expectations about monetary policy in unprecedented times.

My objective for this paper is to determine the effects of monetary policy uncertainty on US asset prices and real macroeconomic aggregates within a vector autoregressive (VAR) framework. To gauge monetary policy uncertainty, I will employ a frontier dataset referred to as the “Monetary Policy Uncertainty index”. This dataset was created by Northwestern University finance professor Scott Baker and his colleagues.

## 2. Literature Review

I proceed with a brief literature review of notable papers pertaining to monetary policy uncertainty. The first paper that relates to my paper is titled “The Stock Market and Investment” by Robert Barro. In this paper, he deviates from many empirical studies that have related business investment to $q$. $q$ is the ratio of the market’s valuation of capital to the long run cost of acquiring new capital. Barro finds for the US that stock market prices explain the growth rate of investment. Furthermore, he finds that the stock market variable outperforms $q$. Barro justifies this result by stating that the equity component of $q$ is a bad proxy for stock market value. Lastly, he concludes that the relationship between stock market prices and the growth rate of investment is not different in stock market crashes than at other times (Barro, 1990).

The second paper I choose to review is titled “What Explains the Stock Market’s Reaction to Federal Reserve Policy?” by Ben Bernanke and Kenneth Kuttner. In this paper, the authors analyze the linkage between monetary policy and asset prices. They use the Fed funds futures as a proxy of monetary policy expectations. Using a stock market value-weighted index, the authors find that an unexpected 25 basis point rate cut would increase stock prices by 1 percent. This result is robust. Moreover, there is evidence of a larger stock market response to monetary policy changes that are more permanent. For example, a reversal in the direction of the Fed funds rate generates a larger stock market response. Lastly, they find that stock market prices respond as they do to monetary policy due to its effects on expected future excess returns or on expected future dividends. This result contradicts the notion that the reaction of stock market prices to monetary policy is not attributable to monetary policy’s effects on the real interest rate (Bernanke & Kuttner, 2003).

The third paper that relates to my paper is titled “Dynamics of Monetary Policy Uncertainty and the Impact on the Macroeconomy” by Nicholas Herro and James Murray. The authors gauge monetary policy uncertainty by measuring deviations of the Fed funds rate from forecasts. They use this measure within a VAR model to analyze the effect monetary policy uncertainty has on inflation, growth of output, and unemployment. Their results suggest that there is not sufficient evidence that monetary policy uncertainty affects inflation, growth of output, and unemployment. However, the authors conclude that greater monetary policy uncertainty leads to greater volatility of growth of output and unemployment (Herro & Murray, 2011).

The last paper that I choose to review is titled “Impact of Uncertainty on High Frequency Response of the US Stock Markets to the Fed’s Policy Surprises” by Hardik Marfatia. In this paper, he analyzes the response of stock market returns to US monetary policy surprise. This topic is supported by the Lucas island model. The Lucas island model suggests that there is an inverse relationship between the effectiveness of a policy and the magnitude of uncertainty. To conduct his research, he estimates the response of stock market returns to monetary policy surprises within a time varying parameter (TVP) model. Marfatia finds that at higher levels of uncertainty, the affect of the Federal Open Market Committee (FOMC) policy surprise on stock market returns decreases. Moreover, he finds that using volatility in the short-term bond market as a proxy of uncertainty provides the highest explanatory power in explaining the impact of uncertainty on the effectiveness of monetary policy surprises. Lastly, Marfatia concludes that the response of stock markets to monetary policy shocks significantly varies across time (Marfatia, 2014).

## 3. Economic Theory

How do exogenous uncertainty shocks fit into Keynes' IS-LM framework? Keynes does not explicitly discuss exogenous uncertainty shocks in his IS-LM framework. However, implicitly he accounts for uncertainty through what he refers to as "animal spirits". By the term "animal spirits", Keynes is referring to the notion that changes in households' and firms' confidence and optimism regarding the economy can lead to self-fulfilling economic booms or busts even if the fundamentals of the economy have not changed. To further elaborate; assume aggregate consumption and investment have the following functional forms.

(1) $$C = c_0 + b(Y - T) - ar$$

(2) $$I = i_0 - dr$$

where:

$a, b, \mathit{and}\ d\ \mathit{are\ parameters}$

$c_0 = \mathit{the\ autonomous\ or\ exogenous\ component\ of\ aggregate\ consumption}$

$i_0 = \mathit{the\ autonomous\ or\ exogenous\ component\ of\ aggregate\ investment}$

$Y - T = \mathit{the\ after - tax\ income}$

$r = \mathit{the\ real}$ □$\mathit{nterest\ rate}$

Keynes argues that these autonomous components ($c_0$ and $i_0$) of aggregate demand are affected by animal spirits. They lead to changes in $C$ and $I$ even though there are no changes in $Y - T$ or $r$. For example, suppose there is an exogenous decrease in $c_0$ or $i_0$ due to pessimism about the economy resulting from monetary policy uncertainty. If the economy is initially in equilibrium, an exogenous decrease in $c_0$ or $i_0$ will shift the IS curve downward to the left. This decrease in aggregate demand leads to a decrease in output as firms cut production in response to reduced demand. As income drops, aggregate demand further falls, which further exacerbates the initial decrease in output. As output drops, there is less demand for loanable funds, which drives down the real interest rate. Through the autonomous components of aggregate demand channel, it is evident that monetary policy uncertainty fits within Keynes' IS-LM framework. To conclude, an exogenous increase in consumers' and firms' pessimism about the economy can lead to a self-fulfilling recession. Conversely, an exogenous increase in consumers' and firms' optimism about the economy can pull an economy out of a recession. I proceed with describing the data I will be using in the model.

**4. Data**

Within a VAR model, I employ five endogenous variables. These five variables are listed with a brief description in the following table.

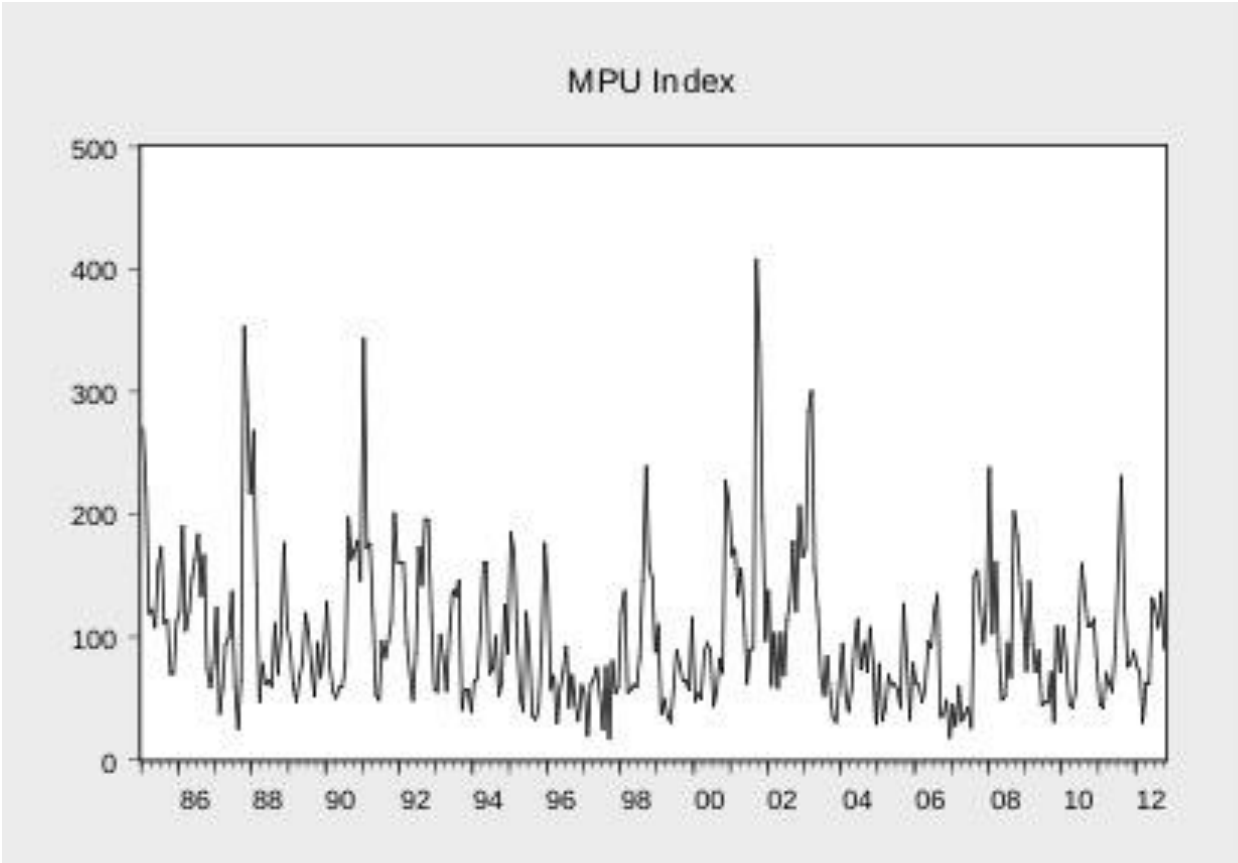
**Table 1: Variables with Description and Source**

| Variable | Description | Source |
|---|---|---|
| mpu | The MPU index is a news-based proxy for US monetary policy uncertainty. The index is computed as the monthly number of articles containing joint references to the Federal Reserve, uncertainty, and the economy. To compensate with changing volumes of articles, they divide the number of articles containing joint references by the total number of articles in the same newspaper for each given month. Next, they normalize each newspaper index to have a unit standard deviation over the period 1985-2012 and add the indices for all newspapers. Lastly, the monthly index is rescaled to have an average value of 100. | SB |
| sp | The monthly return of the S&P 500 index. The index is widely regarded as the best single gauge of large-cap | Quandl |

| | | |
|---|---|---|
| | US equities. The index includes 500 leading companies and captures approximately 80% coverage of available market capitalization. | |
| dlipi | The log first-differences of the Industrial Production index. It is an economic indicator that measures real output for all facilities located in the US manufacturing, mining, and electric, and gas utilities. This index is compiled on a monthly basis to bring attention to short-term changes in industrial production. It measures movements in production output and highlights structural developments in the economy. | FRED |
| dlur | The log first-differences of the unemployment rate. The unemployment rate represents the number of unemployed as a percentage of the labor force. | FRED |
| ffr | The level of the federal funds rate. The federal funds rate is the interest rate at which depository institutions trade federal funds with each other overnight. | FRED |

To note, the abbreviated sources stand for the following:
FRED: Federal Reserve Economic Data - St. Louis Fed
SB: Scott Baker and colleagues

All five variables are observed on a monthly basis from January 1985 to October 2012. In total, there are 334 observations for each variable. To obtain a better sense of the MPU index, I plot the MPU index against time. The following figure illustrates the stationarity and volatility properties of the MPU index.




**5. Unit Root Tests**

Before I begin estimating a VAR model, I must ensure that each one of my time series variables is stationary. We know that if each time series variable is not stationary, then when we estimate the model via ordinary least squares (OLS), the t-statistics will tend to overstate significance of Granger causality. This is the case even when the time series variables are independent of each other. This is referred to as the spurious correlation problem.

To reduce the chance of a spurious correlation problem, I test each time series variable individually for a unit root. The unit root test I use is the Augmented Dickey-Fuller (ADF) test. Within the ADF unit root test, there are three different models. The three models are the following: with drift and trend, with drift only, and without drift and trend. I use these three models of ADF for each of my time series. In general, the former of the three models can be expressed as follows.

(3)

$$\Delta y_t = \alpha_0 + \gamma y_{t-1} + \alpha_2 t + \sum_{i=2}^{p} \beta_i \Delta y_{t-i+1} + \varepsilon_t$$

The parameter of interest is $\gamma$. The null hypothesis is that $\gamma = 0$ or that there is a unit root. The alternative hypothesis is that $\gamma < 0$. I conduct my unit root tests in the following manner. First, I estimate equation (3). If the time series is not stationary, I remove the trend term from equation (3) and re-estimate. If the time series is still not stationary, I remove the drift and trend term from equation (3) and re-estimate. Lastly, if the time series is still not stationary after removing the drift and trend term, I transform the time series to log first-differences and conduct the aforementioned unit root test process again. I present my unit root test results in the following table.

**Table 2: Unit Root Test Statistics**

| | **Augmented Dickey-Fuller test statistic** | | | |
|---|---|---|---|---|
| | **with constant and trend** | **with constant** | **none** | **result** |
| mpu | -9.59***<br>(0.00) | -9.50***<br>(0.00) | -4.66***<br>(0.00) | stationary |
| sp | -17.18***<br>(0.00) | -17.12***<br>(0.00) | -16.74***<br>(0.00) | stationary |
| ipi | -2.22<br>(0.48) | -1.33<br>(0.62) | 1.25<br>(0.95) | non-stationary |
| Dlog(ipi) | -4.88***<br>(0.00) | -4.79***<br>(0.00) | -4.42***<br>(0.00) | stationary |
| ur | -2.56<br>(0.30) | -2.38<br>(0.15) | -0.63<br>(0.44) | non-stationary |
| Dlog(ur) | -6.78***<br>(0.00) | -4.58***<br>(0.00) | -4.59***<br>(0.00) | stationary |

| | | | | |
|---|---|---|---|---|
| ffr | -2.71<br>(0.23) | -1.36<br>(0.60) | -1.77*<br>(0.07) | stationary |

***, **, and * denotes significant at 1%, 5%, and 10% level, respectively
( ) denotes MacKinnon one-sided p-values

From table 2, I find that mpu, sp, and ffr are stationary. Conversely, I find that ipi and ur are not stationary. To ensure stationarity, I transform ipi and ur to log first-differences. After transforming these time series, I conduct the ADF unit root test again. The ADF test statistics for log first-differences of ipi and ur conclude stationarity.

**6. Model**

My primary objective is to observe the effects of monetary policy uncertainty (mpu) on the S&P 500 index (sp), the Industrial Production index (dlipi), unemployment rate (dlur), and federal funds rate (ffr). The economic intuition is as follows. Suppose mpu increases pessimism about the economy resulting in a decrease of the autonomous component of aggregate consumption and aggregate investment. This decrease in aggregate demand leads to a decrease in output as firms cut production in response to reduced demand. As firms cut production, labor is laid off. As income drops, aggregate demand falls further, which further exacerbates the initial decrease in output. As output drops, there is less demand for loanable funds, which drives down the real interest rate. In addition, there may be another channel that decreases the real interest rate. It may be the case that the Federal Reserve observes the deteriorating economic conditions and decides to stimulate the economy by driving down the real interest rate. In sum, an increase in consumers' and firms' pessimism about the economy resulting from mpu may lead to a self-fulfilling recession.

First, I must determine the appropriate lag length for my VAR model. To do so, I use EViews software and obtain the following table.

**Table 3: Lag Order Selection Criteria**

| Lag | LogL | LR | FPE | AIC |
|---|---|---|---|---|
| 0 | -1566.9400 | NA | 0.0109 | 9.6735 |
| 1 | -569.4104 | 1958.2280 | 0.0000 | 3.6887 |
| 2 | -504.5625 | 125.3062 | 0.0000 | 3.4435 |
| 3 | -472.6058 | 60.7668* | 2.06e-05* | 3.4007* |
| 4 | -452.6375 | 37.3561 | 0.0000 | 3.4316 |
| 5 | -432.2351 | 37.5405 | 0.0000 | 3.4599 |
| 6 | -417.8091 | 26.0999 | 0.0000 | 3.5250 |
| 7 | -400.8709 | 30.1239 | 0.0000 | 3.5746 |
| 8 | -386.6621 | 24.8326 | 0.0000 | 3.6410 |

* denotes lag order selected by the criterion
LR denotes sequential modified LR test statistic
FPE denotes Final prediction error
AIC denotes Akaike information criterion

From table 3, LR, FPE, and AIC test statistics suggest that three lags is the appropriate lag length.

Now that I have determined the appropriate lag length, my structural VAR model can be expressed as follows.

$$(4) \qquad B_{5\times5}X_{t_{5\times1}} = \Gamma_{0_{5\times1}} + \Gamma_{1_{5\times5}}X_{t-1_{5\times1}} + \Gamma_{2_{5\times5}}X_{t-2_{5\times1}} + \Gamma_{3_{5\times5}}X_{t-3_{5\times1}} + \varepsilon_{t_{5\times1}}$$

In addition, matrix $X$ is a column vector of mpu, sp, dlipi, dlur, and ffr. From my above structural VAR model, there are a total of 105 parameters. The parameters are distributed as follows. There are 20 parameters in $B$, five parameters in $\Gamma_0$, 25 parameters each in $\Gamma_1, \Gamma_2$, and $\Gamma_3$, and five parameters in $\Sigma$.

In practice, my structural VAR model cannot be estimated. Therefore, I must use my structural VAR model to construct a reduced form VAR model.

From equation (4), I obtain my reduced from VAR model as follows. By multiplying equation (4) by $B^{-1}$, I obtain equation (5).

(5) $$B^{-1}BX_t = B^{-1}\Gamma_0 + B^{-1}\Gamma_1 X_{t-1} + B^{-1}\Gamma_2 X_{t-2} + B^{-1}\Gamma_3 X_{t-3} + B^{-1}\varepsilon_t$$

By simplifying equation (5), I obtain equation (6).

(6) $$X_t = A_0 + A_1 X_{t-1} + A_2 X_{t-2} + A_3 X_{t-3} + e_t$$

From my above reduced form VAR model, there are a total of 95 parameters. The parameters are distributed as follows. There are five parameters in $A_0$, 25 parameters each in $A_1, A_2,$ and $A_3$, and 15 parameters in $\Sigma$. Again, only 95 parameters are estimable within my reduced form VAR model. However, my structural VAR model contains 105 parameters. To reconcile the difference in the number of parameters between my VAR models, I impose restrictions on 10 parameters. These restrictions are imposed from aforementioned economic theory.

By following previously mentioned economic theory, my variables are ordered recursively as such: mpu, sp, dlipi, dlur, and ffr. The intuition for such ordering is as follows. By placing mpu first, the assumption is that an exogenous shock to mpu affects the remaining variables. More specifically, an exogenous shock to mpu affects sp, the combined effect of mpu and sp affects dlipi, the combined effect of mpu, sp, and dlipi affects dlur, and the combined effect of mpu, sp, dlipi, and dlur affects ffr. To obtain this structure, I restrict the upper off-diagonal elements of $B$ to zero. Therefore, $B$ can be expressed as follows.

(7)

$$B = \begin{pmatrix} 1 & 0 & 0 & 0 & 0 \\ b_{21} & 1 & 0 & 0 & 0 \\ b_{31} & b_{32} & 1 & 0 & 0 \\ b_{41} & b_{42} & b_{43} & 1 & 0 \\ b_{51} & b_{52} & b_{53} & b_{54} & 1 \end{pmatrix}$$

Now that I have restricted the 10 upper off-diagonal elements of $B$ to zero, the number of parameters in my structural VAR model equals the number of parameters in my reduced form VAR model. By imposing these restrictions on my structural VAR model, the order of shocks can be expressed as follows.

(8)

$$\begin{pmatrix} \varepsilon_t^{mpu} \\ \varepsilon_t^{sp} \\ \varepsilon_t^{dlipi} \\ \varepsilon_t^{dlur} \\ \varepsilon_t^{ffr} \end{pmatrix} = \begin{pmatrix} 1 & 0 & 0 & 0 & 0 \\ a_{21} & 1 & 0 & 0 & 0 \\ a_{31} & a_{32} & 1 & 0 & 0 \\ a_{41} & a_{42} & a_{43} & 1 & 0 \\ a_{51} & a_{52} & a_{53} & a_{54} & 1 \end{pmatrix} \begin{pmatrix} e_t^{mpu} \\ e_t^{sp} \\ e_t^{dlipi} \\ e_t^{dlur} \\ e_t^{ffr} \end{pmatrix}$$

From (8), the $e_t$ terms denote mpu, sp, dlipi, dlur, and ffr shocks. Now, the structure of my VAR model is clearer. With my VAR model identified, I estimate my reduced form VAR model in equation (6) via EViews software. The following table reports the estimated parameters of my VAR model.

**Table 4: VAR Estimates**

| | mpu | sp | dlipi | dlur | ffr |
|---|---|---|---|---|---|
| mpu(-1) | 0.504832<br>(0.059300)<br>[ 8.51382] | 0.000891<br>(0.005530)<br>[ 0.16110] | -0.000002<br>(0.000007<br>)<br>[-0.34219] | -0.000002<br>(0.000029<br>)<br>[-0.07412] | -0.001001<br>(0.000210<br>)<br>[-4.71839] |
| mpu(-2) | -0.017335<br>(0.066550)<br>[-0.26047] | 0.017768<br>(0.006210)<br>[ 2.86335] | 3.22E-06<br>(0.000008<br>)<br>[ 0.41171] | -2.29E-06<br>(0.000033<br>)<br>[-0.06957] | 0.000144<br>(0.000240<br>)<br>[ 0.60615] |

| | | | | | |
|---|---|---|---|---|---|
| mpu(-3) | -0.038406 | -0.00109 | 3.60E-06 | -2.20E-05 | 0.000285 |
| | (0.058310) | (0.005440) | (0.000007) | (0.000029) | (0.000210) |
| | [-0.65860] | [-0.20053] | [ 0.52471] | [-0.76235] | [ 1.36559] |
| sp(-1) | -2.004663 | 0.046969 | 5.47E-05 | -0.000408 | 0.000872 |
| | (0.634930) | (0.059200) | (0.000075) | (0.000310) | (0.002270) |
| | [-3.15732] | [ 0.79341] | [ 0.73224] | [-1.29754] | [ 0.38380] |
| sp(-2) | -1.340087 | -0.009103 | 0.000168 | -0.000244 | 0.000626 |
| | (0.633740) | (0.059090) | (0.000075) | (0.000310) | (0.002270) |
| | [-2.11457] | [-0.15406] | [ 2.24999] | [-0.77770] | [ 0.27605] |
| sp(-3) | -0.806129 | 0.040097 | 0.000367 | -0.000496 | -0.003523 |
| | (0.620520) | (0.057860) | (0.000073) | (0.000310) | (0.002220) |
| | [-1.29912] | [ 0.69304] | [ 5.03410] | [-1.61508] | [-1.58641] |
| dlipi(-1) | 49.27393 | 105.2462 | -0.010988 | -0.758972 | 4.984631 |
| | (477.846000) | (44.553800) | (0.056210) | (0.236430) | (1.710060) |
| | [ 0.10312] | [ 2.36223] | [-0.19546] | [-3.21007] | [ 2.91488] |
| dlipi(-2) | -68.88872 | 67.32418 | 0.163918 | -0.857561 | 0.667138 |
| | (490.446000) | (45.728700) | (0.057700) | (0.242670) | (1.755150) |
| | [-0.14046] | [ 1.47225] | [ 2.84105] | [-3.53387] | [ 0.38010] |
| dlipi(-3) | 287.2274 | -79.63827 | 0.203457 | -0.632247 | -0.943343 |
| | (494.761000) | (46.131000) | (0.058200) | (0.244800) | (1.770600) |
| | [ 0.58054] | [-1.72635] | [ 3.49560] | [-2.58266] | [-0.53278] |
| dlur(-1) | 124.3934 | -9.882428 | -0.028236 | -0.233066 | -0.705575 |
| | (116.605000) | (10.872100) | (0.013720) | (0.057700) | (0.417290) |
| | [ 1.06679] | [-0.90897] | [-2.05840] | [-4.03961] | [-1.69084] |
| dlur(-2) | 89.42366 | -6.857517 | -0.003972 | -0.032724 | -0.525472 |
| | (120.179000) | (11.205400) | (0.014140) | (0.059460) | (0.430080) |
| | [ 0.74409] | [-0.61198] | [-0.28098] | [-0.55031] | [-1.22179] |
| dlur(-3) | 171.0945 | -7.99441 | -0.014124 | 0.119206 | -0.44587 |
| | (115.516000) | (10.770500) | (0.013590) | (0.057160) | (0.413390) |
| | [ 1.48114] | [-0.74225] | [-1.03934] | [ 2.08561] | [-1.07856] |
| ffr(-1) | 4.394742 | 0.479646 | 0.001464 | -0.021002 | 1.343285 |
| | (15.840600) | (1.476960) | (0.001860) | (0.007840) | (0.056690) |
| | [ 0.27744] | [ 0.32475] | [ 0.78553] | [-2.67960] | [ 23.6959] |

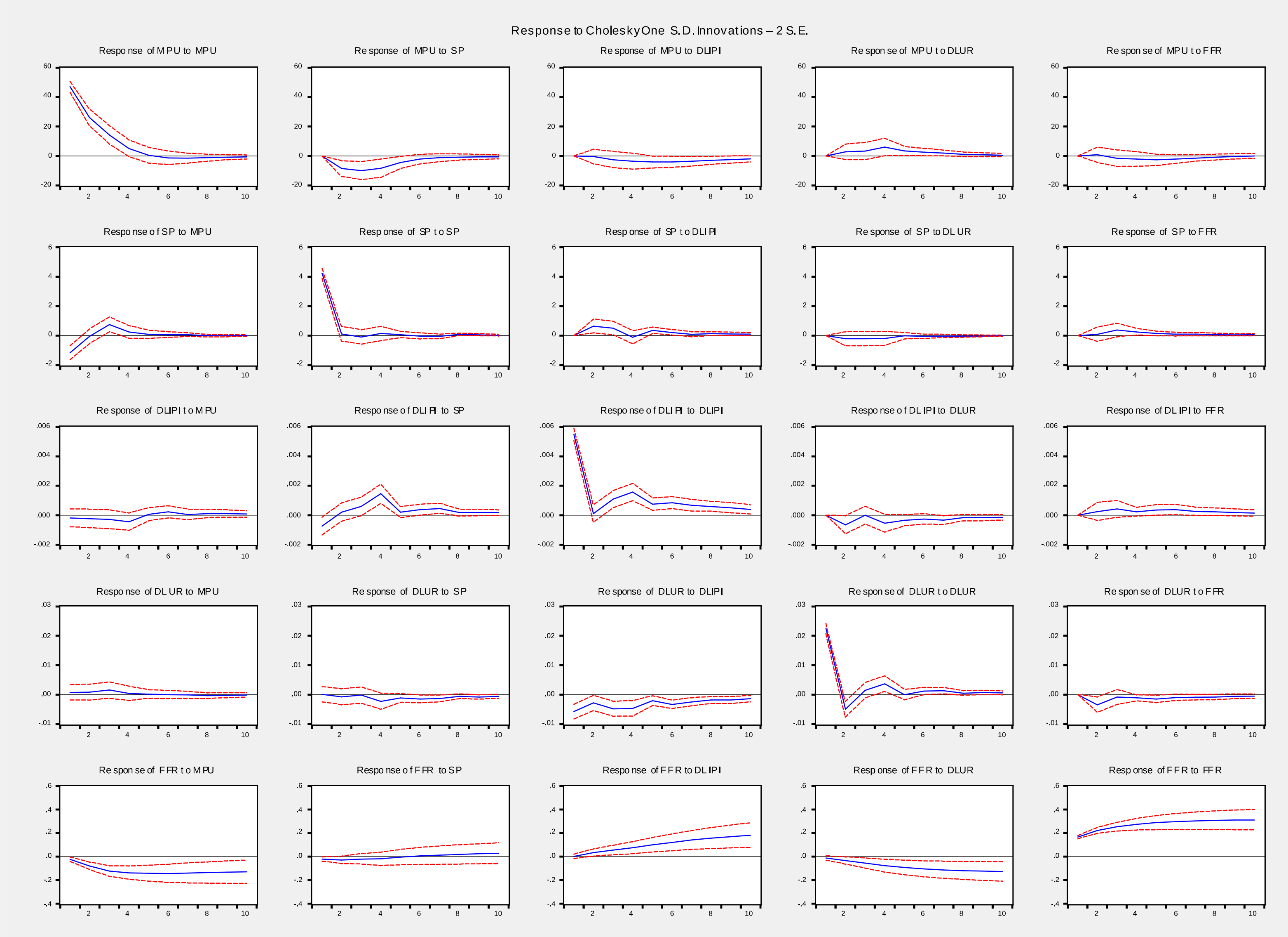
| | | | | | |
|---|---|---|---|---|---|
| ffr(-2) | -14.76729 | 1.199582 | -1.95E-05 | 0.019514 | -0.284513 |
| | (26.150600) | (2.438250) | (0.003080) | (0.012940) | (0.093580) |
| | [-0.56470] | [ 0.49198] | [-0.00635] | [ 1.50815] | [-3.04017] |
| ffr(-3) | 12.29151 | -1.617449 | -0.001559 | 0.0016 | -0.064093 |
| | (15.925500) | (1.484880) | (0.001870) | (0.007880) | (0.056990) |
| | [ 0.77181] | [-1.08928] | [-0.83215] | [ 0.20309] | [-1.12458] |
| c | 48.16762 | -1.421258 | 0.000842 | 0.006553 | 0.058771 |
| | (8.142750) | (0.759220) | (0.000960) | (0.004030) | (0.029140) |
| | [ 5.91540] | [-1.87199] | [ 0.87929] | [ 1.62655] | [ 2.01681] |
| R-squared | 0.397526 | 0.094508 | 0.283037 | 0.242564 | 0.996096 |
| Adj. R-squared | 0.368745 | 0.051252 | 0.248788 | 0.20638 | 0.995909 |

( ) denotes standard errors
[ ] denotes t-statistics

I reported the estimated parameters of my VAR model for completeness. However, a shortfall of VAR models is the difficulty in interpreting the estimated parameters. A more intuitive approach used by economists is to estimate the impulse response function (IRF).

The IRF traces out the response of the endogenous variable in the VAR model to shocks in the error term. Suppose the error term in the mpu equation increases by one standard deviation. Such a shock will change mpu in the current period, as well as future periods. Since mpu appears in the sp, dlipi, dlur, and ffr equations, the change in the error term of mpu also affects sp, dlipi, dlur, and ffr. The IRF is the centerpiece of VAR model analysis. I present the IRFs of my VAR model in the following table.

# Table 5: Impulse Response Functions



From the previous table, the IRFs are interpreted as follows. For each IRF, the magnitude of the response function is plotted on the vertical axis. The time in months is plotted on the horizontal axis. Furthermore, the dashed lines denote the confidence interval. The first column represents the structure of my VAR model. In the first month, a one standard deviation shock to mpu decreases sp. After the first month, the effect of mpu on sp is positive. Thereafter, the effect of mpu on sp is statistically insignificant. Moreover, the effect of mpu on dlipi and dlur is statistically insignificant. From the first column, last row, the response of ffr to a one standard deviation shock to mpu is in accordance with economic theory, and is statistically significant 10 months into the future. The previous finding follows economic theory that the Federal Reserve lowers the interest rate in response to the unemployment rate. Lastly, from the second column, third row, the response of dlipi to a one standard deviation shock to sp is positive. This result is also in accordance with economic theory. Firms observe higher asset prices. In turn, they increase investment in capital.

Another purpose of VAR analysis is observing causality between endogenous variables. This is referred to as Granger causality. In general, Granger causality informs us about the existence and direction of causality among endogenous variables. Furthermore, it informs us whether there is one-way or two-way causality between endogenous variables. For example, sp, dlipi, dlur, and ffr do not Granger cause mpu if and only if all of the lagged coefficients in the mpu equation are equal to zero. More formally, from equation (6), if the off-diagonal elements of $A_1, A_2,$ and $A_3$ are equal to zero, then, there is no Granger causality among endogenous variables in my VAR model. The way to test Granger causality is to use a standard F-test. I reported the results of Granger causality in the following table.

**Table 6: Granger Causality**

| Excluded | Chi-sq | df | Prob. | Sig. |
|---|---|---|---|---|
| **Dependent variable: mpu** | | | | |
| sp | 15.6960 | 3 | 0.0013 | *** |
| dlipi | 0.3928 | 3 | 0.9417 | |
| dlur | 3.1973 | 3 | 0.3622 | |
| ffr | 4.0933 | 3 | 0.2516 | |
| all | 26.7639 | 12 | 0.0084 | *** |
| **Dependent variable: sp** | | | | |
| mpu | 13.1937 | 3 | 0.0042 | *** |
| dlipi | 10.0847 | 3 | 0.0179 | ** |
| dlur | 1.3653 | 3 | 0.7137 | |
| ffr | 2.2135 | 3 | 0.5293 | |
| all | 29.8248 | 12 | 0.0030 | *** |
| **Dependent variable: dlipi** | | | | |
| mpu | 0.7872 | 3 | 0.8525 | |
| sp | 30.6571 | 3 | 0.0000 | *** |
| dlur | 5.3348 | 3 | 0.1489 | |
| ffr | 3.0551 | 3 | 0.3832 | |
| all | 48.8019 | 12 | 0.0000 | *** |
| **Dependent variable: dlur** | | | | |
| mpu | 0.9215 | 3 | 0.8202 | |
| sp | 4.6974 | 3 | 0.1953 | |
| dlipi | 31.2350 | 3 | 0.0000 | *** |
| ffr | 8.9156 | 3 | 0.0304 | ** |
| all | 53.0363 | 12 | 0.0000 | *** |
| **Dependent variable: ffr** | | | | |
| mpu | 24.7930 | 3 | 0.0000 | *** |
| sp | 2.8028 | 3 | 0.4230 | |
| dlipi | 8.7031 | 3 | 0.0335 | ** |
| dlur | 4.2025 | 3 | 0.2404 | |
| all | 60.7179 | 12 | 0.0000 | *** |

***, **, and * denotes significant at 1%, 5%, and 10% level, respectively

From table 6, there is evidence that sp Granger causes mpu. Moreover, mpu and dlipi Granger cause sp. In regards to dlipi, sp Granger causes it. Furthermore, dlipi and ffr Granger cause dlur. Lastly, mpu and dlipi Granger cause ffr. Except for the lack of evidence that dlur Granger causes ffr, the direction of causality among variables is in accordance with aforementioned economic theory.

Now that I have observed the existence and direction of Granger causality among variables, it is important to observe the contribution and decomposition of causality among variables. This is referred to as forecast error variance decomposition. Forecast error variance decomposition is also more simply known as variance decomposition. In general, variance decomposition tells us the proportion of the movements in a series due to its own shock versus the proportion of the movements due to shocks to the other variables in the model. For example, if mpu shocks do not explain the forecast error variance of sp at all forecast horizons, then, the sp series is independent of mpu shocks and of the mpu series. The sum of previously estimated impulse response functions and variance decompositions is referred to as innovation accounting. I estimated variance decompositions for all five of my series and reported them in table 7.

**Table 7: Variance Decomposition**

| Variance decomposition of mpu | | | | | | |
|---|---|---|---|---|---|---|
| Period | SE | mpu | sp | dlipi | dlur | ffr |
| 1 | 47.0908 | 100.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 2 | 54.6068 | 97.2437 | 2.4788 | 0.0066 | 0.2532 | 0.0176 |
| 3 | 57.4913 | 93.8372 | 5.2987 | 0.2137 | 0.5496 | 0.1008 |
| 4 | 58.8079 | 90.4409 | 7.1447 | 0.5846 | 1.5879 | 0.2418 |
| 5 | 59.2912 | 88.9767 | 7.5992 | 1.0830 | 1.8885 | 0.4527 |
| 6 | 59.5898 | 88.1403 | 7.6624 | 1.5589 | 2.0611 | 0.5772 |
| 7 | 59.7840 | 87.6368 | 7.6552 | 1.9223 | 2.1529 | 0.6328 |
| 8 | 59.8955 | 87.3553 | 7.6448 | 2.1731 | 2.1761 | 0.6508 |
| 9 | 59.9671 | 87.1710 | 7.6412 | 2.3485 | 2.1865 | 0.6528 |
| 10 | 60.0118 | 87.0561 | 7.6441 | 2.4570 | 2.1910 | 0.6518 |
| **Variance decomposition of sp** | | | | | | |
| Period | SE | mpu | sp | dlipi | dlur | ffr |
| 1 | 4.3907 | 7.1961 | 92.8039 | 0.0000 | 0.0000 | 0.0000 |
| 2 | 4.4447 | 7.0355 | 90.6218 | 2.0451 | 0.2659 | 0.0317 |
| 3 | 4.5563 | 9.4212 | 86.2882 | 3.1318 | 0.4749 | 0.6839 |
| 4 | 4.5774 | 9.6051 | 85.5792 | 3.1838 | 0.6766 | 0.9553 |
| 5 | 4.5934 | 9.5666 | 84.9993 | 3.7277 | 0.6739 | 1.0325 |
| 6 | 4.5998 | 9.5548 | 84.7692 | 3.9260 | 0.6877 | 1.0623 |
| 7 | 4.6022 | 9.5577 | 84.6998 | 3.9534 | 0.6950 | 1.0941 |
| 8 | 4.6050 | 9.5471 | 84.6210 | 4.0228 | 0.6997 | 1.1095 |
| 9 | 4.6068 | 9.5427 | 84.5647 | 4.0678 | 0.7060 | 1.1188 |
| 10 | 4.6080 | 9.5377 | 84.5212 | 4.1012 | 0.7096 | 1.1304 |
| **Variance decomposition of dlipi** | | | | | | |
| Period | SE | mpu | sp | dlipi | dlur | ffr |
| 1 | 0.0055 | 0.1110 | 1.7806 | 98.1084 | 0.0000 | 0.0000 |
| 2 | 0.0056 | 0.2776 | 1.8815 | 96.2786 | 1.3757 | 0.1866 |
| 3 | 0.0058 | 0.5034 | 2.8370 | 94.6502 | 1.3017 | 0.7077 |
| 4 | 0.0062 | 0.9729 | 7.9768 | 88.3691 | 1.9392 | 0.7420 |
| 5 | 0.0062 | 0.9604 | 7.9095 | 87.8602 | 2.2180 | 1.0520 |
| 6 | 0.0063 | 1.0488 | 8.0187 | 87.2325 | 2.3296 | 1.3704 |
| 7 | 0.0064 | 1.0319 | 8.3682 | 86.5273 | 2.5713 | 1.5012 |
| 8 | 0.0064 | 1.0496 | 8.3426 | 86.3863 | 2.6149 | 1.6066 |
| 9 | 0.0065 | 1.0692 | 8.3474 | 86.2535 | 2.6625 | 1.6674 |
| 10 | 0.0065 | 1.0753 | 8.3686 | 86.1514 | 2.7049 | 1.6997 |
| **Variance decomposition of dlur** | | | | | | |
| Period | SE | mpu | sp | dlipi | dlur | ffr |
| 1 | 0.0233 | 0.1058 | 0.0018 | 6.1956 | 93.6969 | 0.0000 |
| 2 | 0.0243 | 0.2124 | 0.0937 | 7.0874 | 90.5666 | 2.0398 |
| 3 | 0.0249 | 0.5673 | 0.0975 | 10.5883 | 86.6867 | 2.0603 |

| | | | | | | |
|---|---|---|---|---|---|---|
| 4 | 0.0257 | 0.5552 | 0.8795 | 13.2464 | 83.2000 | 2.1189 |
| 5 | 0.0259 | 0.5522 | 1.0753 | 13.7425 | 82.2048 | 2.4252 |
| 6 | 0.0262 | 0.5392 | 1.3862 | 15.0657 | 80.4984 | 2.5105 |
| 7 | 0.0264 | 0.5342 | 1.6224 | 15.7056 | 79.5494 | 2.5884 |
| 8 | 0.0264 | 0.5497 | 1.6618 | 16.0877 | 79.0269 | 2.6739 |
| 9 | 0.0265 | 0.5555 | 1.7496 | 16.4616 | 78.5248 | 2.7086 |
| 10 | 0.0266 | 0.5596 | 1.7947 | 16.6745 | 78.2401 | 2.7312 |

**Variance decomposition of ffr**

| Period | SE | mpu | sp | dlipi | dlur | ffr |
|---|---|---|---|---|---|---|
| 1 | 0.1685 | 1.8519 | 1.6128 | 0.0100 | 0.6063 | 95.9190 |
| 2 | 0.2952 | 8.0307 | 1.4788 | 1.3077 | 1.4889 | 87.6938 |
| 3 | 0.4165 | 12.8833 | 0.9794 | 2.4034 | 2.5477 | 81.1862 |
| 4 | 0.5287 | 14.7648 | 0.7433 | 3.5287 | 3.6924 | 77.2708 |
| 5 | 0.6338 | 15.3545 | 0.5230 | 4.9562 | 4.7141 | 74.4522 |
| 6 | 0.7323 | 15.3423 | 0.3961 | 6.4364 | 5.5832 | 72.2421 |
| 7 | 0.8253 | 14.9548 | 0.3299 | 7.9941 | 6.2664 | 70.4548 |
| 8 | 0.9133 | 14.4399 | 0.3073 | 9.4922 | 6.8290 | 68.9316 |
| 9 | 0.9968 | 13.9015 | 0.3121 | 10.9031 | 7.2805 | 67.6029 |
| 10 | 1.0761 | 13.3803 | 0.3354 | 12.2202 | 7.6451 | 66.4190 |

Cholesky ordering: mpu, sp, dlipi, dlur, ffr

In table 7, the variance decomposition is reported up to 12 months. Also, the contribution of each variable is expressed as a percentage. Therefore, each row sums to 100. Interpretation of variance decomposition of ffr is as follows. In month 10, out of total variation in ffr, 13.38% is explained by mpu, 0.34% is explained by sp, 12.22% is explained by dlipi, 7.65% is explained by dlur, and 66.42% is self explained.

From the variance decomposition of sp, other than itself, mpu explains a majority of the variation in sp. Similarly, for dlipi, other than itself, sp explains a majority of the variation in dlipi. Also, for dlur, other than itself, dlipi explains a majority of the variation in dlur. Lastly, from the variance decomposition of ffr, a majority is explained by mpu. My variance decomposition results suggest that the structure of my VAR model is appropriate.

**7. Conclusion**

For this paper, my primary objective was to observe the effects of monetary policy uncertainty (mpu) on the S&P 500 (sp), Industrial Production index (dlipi), unemployment rate (dlur), and federal funds rate (ffr) within a VAR model. Furthermore, I estimated my VAR model and obtained the impulse response functions, variance decompositions, and checked for Granger causality. In brief, this paper was motivated by the economic intuition that an increase in consumers' and firms' pessimism about the economy resulting from monetary policy uncertainty may lead to a self-fulfilling recession. I find evidence that mpu negatively affects sp in the short-run. This result is in accordance with papers by Bernanke and Kuttner, and Marfatia. Moreover, my results suggest that as sp rebounds, dlipi positively reacts. This result supports the paper by Barro. When dlipi positively reacts, the effect on dlur is minimal. Lastly, there is no direct effect of mpu on dlipi and dlur. This result is in accordance with the paper by Herro and Murray that monetary policy uncertainty does not affect growth of output and unemployment.

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# APPENDIX

## Appendix A

**Table 8: Data**

| Date | mpu | sp | dlipi | dlur | ffr |
|---|---|---|---|---|---|
| 1985-01-01 | 270.4692 | 7.4085 | 54.4371 | 7.3000 | 8.3500 |
| 1985-02-01 | 219.8357 | 0.8629 | 54.6664 | 7.2000 | 8.5000 |
| 1985-03-01 | 119.0345 | -0.2870 | 54.7455 | 7.2000 | 8.5800 |
| 1985-04-01 | 122.0448 | -0.4594 | 54.6042 | 7.3000 | 8.2700 |
| 1985-05-01 | 107.5736 | 5.4051 | 54.6782 | 7.2000 | 7.9700 |
| 1985-06-01 | 156.6430 | 1.2134 | 54.7159 | 7.4000 | 7.5300 |
| 1985-07-01 | 173.4076 | -0.4848 | 54.3390 | 7.4000 | 7.8800 |
| 1985-08-01 | 111.3308 | -1.1995 | 54.5707 | 7.1000 | 7.9000 |
| 1985-09-01 | 113.5899 | -3.4724 | 54.8135 | 7.1000 | 7.9200 |
| 1985-10-01 | 69.6072 | 4.2509 | 54.5916 | 7.1000 | 7.9900 |
| 1985-11-01 | 70.2456 | 6.5062 | 54.7719 | 7.0000 | 8.0500 |
| 1985-12-01 | 112.5639 | 4.5061 | 55.3412 | 7.0000 | 8.2700 |
| 1986-01-01 | 119.5476 | 0.2367 | 55.6062 | 6.7000 | 8.1400 |
| 1986-02-01 | 190.2599 | 7.1489 | 55.2091 | 7.2000 | 7.8600 |
| 1986-03-01 | 104.9775 | 5.2794 | 54.8519 | 7.2000 | 7.4800 |
| 1986-04-01 | 120.6131 | -1.4148 | 54.8839 | 7.1000 | 6.9900 |
| 1986-05-01 | 148.3625 | 5.0229 | 54.9927 | 7.2000 | 6.8500 |
| 1986-06-01 | 162.7708 | 1.4110 | 54.8165 | 7.2000 | 6.9200 |
| 1986-07-01 | 183.8203 | -5.8683 | 55.1675 | 7.0000 | 6.5600 |
| 1986-08-01 | 132.9929 | 7.1193 | 55.0457 | 6.9000 | 6.1700 |
| 1986-09-01 | 166.7552 | -8.5439 | 55.1503 | 7.0000 | 5.8900 |
| 1986-10-01 | 73.6033 | 5.4729 | 55.3968 | 7.0000 | 5.8500 |
| 1986-11-01 | 58.4130 | 2.1477 | 55.6593 | 6.9000 | 6.0400 |
| 1986-12-01 | 79.1356 | -2.8288 | 56.1333 | 6.6000 | 6.9100 |
| 1987-01-01 | 124.1594 | 13.1767 | 55.9679 | 6.6000 | 6.4300 |
| 1987-02-01 | 37.3839 | 3.6924 | 56.6775 | 6.6000 | 6.1000 |
| 1987-03-01 | 58.1611 | 2.6390 | 56.7642 | 6.6000 | 6.1300 |
| 1987-04-01 | 93.7138 | -1.1450 | 57.1169 | 6.3000 | 6.3700 |
| 1987-05-01 | 98.8715 | 0.6034 | 57.4935 | 6.3000 | 6.8500 |
| 1987-06-01 | 137.0816 | 4.7914 | 57.7707 | 6.2000 | 6.7300 |
| 1987-07-01 | 59.4997 | 4.8224 | 58.1523 | 6.1000 | 6.5800 |
| 1987-08-01 | 24.4365 | 3.4959 | 58.6196 | 6.0000 | 6.7300 |
| 1987-09-01 | 64.6670 | -2.4166 | 58.7737 | 5.9000 | 7.2200 |
| 1987-10-01 | 353.3000 | -21.7630 | 59.6354 | 6.0000 | 7.2900 |
| 1987-11-01 | 289.5950 | -8.5349 | 59.9604 | 5.8000 | 6.6900 |
| 1987-12-01 | 216.7241 | 7.2861 | 60.2533 | 5.7000 | 6.7700 |
| 1988-01-01 | 268.1962 | 4.0432 | 60.2832 | 5.7000 | 6.8300 |
| 1988-02-01 | 142.5190 | 4.1817 | 60.5286 | 5.7000 | 6.5800 |
| 1988-03-01 | 46.6377 | -3.3343 | 60.6669 | 5.7000 | 6.5800 |
| 1988-04-01 | 77.7090 | 0.9425 | 60.9879 | 5.4000 | 6.8700 |
| 1988-05-01 | 61.1958 | 0.3176 | 60.9180 | 5.6000 | 7.0900 |

| | | | | | |
|---|---|---|---|---|---|
| 1988-06-01 | 64.5013 | 4.3256 | 61.0765 | 5.4000 | 7.5100 |
| 1988-07-01 | 59.1343 | -0.5411 | 61.1063 | 5.4000 | 7.7500 |
| 1988-08-01 | 110.9631 | -3.8600 | 61.3905 | 5.6000 | 8.0100 |
| 1988-09-01 | 69.6130 | 3.9729 | 61.2132 | 5.4000 | 8.1900 |
| 1988-10-01 | 103.5281 | 2.5964 | 61.5021 | 5.4000 | 8.3000 |
| 1988-11-01 | 176.5999 | -1.8891 | 61.6122 | 5.3000 | 8.3500 |
| 1988-12-01 | 109.4703 | 1.4688 | 61.8936 | 5.3000 | 8.7600 |
| 1989-01-01 | 94.2344 | 7.1115 | 62.0714 | 5.4000 | 9.1200 |
| 1989-02-01 | 60.8768 | -2.8944 | 61.8060 | 5.2000 | 9.3600 |
| 1989-03-01 | 47.0229 | 2.0806 | 61.9610 | 5.0000 | 9.8500 |
| 1989-04-01 | 67.4642 | 5.0090 | 62.0166 | 5.2000 | 9.8400 |
| 1989-05-01 | 78.5050 | 3.5137 | 61.5631 | 5.2000 | 9.8100 |
| 1989-06-01 | 119.2716 | -0.7925 | 61.6029 | 5.3000 | 9.5300 |
| 1989-07-01 | 103.3324 | 8.8370 | 61.0102 | 5.2000 | 9.2400 |
| 1989-08-01 | 74.3222 | 1.5517 | 61.5621 | 5.2000 | 8.9900 |
| 1989-09-01 | 51.4155 | -0.6544 | 61.3843 | 5.3000 | 9.0200 |
| 1989-10-01 | 95.2859 | -2.5175 | 61.3103 | 5.3000 | 8.8400 |
| 1989-11-01 | 67.4101 | 1.6541 | 61.5146 | 5.4000 | 8.5500 |
| 1989-12-01 | 91.1619 | 2.1417 | 61.8768 | 5.4000 | 8.4500 |
| 1990-01-01 | 128.5027 | -6.8817 | 61.4882 | 5.4000 | 8.2300 |
| 1990-02-01 | 75.2743 | 0.8539 | 62.0678 | 5.3000 | 8.2400 |
| 1990-03-01 | 55.4767 | 2.4255 | 62.3988 | 5.2000 | 8.2800 |
| 1990-04-01 | 49.9482 | -2.6887 | 62.3357 | 5.4000 | 8.2600 |
| 1990-05-01 | 58.8046 | 9.1989 | 62.4364 | 5.4000 | 8.1800 |
| 1990-06-01 | 58.9016 | -0.8886 | 62.6392 | 5.2000 | 8.2900 |
| 1990-07-01 | 77.4366 | -0.5223 | 62.5683 | 5.5000 | 8.1500 |
| 1990-08-01 | 197.2009 | -9.4314 | 62.7314 | 5.7000 | 8.1300 |
| 1990-09-01 | 162.9438 | -5.1184 | 62.8608 | 5.9000 | 8.2000 |
| 1990-10-01 | 170.2559 | -0.6698 | 62.3779 | 5.9000 | 8.1100 |
| 1990-11-01 | 178.2024 | 5.9934 | 61.6370 | 6.2000 | 7.8100 |
| 1990-12-01 | 145.6719 | 2.4828 | 61.2198 | 6.3000 | 7.3100 |
| 1991-01-01 | 343.6688 | 4.1518 | 60.9412 | 6.4000 | 6.9100 |
| 1991-02-01 | 172.3233 | 6.7281 | 60.5393 | 6.6000 | 6.2500 |
| 1991-03-01 | 176.3830 | 2.2203 | 60.2144 | 6.8000 | 6.1200 |
| 1991-04-01 | 117.5937 | 0.0320 | 60.3452 | 6.7000 | 5.9100 |
| 1991-05-01 | 52.7830 | 3.8605 | 60.9449 | 6.9000 | 5.7800 |
| 1991-06-01 | 48.2396 | -4.7893 | 61.5109 | 6.9000 | 5.9000 |
| 1991-07-01 | 96.6724 | 4.4859 | 61.5154 | 6.8000 | 5.8200 |
| 1991-08-01 | 82.4852 | 1.9649 | 61.5997 | 6.9000 | 5.6600 |
| 1991-09-01 | 96.2196 | -1.9144 | 62.1313 | 6.9000 | 5.4500 |
| 1991-10-01 | 111.7931 | 1.1834 | 61.9921 | 7.0000 | 5.2100 |
| 1991-11-01 | 201.0341 | -4.3904 | 61.9329 | 7.0000 | 4.8100 |
| 1991-12-01 | 160.0888 | 11.1588 | 61.6968 | 7.3000 | 4.4300 |
| 1992-01-01 | 160.1280 | -1.9924 | 61.3162 | 7.3000 | 4.0300 |
| 1992-02-01 | 160.0204 | 0.9590 | 61.7625 | 7.4000 | 4.0600 |
| 1992-03-01 | 95.0253 | -2.1832 | 62.3018 | 7.4000 | 3.9800 |

| | | | | | |
|---|---|---|---|---|---|
| 1992-04-01 | 71.4780 | 2.7893 | 62.7350 | 7.4000 | 3.7300 |
| 1992-05-01 | 48.0407 | 0.0964 | 62.9477 | 7.6000 | 3.8200 |
| 1992-06-01 | 86.1821 | -1.7359 | 62.9333 | 7.8000 | 3.7600 |
| 1992-07-01 | 173.2417 | 3.9374 | 63.4966 | 7.7000 | 3.2500 |
| 1992-08-01 | 141.7331 | -2.3998 | 63.1933 | 7.6000 | 3.3000 |
| 1992-09-01 | 195.9262 | 0.9106 | 63.3374 | 7.6000 | 3.2200 |
| 1992-10-01 | 195.2485 | 0.2106 | 63.8251 | 7.3000 | 3.1000 |
| 1992-11-01 | 117.0326 | 3.0262 | 64.0929 | 7.4000 | 3.0900 |
| 1992-12-01 | 57.6082 | 1.0108 | 64.1359 | 7.4000 | 2.9200 |
| 1993-01-01 | 55.1599 | 0.7046 | 64.4420 | 7.3000 | 3.0200 |
| 1993-02-01 | 101.6173 | 1.0484 | 64.6798 | 7.1000 | 3.0300 |
| 1993-03-01 | 82.2864 | 1.8697 | 64.6500 | 7.0000 | 3.0700 |
| 1993-04-01 | 55.4737 | -2.5417 | 64.8439 | 7.1000 | 2.9600 |
| 1993-05-01 | 105.5729 | 2.2717 | 64.6069 | 7.1000 | 3.0000 |
| 1993-06-01 | 137.5609 | 0.0755 | 64.7218 | 7.0000 | 3.0400 |
| 1993-07-01 | 132.8890 | -0.5327 | 64.9088 | 6.9000 | 3.0600 |
| 1993-08-01 | 145.9587 | 3.4432 | 64.8689 | 6.8000 | 3.0300 |
| 1993-09-01 | 40.2690 | -0.9988 | 65.1755 | 6.7000 | 3.0900 |
| 1993-10-01 | 56.8905 | 1.9393 | 65.6744 | 6.8000 | 2.9900 |
| 1993-11-01 | 57.2033 | -1.2911 | 65.9414 | 6.6000 | 3.0200 |
| 1993-12-01 | 38.6565 | 1.0091 | 66.2823 | 6.5000 | 2.9600 |
| 1994-01-01 | 63.9599 | 3.2501 | 66.5527 | 6.6000 | 3.0500 |
| 1994-02-01 | 65.7915 | -3.0045 | 66.5732 | 6.6000 | 3.2500 |
| 1994-03-01 | 104.5889 | -4.5747 | 67.2551 | 6.5000 | 3.3400 |
| 1994-04-01 | 159.8695 | 1.1531 | 67.6129 | 6.4000 | 3.5600 |
| 1994-05-01 | 160.7678 | 1.2397 | 67.9941 | 6.1000 | 4.0100 |
| 1994-06-01 | 69.7745 | -2.6791 | 68.4527 | 6.1000 | 4.2500 |
| 1994-07-01 | 73.5705 | 3.1490 | 68.5674 | 6.1000 | 4.2600 |
| 1994-08-01 | 100.5066 | 3.7599 | 68.9525 | 6.0000 | 4.4700 |
| 1994-09-01 | 51.9716 | -2.6878 | 69.1966 | 5.9000 | 4.7300 |
| 1994-10-01 | 61.6265 | 2.0834 | 69.7795 | 5.8000 | 4.7600 |
| 1994-11-01 | 126.3685 | -3.9505 | 70.2111 | 5.6000 | 5.2900 |
| 1994-12-01 | 86.4361 | 1.2299 | 70.9325 | 5.5000 | 5.4500 |
| 1995-01-01 | 185.1981 | 2.4278 | 71.0773 | 5.6000 | 5.5300 |
| 1995-02-01 | 166.7413 | 3.6074 | 71.0101 | 5.4000 | 5.9200 |
| 1995-03-01 | 96.2986 | 2.7329 | 71.1135 | 5.4000 | 5.9800 |
| 1995-04-01 | 49.7331 | 2.7960 | 71.0925 | 5.8000 | 6.0500 |
| 1995-05-01 | 39.3714 | 3.6312 | 71.3036 | 5.6000 | 6.0100 |
| 1995-06-01 | 120.1633 | 2.1279 | 71.5868 | 5.6000 | 6.0000 |
| 1995-07-01 | 88.6465 | 3.1776 | 71.2946 | 5.7000 | 5.8500 |
| 1995-08-01 | 35.9212 | -0.0320 | 72.2460 | 5.7000 | 5.7400 |
| 1995-09-01 | 32.4845 | 4.0097 | 72.5149 | 5.6000 | 5.8000 |
| 1995-10-01 | 42.0681 | -0.4979 | 72.4092 | 5.5000 | 5.7600 |
| 1995-11-01 | 93.9392 | 4.1049 | 72.5899 | 5.6000 | 5.8000 |
| 1995-12-01 | 176.5157 | 1.7444 | 72.8672 | 5.6000 | 5.6000 |
| 1996-01-01 | 138.4710 | 3.2617 | 72.3857 | 5.6000 | 5.5600 |

| | | | | | |
|---|---|---|---|---|---|
| 1996-02-01 | 57.5227 | 0.6934 | 73.5162 | 5.5000 | 5.2200 |
| 1996-03-01 | 68.2239 | 0.7917 | 73.4143 | 5.5000 | 5.3100 |
| 1996-04-01 | 29.4123 | 1.3431 | 74.0513 | 5.6000 | 5.2200 |
| 1996-05-01 | 57.6879 | 2.2853 | 74.5812 | 5.6000 | 5.2400 |
| 1996-06-01 | 71.4147 | 0.2257 | 75.2056 | 5.3000 | 5.2700 |
| 1996-07-01 | 92.1338 | -4.5748 | 75.0578 | 5.5000 | 5.4000 |
| 1996-08-01 | 42.3408 | 1.8814 | 75.5237 | 5.1000 | 5.2200 |
| 1996-09-01 | 68.9522 | 5.4203 | 76.0082 | 5.2000 | 5.3000 |
| 1996-10-01 | 45.3565 | 2.6101 | 75.9507 | 5.2000 | 5.2400 |
| 1996-11-01 | 31.4628 | 7.3376 | 76.6062 | 5.4000 | 5.3100 |
| 1996-12-01 | 60.6549 | -2.1505 | 77.0862 | 5.4000 | 5.2900 |
| 1997-01-01 | 53.1312 | 6.1317 | 77.2068 | 5.3000 | 5.2500 |
| 1997-02-01 | 19.4238 | 0.5928 | 78.1421 | 5.2000 | 5.1900 |
| 1997-03-01 | 60.9591 | -4.2614 | 78.6905 | 5.2000 | 5.3900 |
| 1997-04-01 | 65.5334 | 5.8406 | 78.7482 | 5.1000 | 5.5100 |
| 1997-05-01 | 75.0374 | 5.8577 | 79.2425 | 4.9000 | 5.5000 |
| 1997-06-01 | 54.0779 | 4.3453 | 79.6340 | 5.0000 | 5.5600 |
| 1997-07-01 | 24.0467 | 7.8146 | 80.3148 | 4.9000 | 5.5200 |
| 1997-08-01 | 75.8822 | -5.7466 | 81.0985 | 4.8000 | 5.5400 |
| 1997-09-01 | 16.5745 | 5.3154 | 81.8177 | 4.9000 | 5.5400 |
| 1997-10-01 | 80.4511 | -3.4478 | 82.5500 | 4.7000 | 5.5000 |
| 1997-11-01 | 53.7214 | 4.4587 | 83.2814 | 4.6000 | 5.5200 |
| 1997-12-01 | 59.1026 | 1.5732 | 83.5471 | 4.7000 | 5.5000 |
| 1998-01-01 | 120.8020 | 1.0150 | 83.9719 | 4.6000 | 5.5600 |
| 1998-02-01 | 137.3872 | 7.0449 | 84.0422 | 4.6000 | 5.5100 |
| 1998-03-01 | 54.3545 | 4.9946 | 84.1094 | 4.7000 | 5.4900 |
| 1998-04-01 | 56.6569 | 0.9076 | 84.4020 | 4.3000 | 5.4500 |
| 1998-05-01 | 60.9189 | -1.8826 | 84.9233 | 4.4000 | 5.4900 |
| 1998-06-01 | 58.8224 | 3.9438 | 84.3698 | 4.5000 | 5.5600 |
| 1998-07-01 | 83.1964 | -1.1615 | 84.0508 | 4.5000 | 5.5400 |
| 1998-08-01 | 146.0988 | -14.5797 | 85.7994 | 4.5000 | 5.5500 |
| 1998-09-01 | 239.2139 | 6.2396 | 85.5797 | 4.6000 | 5.5100 |
| 1998-10-01 | 157.4840 | 8.0294 | 86.2410 | 4.5000 | 5.0700 |
| 1998-11-01 | 148.7491 | 5.9126 | 86.2060 | 4.4000 | 4.8300 |
| 1998-12-01 | 87.6340 | 5.6375 | 86.5085 | 4.4000 | 4.6800 |
| 1999-01-01 | 109.7779 | 4.1009 | 86.9117 | 4.3000 | 4.6300 |
| 1999-02-01 | 37.1589 | -3.2283 | 87.3052 | 4.4000 | 4.7600 |
| 1999-03-01 | 49.2165 | 3.8794 | 87.4728 | 4.2000 | 4.8100 |
| 1999-04-01 | 34.7273 | 3.7944 | 87.6419 | 4.3000 | 4.7400 |
| 1999-05-01 | 30.1506 | -2.4970 | 88.3165 | 4.2000 | 4.7400 |
| 1999-06-01 | 58.4994 | 5.4438 | 88.1778 | 4.3000 | 4.7600 |
| 1999-07-01 | 89.1978 | -3.2046 | 88.7370 | 4.3000 | 4.9900 |
| 1999-08-01 | 77.3876 | -0.6254 | 89.0973 | 4.2000 | 5.0700 |
| 1999-09-01 | 64.4869 | -2.8552 | 88.7815 | 4.2000 | 5.2200 |
| 1999-10-01 | 64.1781 | 6.2540 | 89.9689 | 4.1000 | 5.2000 |
| 1999-11-01 | 56.3339 | 1.9062 | 90.4104 | 4.1000 | 5.4200 |

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|---|---|---|---|---|---|
| 1999-12-01 | 115.6896 | 5.7844 | 91.1008 | 4.0000 | 5.3000 |
| 2000-01-01 | 47.4697 | -5.0904 | 91.1343 | 4.0000 | 5.4500 |
| 2000-02-01 | 53.6419 | -2.0108 | 91.4065 | 4.1000 | 5.7300 |
| 2000-03-01 | 49.1806 | 9.6720 | 91.7982 | 4.0000 | 5.8500 |
| 2000-04-01 | 86.9339 | -3.0796 | 92.4720 | 3.8000 | 6.0200 |
| 2000-05-01 | 95.2413 | -2.1915 | 92.6710 | 4.0000 | 6.2700 |
| 2000-06-01 | 88.4576 | 2.3934 | 92.7438 | 4.0000 | 6.5300 |
| 2000-07-01 | 43.2638 | -1.6341 | 92.6345 | 4.0000 | 6.5400 |
| 2000-08-01 | 55.6019 | 6.0699 | 92.3191 | 4.1000 | 6.5000 |
| 2000-09-01 | 82.0673 | -5.3483 | 92.6699 | 3.9000 | 6.5200 |
| 2000-10-01 | 70.2835 | -0.4949 | 92.3486 | 3.9000 | 6.5100 |
| 2000-11-01 | 227.2234 | -8.0069 | 92.3421 | 3.9000 | 6.5100 |
| 2000-12-01 | 210.6738 | 0.4053 | 92.0670 | 3.9000 | 6.4000 |
| 2001-01-01 | 166.2386 | 3.4637 | 91.3956 | 4.2000 | 5.9800 |
| 2001-02-01 | 171.6383 | -9.2291 | 90.8272 | 4.2000 | 5.4900 |
| 2001-03-01 | 133.9730 | -6.4205 | 90.5589 | 4.3000 | 5.3100 |
| 2001-04-01 | 155.7892 | 7.6814 | 90.2884 | 4.4000 | 4.8000 |
| 2001-05-01 | 114.2697 | 0.5090 | 89.6315 | 4.3000 | 4.2100 |
| 2001-06-01 | 61.8428 | -2.5035 | 89.0366 | 4.5000 | 3.9700 |
| 2001-07-01 | 89.4562 | -1.0740 | 88.5620 | 4.6000 | 3.7700 |
| 2001-08-01 | 90.2477 | -6.4108 | 88.3842 | 4.9000 | 3.6500 |
| 2001-09-01 | 407.9409 | -8.1723 | 88.0735 | 5.0000 | 3.0700 |
| 2001-10-01 | 337.9183 | 1.8099 | 87.6361 | 5.3000 | 2.4900 |
| 2001-11-01 | 197.3382 | 7.5176 | 87.1612 | 5.5000 | 2.0900 |
| 2001-12-01 | 96.7887 | 0.7574 | 87.1764 | 5.7000 | 1.8200 |
| 2002-01-01 | 137.5605 | -1.5574 | 87.7152 | 5.7000 | 1.7300 |
| 2002-02-01 | 60.0046 | -2.0766 | 87.7275 | 5.7000 | 1.7400 |
| 2002-03-01 | 103.1454 | 3.6739 | 88.4132 | 5.7000 | 1.7300 |
| 2002-04-01 | 57.9641 | -6.1418 | 88.8118 | 5.9000 | 1.7500 |
| 2002-05-01 | 103.2968 | -0.9081 | 89.1944 | 5.8000 | 1.7500 |
| 2002-06-01 | 68.2160 | -7.2455 | 90.0487 | 5.8000 | 1.7500 |
| 2002-07-01 | 114.2602 | -7.9004 | 89.8366 | 5.8000 | 1.7300 |
| 2002-08-01 | 131.1420 | 0.4881 | 89.8543 | 5.7000 | 1.7400 |
| 2002-09-01 | 178.2958 | -11.0024 | 89.9448 | 5.7000 | 1.7500 |
| 2002-10-01 | 120.5767 | 8.6449 | 89.6630 | 5.7000 | 1.7500 |
| 2002-11-01 | 206.8670 | 5.7070 | 90.1208 | 5.9000 | 1.3400 |
| 2002-12-01 | 165.0227 | -6.0333 | 89.6894 | 6.0000 | 1.2400 |
| 2003-01-01 | 171.7553 | -2.7415 | 90.2943 | 5.8000 | 1.2400 |
| 2003-02-01 | 283.7970 | -1.7004 | 90.5477 | 5.9000 | 1.2600 |
| 2003-03-01 | 300.7496 | 0.8358 | 90.3587 | 5.9000 | 1.2500 |
| 2003-04-01 | 155.5913 | 8.1044 | 89.6553 | 6.0000 | 1.2600 |
| 2003-05-01 | 121.9248 | 5.0899 | 89.6978 | 6.1000 | 1.2600 |
| 2003-06-01 | 67.7909 | 1.1322 | 89.7318 | 6.3000 | 1.2200 |
| 2003-07-01 | 51.7466 | 1.6224 | 90.2652 | 6.2000 | 1.0100 |
| 2003-08-01 | 84.1955 | 1.7873 | 90.0358 | 6.1000 | 1.0300 |
| 2003-09-01 | 53.8378 | -1.1944 | 90.5492 | 6.1000 | 1.0100 |

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|---|---|---|---|---|---|
| 2003-10-01 | 33.8637 | 5.4961 | 90.6137 | 6.0000 | 1.0100 |
| 2003-11-01 | 30.2922 | 0.7129 | 91.3041 | 5.8000 | 1.0000 |
| 2003-12-01 | 60.4765 | 5.0766 | 91.2014 | 5.7000 | 0.9800 |
| 2004-01-01 | 94.5119 | 1.7276 | 91.4431 | 5.7000 | 1.0000 |
| 2004-02-01 | 53.0718 | 1.2209 | 91.9245 | 5.6000 | 1.0100 |
| 2004-03-01 | 38.9158 | -1.6359 | 91.4496 | 5.8000 | 1.0000 |
| 2004-04-01 | 57.1570 | -1.6791 | 91.7958 | 5.6000 | 1.0000 |
| 2004-05-01 | 92.6778 | 1.2083 | 92.4943 | 5.6000 | 1.0000 |
| 2004-06-01 | 114.7361 | 1.7989 | 91.7493 | 5.6000 | 1.0300 |
| 2004-07-01 | 73.3491 | -3.4291 | 92.4549 | 5.5000 | 1.2600 |
| 2004-08-01 | 95.1246 | 0.2287 | 92.4832 | 5.4000 | 1.4300 |
| 2004-09-01 | 71.3217 | 0.9364 | 92.5476 | 5.4000 | 1.6100 |
| 2004-10-01 | 107.7022 | 1.4014 | 93.4371 | 5.5000 | 1.7600 |
| 2004-11-01 | 78.5755 | 3.8595 | 93.6306 | 5.4000 | 1.9300 |
| 2004-12-01 | 28.5923 | 3.2458 | 94.2703 | 5.4000 | 2.1600 |
| 2005-01-01 | 77.8328 | -2.5290 | 94.7136 | 5.3000 | 2.2800 |
| 2005-02-01 | 31.3405 | 1.8903 | 95.3245 | 5.4000 | 2.5000 |
| 2005-03-01 | 42.2533 | -1.9118 | 95.2402 | 5.2000 | 2.6300 |
| 2005-04-01 | 68.8373 | -2.0109 | 95.3681 | 5.2000 | 2.7900 |
| 2005-05-01 | 60.5929 | 2.9952 | 95.5331 | 5.1000 | 3.0000 |
| 2005-06-01 | 61.4135 | -0.0143 | 95.9120 | 5.0000 | 3.0400 |
| 2005-07-01 | 56.6082 | 3.5968 | 95.7242 | 5.0000 | 3.2600 |
| 2005-08-01 | 42.4126 | -1.1222 | 95.8708 | 4.9000 | 3.5000 |
| 2005-09-01 | 126.8744 | 0.6949 | 93.9661 | 5.0000 | 3.6200 |
| 2005-10-01 | 80.4572 | -1.7741 | 95.1806 | 5.0000 | 3.7800 |
| 2005-11-01 | 32.4661 | 3.5186 | 96.1177 | 5.0000 | 4.0000 |
| 2005-12-01 | 78.7382 | -0.0952 | 96.6690 | 4.9000 | 4.1600 |
| 2006-01-01 | 62.2224 | 2.5467 | 96.7856 | 4.7000 | 4.2900 |
| 2006-02-01 | 60.3716 | 0.0453 | 96.8261 | 4.8000 | 4.4900 |
| 2006-03-01 | 46.3808 | 1.1096 | 97.0742 | 4.7000 | 4.5900 |
| 2006-04-01 | 57.9446 | 1.2156 | 97.4400 | 4.7000 | 4.7900 |
| 2006-05-01 | 95.8681 | -3.0917 | 97.3002 | 4.6000 | 4.9400 |
| 2006-06-01 | 91.2169 | 0.0087 | 97.6752 | 4.6000 | 4.9900 |
| 2006-07-01 | 120.1636 | 0.5086 | 97.6870 | 4.7000 | 5.2400 |
| 2006-08-01 | 134.5969 | 2.1274 | 98.0138 | 4.7000 | 5.2500 |
| 2006-09-01 | 35.0633 | 2.4566 | 97.8423 | 4.5000 | 5.2500 |
| 2006-10-01 | 36.0966 | 3.1508 | 97.8060 | 4.4000 | 5.2500 |
| 2006-11-01 | 48.1965 | 1.6467 | 97.6811 | 4.5000 | 5.2500 |
| 2006-12-01 | 17.6162 | 1.2616 | 98.6347 | 4.4000 | 5.2400 |
| 2007-01-01 | 44.7217 | 1.4059 | 98.1696 | 4.6000 | 5.2500 |
| 2007-02-01 | 27.4846 | -2.1846 | 99.2354 | 4.5000 | 5.2600 |
| 2007-03-01 | 59.7327 | 0.9980 | 99.3706 | 4.4000 | 5.2600 |
| 2007-04-01 | 31.2326 | 4.3291 | 100.0920 | 4.5000 | 5.2500 |
| 2007-05-01 | 36.2766 | 3.2549 | 100.1357 | 4.4000 | 5.2500 |
| 2007-06-01 | 42.4600 | -1.7816 | 100.1295 | 4.6000 | 5.2500 |
| 2007-07-01 | 25.4343 | -3.1982 | 100.1757 | 4.7000 | 5.2600 |

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|---|---|---|---|---|---|
| 2007-08-01 | 148.9329 | 1.2864 | 100.3027 | 4.6000 | 5.0200 |
| 2007-09-01 | 154.1409 | 3.5794 | 100.6868 | 4.7000 | 4.9400 |
| 2007-10-01 | 122.1360 | 1.4822 | 100.1968 | 4.7000 | 4.7600 |
| 2007-11-01 | 94.6922 | -4.4043 | 100.7645 | 4.7000 | 4.4900 |
| 2007-12-01 | 125.2693 | -0.8629 | 100.7407 | 5.0000 | 4.2400 |
| 2008-01-01 | 238.2866 | -6.1163 | 100.4921 | 5.0000 | 3.9400 |
| 2008-02-01 | 102.7505 | -3.4761 | 100.2213 | 4.9000 | 2.9800 |
| 2008-03-01 | 161.2357 | -0.5960 | 99.9541 | 5.1000 | 2.6100 |
| 2008-04-01 | 88.1525 | 4.7547 | 99.2345 | 5.0000 | 2.2800 |
| 2008-05-01 | 48.3197 | 1.0674 | 98.7761 | 5.4000 | 1.9800 |
| 2008-06-01 | 51.2132 | -8.5962 | 98.5790 | 5.6000 | 2.0000 |
| 2008-07-01 | 94.8811 | -0.9859 | 98.0964 | 5.8000 | 2.0100 |
| 2008-08-01 | 66.7890 | 1.2190 | 96.5934 | 6.1000 | 2.0000 |
| 2008-09-01 | 202.1721 | -9.0791 | 92.5289 | 6.1000 | 1.8100 |
| 2008-10-01 | 181.9019 | -16.9425 | 93.3148 | 6.5000 | 0.9700 |
| 2008-11-01 | 142.7077 | -7.4849 | 92.1210 | 6.8000 | 0.3900 |
| 2008-12-01 | 113.5509 | 0.7822 | 89.5075 | 7.3000 | 0.1600 |
| 2009-01-01 | 71.8785 | -8.5657 | 87.5382 | 7.8000 | 0.1500 |
| 2009-02-01 | 145.2466 | -10.9931 | 86.9117 | 8.3000 | 0.2200 |
| 2009-03-01 | 93.0961 | 8.5404 | 85.6157 | 8.7000 | 0.1800 |
| 2009-04-01 | 71.0436 | 9.3925 | 84.9483 | 9.0000 | 0.1500 |
| 2009-05-01 | 88.8360 | 5.3081 | 84.0497 | 9.4000 | 0.1800 |
| 2009-06-01 | 44.0261 | 0.0196 | 83.7320 | 9.5000 | 0.2100 |
| 2009-07-01 | 46.6046 | 7.4142 | 84.5670 | 9.5000 | 0.1600 |
| 2009-08-01 | 46.0474 | 3.3560 | 85.3735 | 9.6000 | 0.1600 |
| 2009-09-01 | 71.1811 | 3.5723 | 85.9988 | 9.8000 | 0.1500 |
| 2009-10-01 | 30.4493 | -1.9762 | 86.3075 | 10.0000 | 0.1200 |
| 2009-11-01 | 108.7671 | 5.7364 | 86.6403 | 9.9000 | 0.1200 |
| 2009-12-01 | 71.0769 | 1.7771 | 86.9300 | 9.9000 | 0.1200 |
| 2010-01-01 | 107.8695 | -3.6974 | 87.9900 | 9.7000 | 0.1100 |
| 2010-02-01 | 80.1170 | 2.8514 | 88.2232 | 9.8000 | 0.1300 |
| 2010-03-01 | 44.5260 | 5.8796 | 88.8923 | 9.9000 | 0.1600 |
| 2010-04-01 | 42.1028 | 1.4759 | 89.2429 | 9.9000 | 0.2000 |
| 2010-05-01 | 54.5991 | -8.1976 | 90.6351 | 9.6000 | 0.2000 |
| 2010-06-01 | 102.0050 | -5.3882 | 90.8407 | 9.4000 | 0.1800 |
| 2010-07-01 | 159.4940 | 6.8778 | 91.4132 | 9.5000 | 0.1800 |
| 2010-08-01 | 133.6368 | -4.7449 | 91.6730 | 9.5000 | 0.1900 |
| 2010-09-01 | 108.2014 | 8.7551 | 91.9146 | 9.5000 | 0.1900 |
| 2010-10-01 | 109.0729 | 3.6856 | 91.6296 | 9.5000 | 0.1900 |
| 2010-11-01 | 114.8108 | -0.2290 | 91.8108 | 9.8000 | 0.1900 |
| 2010-12-01 | 77.0029 | 6.5300 | 92.5893 | 9.4000 | 0.1800 |
| 2011-01-01 | 44.6737 | 2.2646 | 92.6124 | 9.1000 | 0.1700 |
| 2011-02-01 | 41.6216 | 3.1957 | 92.1015 | 9.0000 | 0.1600 |
| 2011-03-01 | 70.4947 | -0.1047 | 93.0194 | 9.0000 | 0.1400 |
| 2011-04-01 | 62.2272 | 2.8495 | 92.5816 | 9.1000 | 0.1000 |
| 2011-05-01 | 55.0815 | -1.3501 | 92.8754 | 9.0000 | 0.0900 |

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|---|---|---|---|---|---|
| 2011-06-01 | 91.9640 | -1.8257 | 93.0939 | 9.1000 | 0.0900 |
| 2011-07-01 | 160.6456 | -2.1474 | 93.6897 | 9.0000 | 0.0700 |
| 2011-08-01 | 231.1490 | -5.6791 | 94.1465 | 9.0000 | 0.1000 |
| 2011-09-01 | 122.6990 | -7.1762 | 94.2426 | 9.0000 | 0.0800 |
| 2011-10-01 | 75.5593 | 10.7723 | 94.7279 | 8.8000 | 0.0700 |
| 2011-11-01 | 78.1790 | -0.5059 | 94.8324 | 8.6000 | 0.0800 |
| 2011-12-01 | 88.3977 | 0.8533 | 95.1997 | 8.5000 | 0.0700 |
| 2012-01-01 | 76.1084 | 4.3583 | 96.0150 | 8.2000 | 0.0800 |
| 2012-02-01 | 71.5501 | 4.0589 | 96.3750 | 8.3000 | 0.1000 |
| 2012-03-01 | 30.0201 | 3.1332 | 96.0067 | 8.2000 | 0.1300 |
| 2012-04-01 | 62.4860 | -0.7497 | 96.7966 | 8.2000 | 0.1400 |
| 2012-05-01 | 61.2218 | -6.2651 | 97.1123 | 8.2000 | 0.1600 |
| 2012-06-01 | 131.7220 | 3.9555 | 97.1618 | 8.2000 | 0.1600 |
| 2012-07-01 | 123.2763 | 1.2598 | 97.7061 | 8.2000 | 0.1600 |
| 2012-08-01 | 107.4256 | 1.9763 | 97.1146 | 8.1000 | 0.1300 |
| 2012-09-01 | 136.6685 | 2.4236 | 97.3865 | 7.8000 | 0.1400 |
| 2012-10-01 | 89.7789 | -1.9789 | 97.3111 | 7.8000 | 0.1600 |

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Research Paper Title:
Monetary Policy Uncertainty

Major Professor: Dr. Scott Gilbert