Appendix A Measuring the Effectiveness of a Federal Agency

To illustrate that the approach described in the Methodology section of the Web site can be used to measure effectiveness, it is worthwhile to examine how the concepts might be applied within a Federal Agency. The Federal Reserve Board's role in establishing monetary policy will be used as an example, and a simplified analysis will demonstrate that even when applied in such a broad context, the approach is valid.

Monetary Policy

A major strategic objective of the Federal Reserve Board is price stability. Using that objective as an example, and using the terminology of the Web site, at a high level we have the following:

Strategic Objective:	Price Stability
Outcome Indicator:	Changes to the Consumer Price Index (CPI)
Organizational Outputs:	1) Changes to the Federal Funds Rate 2) Changes to the Discount Rate
External Factor:	Changes to the Unemployment Rate

Unemployment Rate was selected as an External Factor because studies have shown that there is an inverse relationship between unemployment and inflation (known as the "Phillips Curve"). If true, we should find some correlation between changes in the unemployment rate and changes in the rate of inflation as represented by the CPI.

This is a simplistic model of the Federal Reserve, but nevertheless is sufficient to demonstrate the concepts involved in measuring effectiveness. The specific question being explored is whether or not the Fed's Outputs affect inflation as represented by changes to the Consumer Price Index, and if they do, how effective they are compared to both known and unknown External Factors.

While one could select as parameters the actual CPI, Fed Funds Rate, Discount Rate, and Unemployment Rate, preliminary analysis indicated that the year-to-year changes to those values are much more sensitive indicators than the values themselves.

Table A-1 shows the public data used to perform the analysis, covering a period of 36 years from 1967 to 2002 inclusive.

Year	CPI Index	CPI (%)	% CPI Change	Fed Funds Rate	Fed Funds Rate Change	Discount Rate	Discount Rate Change	Unemployment Rate	Unemployment Rate Change
1967	100	0.00%	N/A	4.22%	N/A	4.00%	N/A	3.80%	N/A
1968	104.2	4.20%	4.20%	5.66%	1.44%	5.50%	1.50%	3.60%	-0.20%
1969	109.8	5.37%	1.17%	8.21%	2.55%	6.00%	0.50%	3.50%	-0.10%
1970	116.3	5.92%	0.55%	7.17%	-1.04%	6.00%	0.00%	4.90%	1.40%
1971	121.3	4.30%	-1.62%	4.67%	-2.50%	4.75%	-1.25%	5.90%	1.00%
1972	125.3	3.30%	-1.00%	4.44%	-0.23%	4.50%	-0.25%	5.60%	-0.30%
1973	133.1	6.23%	2.93%	8.74%	4.30%	7.00%	2.50%	4.90%	-0.70%
1974	147.7	10.97%	4.74%	10.51%	1.77%	8.00%	1.00%	5.60%	0.70%
1975	161.2	9.14%	-1.83%	5.82%	-4.69%	6.00%	-2.00%	8.50%	2.90%
1976	170.5	5.77%	-3.37%	5.05%	-0.77%	5.50%	-0.50%	7.70%	-0.80%
1977	181.5	6.45%	0.68%	5.54%	0.49%	5.25%	-0.25%	7.10%	-0.60%
1978	195.4	7.66%	1.21%	7.94%	2.40%	7.25%	2.00%	6.10%	-1.00%
1979	217.4	11.26%	3.60%	11.20%	3.26%	9.50%	2.25%	5.80%	-0.30%
1980	246.8	13.52%	2.26%	13.35%	2.15%	11.00%	1.50%	7.10%	1.30%
1981	272.4	10.37%	-3.15%	16.39%	3.04%	14.00%	3.00%	7.60%	0.50%
1982	289.1	6.13%	-4.24%	12.24%	-4.15%	12.00%	-2.00%	9.70%	2.10%
1983	298.4	3.22%	-2.91%	9.09%	-3.15%	8.50%	-3.50%	9.60%	-0.10%
1984	311.1	4.26%	1.04%	10.23%	1.14%	9.00%	0.50%	7.50%	-2.10%
1985	322.2	3.57%	-0.69%	8.10%	-2.13%	7.50%	-1.50%	7.20%	-0.30%
1986	328.4	1.92%	-1.64%	6.80%	-1.30%	6.50%	-1.00%	7.00%	-0.20%
1987	340.4	3.65%	1.73%	6.66%	-0.14%	5.50%	-1.00%	6.20%	-0.80%
1988	354.3	4.08%	0.43%	7.57%	0.91%	6.00%	0.50%	5.50%	-0.70%
1989	371.3	4.80%	0.71%	9.21%	1.64%	7.00%	1.00%	5.30%	-0.20%
1990	391.4	5.41%	0.62%	8.10%	-1.11%	7.00%	0.00%	5.60%	0.30%
1991	408	4.24%	-1.17%	5.69%	-2.41%	5.50%	-1.50%	6.80%	1.20%
1992	420.3	3.01%	-1.23%	3.52%	-2.17%	3.00%	-2.50%	7.50%	0.70%
1993	432.7	2.95%	-0.06%	3.02%	-0.50%	3.00%	0.00%	6.90%	-0.60%
1994	444	2.61%	-0.34%	4.21%	1.19%	3.50%	0.50%	6.10%	-0.80%
1995	456.5	2.82%	0.20%	5.83%	1.62%	5.25%	1.75%	5.60%	-0.50%
1996	469.9	2.94%	0.12%	5.30%	-0.53%	5.00%	-0.25%	5.40%	-0.20%
1997	480.8	2.32%	-0.62%	5.46%	0.16%	5.00%	0.00%	4.90%	-0.50%
1998	488.3	1.56%	-0.76%	5.35%	-0.11%	5.00%	0.00%	4.50%	-0.40%
1999	499	2.19%	0.63%	4.97%	-0.38%	4.50%	-0.50%	4.20%	-0.30%
2000	515.8	3.37%	1.18%	6.24%	1.27%	6.00%	1.50%	4.00%	-0.20%
2001	530.4	2.83%	-0.54%	3.88%	-2.36%	3.25%	-2.75%	4.70%	0.70%
2002	538.8	1.58%	-1.25%	1.67%	-2.21%	1.25%	-2.00%	5.80%	1.10%

Table A-1 CPI, Fed Funds Rate, Discount Rate, and Unemployment Rate; 1967-2002

In an effort to minimize the data volume, Table A-1 only reflects annual averages of the Consumer Price Index (all items), Unemployment Rate, and Fed Funds Rate, and reflects the Discount Rate that was in effect on July 1 of that year. In practice, the Federal Reserve Board changes the Fed Funds Rate (the rate at which banks borrow from each other) and Discount Rate (the rate at which banks borrow from the Federal Reserve) as necessary during the course of a year, and gathers much more information on the economy to support its deliberations. The result is significantly more activity and data available to the Federal Reserve than is represented by Table A-1, again highlighting the fact that this is a simplified approach.

Monetary Policy Analysis

Analysis of the effectiveness of a program involves exploring the statistical significance of the relationships between the parameter that represents the strategic objective (the dependent variable; in this case changes to the CPI) and the independent variables that are postulated to affect the strategic objective, i.e. the organization's outputs and any identified external factors.

However, for a proper analysis of the independent variables that might affect the parameter of interest, it is important to first ensure that they are truly independent. In this example, the Discount Rate and Fed Funds rate were found to be closely correlated, i.e. when the Fed makes a change to one parameter, it tends to make a similar change to the other. See Figures A-1 and A-2.

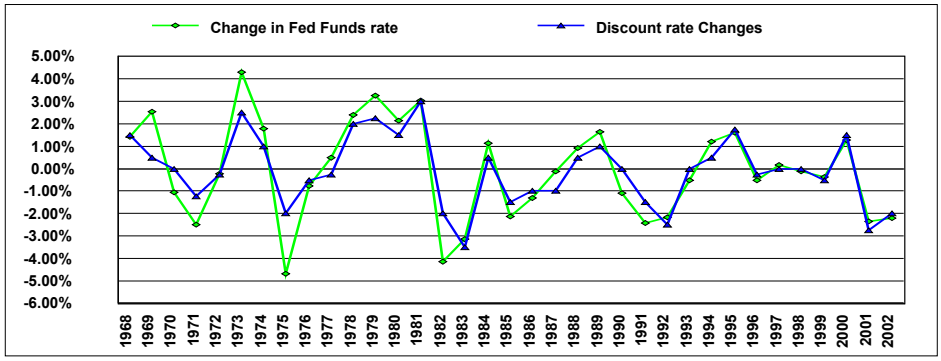

Figure A-1 Changes to Fed Funds & Discount Rates since 1968

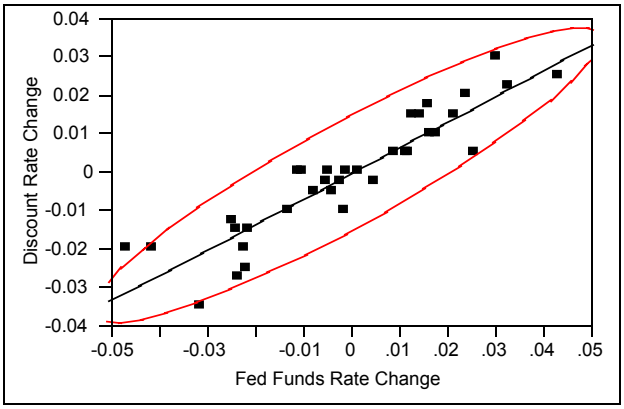

Figure A-2 Relationship between Discount Rate Changes & Fed Funds Rate Changes

Figures A-1 and A-2 included all years in the data set with no exclusions. The ellipse in Figure A-2 captures 95% of the data and supports the impression given by Figure A-1 that the two Fed outputs tend to be linearly related and are not independent. This lack of independence between changes to the discount rate and the fed funds rate, called collinearity, could skew the results if both parameters were used, so it is important to select only one of those two variables in the effectiveness analysis. Changes to the Fed Funds Rate were subsequently found to have a tighter correlation with changes to the CPI, so it was selected as the primary "Output" of the Fed, and the Discount Rate changes were dropped from the analysis.

Ignoring the Discount Rate leaves us with three parameters to analyze: changes to the CPI, changes to Fed Funds Rate, and changes to the Unemployment Rate. Before doing any statistical analysis, it is helpful to visualize these relationships. See Figures A-3 and A-4.

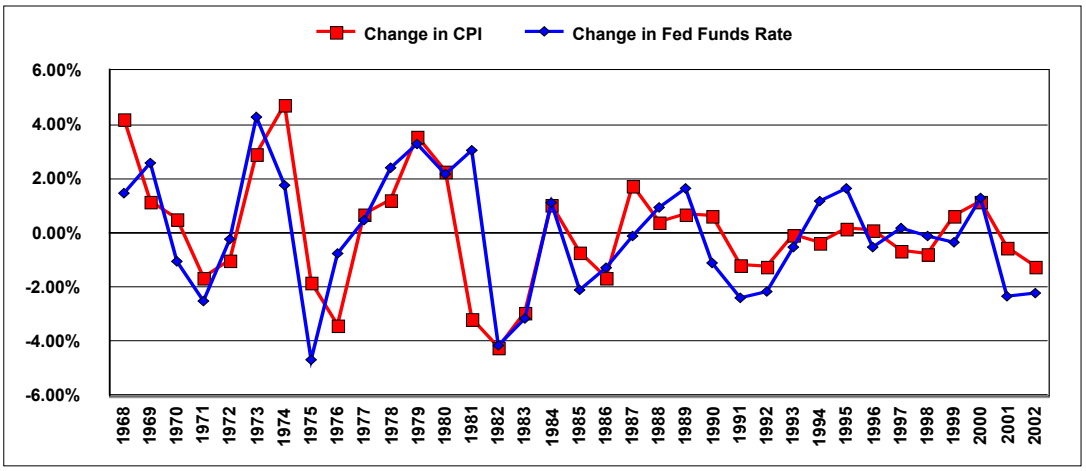

Figure A-3 Relationship between CPI Changes and Fed Funds Rate Changes

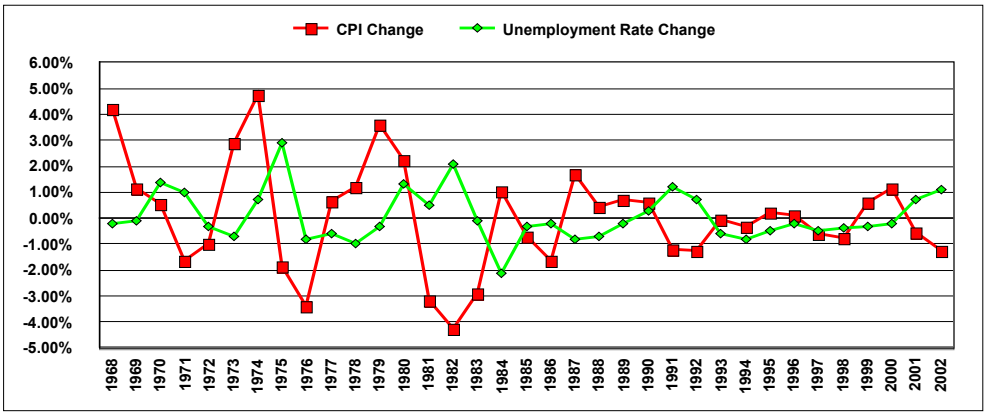

Figure A-4 Relationship Between CPI Changes and Unemployment Rate Changes

Figure A-3 shows that there is some degree of correlation that exists between the changes in the Fed Funds Rate and the changes to CPI, and Figure A-4 reflects what appears to be a validation of the inverse relationship between Unemployment Rate changes and CPI changes as discussed earlier; this is to be expected – when unemployment is low, wages tend to rise to attract additional workers. However, it is reasonable to assume that there are lags in the economic system and the CPI changes in any given year may be the result of earlier Fed action and earlier changes to the unemployment rate. Therefore, a proper analysis should take into consideration possible time lags in order to fully examine whether the relative effects of the Fed actions and unemployment rate changes upon future CPI changes are statistically significant.

Having identified the two primary independent variables that might impact the CPI, the next step in the process involves conducting various trials and searching for statistical significance among various combinations of those variables. Examples of potential trials include time-lagging the variables by various periods, using year-to-year changes to the parameters or the parameters themselves, looking at cumulative changes from year to year, omitting data that is clearly out of line with the preponderance of evidence, etc. etc.

In this search for statistical significance, it is essential that the combinations of data employed in the analysis meet the test of logic as well. As an example, Figure A-3 shows reasonable correlation between the Federal Funds Rate changes and the CPI changes, but note that they are in the same direction, indicating that increasing the Fed Funds rate (a tight money policy) would tend to increase inflation. This is not a reasonable conclusion even if analysis shows strong statistical evidence of the correlation. More likely, the effect seen in Figure A-3 is that of the Fed reacting to changes in inflation experienced that same year, with the objective being to reduce inflation *in the future.*

Omitting data points from the analysis that do not fit with the pattern established by the bulk of other data is sometimes necessary but can also be problematic; exclusion of data should be accompanied by justifications as to why it is reasonable to omit those data points.

Analysis Results

Taking all of the foregoing into consideration, multiple trials were conducted with the data using statistical software to determine what relationships exist, if any, between changes to the Fed Funds Rate (what the Fed can control), the Unemployment Rate (what the Fed has little control over), and the Strategic Objective of Price Stability. If the relationships were found to be statistically significant, it would demonstrate the relative effectiveness of the Fed's actions versus the influence of an external factor (the Unemployment Rate).

It became evident during those trials that data from several years during the 1970's and early 80's (when the Fed was struggling with extraordinarily high inflation rates) simply did not fit the pattern established by all the other years. As a result, it was necessary to exclude 6 years (1973, 1975, 1979, 1980, 1982, and 1985), with the justification being that some occurred during a period of steep increases in energy costs never before encountered and others occurred during an unusual period of 'stagflation' – high unemployment and high inflation at the same time. The fact that the data used for this analysis has been simplified to reflect annual averages may also have contributed to the lack of fit for those years. However, the subsequent section on 'Validation of Results' shows that this exclusion of data did not result in false conclusions.

The results of the analysis are displayed in Figure A-5, which shows that the Fed Funds Rate Change (2 years earlier) and the Unemployment Rate (1 year earlier) are the factors that have the most significant effect on the change to the current year CPI. Both factors were significant at a confidence level in excess of 99%. We can therefore rely on the results and establish a *predictive* equation that reflects what is likely to happen 2 years in the future based on what the Fed does this year and what change to the unemployment rate occurs next year. The parameters in Table A-2 reflect the weighting factors (coefficients) of the resultant predictive equation, and the Actual by Predicted Chart in the lower section of Figure A-5 graphically displays how closely the historical data fits the prediction equation.

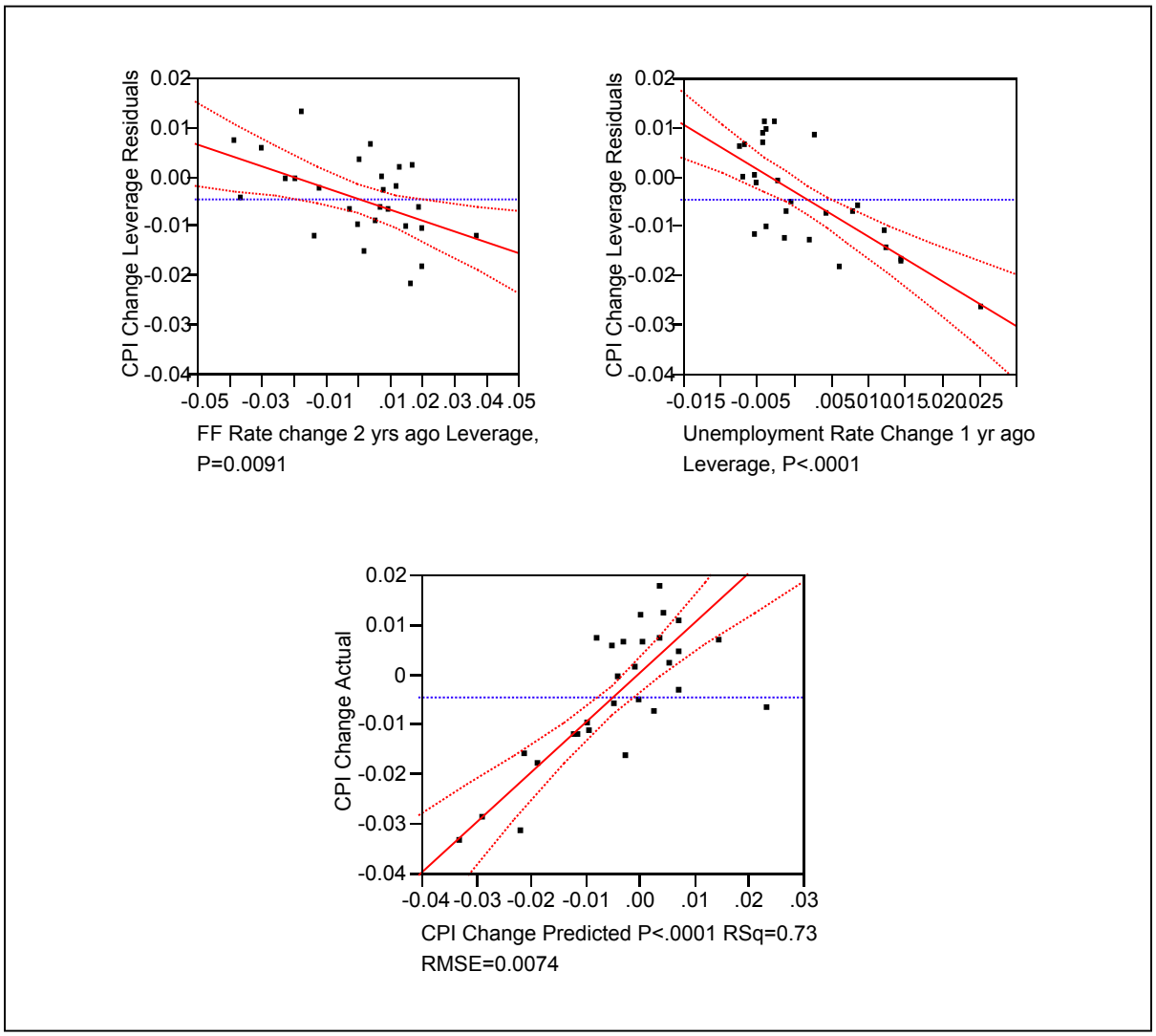

Figure A-5 Individual Effects of Fed Funds Rate (2 years earlier) and Unemployment Rate (1 year earlier), and Actual vs Predicted CPI Change

Summary of Fit

RSquare	0.732087
RSquare Adj	0.709761
Root Mean Square Error	0.007377
Mean of Response	-0.00459
Observations (or Sum Wgts)	27

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	2	0.00356926	0.001785	32.7906
Error	24	0.00130620	0.000054	Prob > F
C. Total	26	0.00487546		<.0001

Parameter Estimates

Term	Estimate	Std Error	t Ratio	Prob>|t|
Intercept	-0.002671	0.001449	-1.84	0.0777
FF Rate change 2 yrs ago	-0.218487	0.076971	-2.84	0.0091
Unemployment Rate Change 1 yr ago	-0.912081	0.173103	-5.27	<.0001

Table A-2 Prediction Equation Parameters and Supporting Statistics

To further assure that the results are meaningful, it is important to examine the distribution of the residual errors (the difference between the predicted values and the actual values). If the pattern is random and follows a normal distribution, our confidence is enhanced, whereas if the residual errors are skewed in one direction, there may be errors in the approach employed, despite the apparent close fit indicated by the statistics.

Figure A-6 represents a scatter plot of the residual errors and Figure A-7 shows the distribution of those errors. Note that the errors tend to be random; this is supported by the near normal distribution pattern shown in Figure A-7.

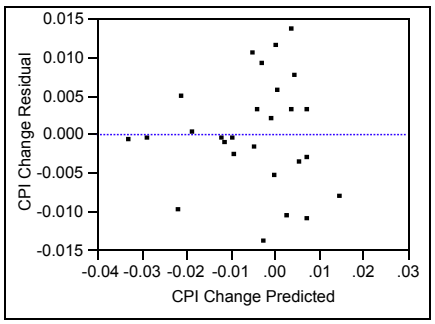

Figure A-6 Residual Error Plot

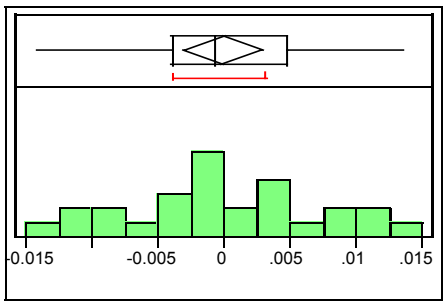

Figure A-7 Residual Error Distribution

The results are quite conclusive. All of the statistical indicators indicate with an exceptionally high degree of confidence that the depicted relationships are valid. The results can be interpreted as follows:

1. The *change* to the Consumer Price Index in any given year is affected by the Federal Reserve Board's *changes* to the average Federal Funds Rate two years previously and the *change* to the Unemployment Rate one year before.

2. Table A-2 lists the correlation coefficients of the predictive equation as follows:

   Change to the current year CPI (%) = - 0.27% - .218 * (average % Fed Funds Rate change 2 yrs earlier) - .912 * (annual % Unemployment Rate Change 1 year earlier)

   The error associated with this predictive error has a standard deviation of 0.74%.

3. Changes to the Unemployment Rate (the external factor) have a much stronger effect on changes to the CPI than do changes the Fed makes to the Fed Funds rate. The results indicate it would take a 4.5% change to the Fed Funds Rate to neutralize an anticipated 1% change in the Unemployment Rate the following year.

In plain language, the Fed's use of the Fed Funds Rate to influence the Consumer Price Index is indeed meaningful, but the impact is delayed by two years and its influence is relatively weak compared to the influence of the Unemployment Rate. Thus, the Federal Reserve Board's efforts are effective, but perhaps not as effective as they would like them to be.

Validation of the Results

The primary objective of this example has been to demonstrate that the techniques described can be applied to measure effectiveness in very complex public sector organizations like the Federal Reserve as well as to more straightforward government programs. There are several reasons to pursue this type of analysis:

1. To determine whether or not a program's outputs are indeed having an impact upon the desired outcome.

2. To determine the relative influence of multiple program outputs upon the desired outcome, when compared to each other and to any external factors that have been identified.

3. To alter the allocation of resources in a manner that will improve progress toward the desired outcome.

Proceeding with decisions of this nature requires strong faith in the effectiveness analysis. Therefore, in the case of the Federal Reserve, it is appropriate to validate the underlying concepts further by taking the results (that were derived by looking backward in time) to see if they can be applied looking forward.

The following test was established to determine how well the results could be used to predict the future:

1. It was initially assumed to be the end of 1988, and there was a desire to *forecast* the expected change in the Consumer Price Index for 1989.

2. Using only data that would have existed at that time, i.e. 1967 to 1988, but excluding the same years that were identified previously, an analysis was performed that was similar to that performed for the entire data set, i.e. the Fed Funds Rate two years earlier and the Unemployment Rate one year earlier were used as the independent variables. Because the data set was smaller, the result was a different set of Parameter Estimates (coefficients) to be employed in the predictive equation.

3. Using the new coefficients, the predicted change in CPI for 1989 was calculated.

4. Since the actual change in CPI for that year is known, the predictive error was computed.

5. The foregoing steps were subsequently applied to each year from 1989 to 2003, in each case using all available data that would have existed up to that time, less the excluded years.

The results, displayed in Table A-3, are a set of predictions that would have occurred using these techniques as compared to the actual results.

Predicted Year	CPI Change Prediction	CPI Change Actual	Predictive Error	Absolute Predictive Error	Expected RMS Error	Model R SQ
1989	0.42%	0.71%	-0.29%	0.29%	0.86%	0.807313
1990	-0.25%	0.62%	-0.87%	0.87%	0.82%	0.815207
1991	-0.80%	-1.17%	0.37%	0.37%	0.82%	0.805955
1992	-1.07%	-1.23%	0.16%	0.16%	0.80%	0.80463
1993	-0.31%	-0.06%	-0.25%	0.25%	0.77%	0.805819
1994	0.93%	-0.34%	1.27%	1.27%	0.75%	0.806047
1995	0.61%	0.20%	0.41%	0.41%	0.78%	0.772785
1996	-0.09%	0.12%	-0.21%	0.21%	0.76%	0.77258
1997	-0.44%	-0.62%	0.18%	0.18%	0.74%	0.773932
1998	0.30%	-0.76%	1.06%	1.06%	0.73%	0.773286
1999	-0.01%	0.63%	-0.64%	0.64%	0.74%	0.749705
2000	-0.00%	1.18%	-1.18%	1.18%	0.74%	0.748389
2001	0.03%	-0.54%	0.57%	0.57%	0.76%	0.734847
2002	-1.18%	-1.25%	0.07%	0.07%	0.75%	0.728567
2003	-0.75%	0.70%	-1.45%	1.45%	0.74%	0.732087
		Average Error	-0.05%	0.60%		

Table A-3 Comparison of Predicted Change in CPI to Actual Change in CPI

Note that the average predicted error for the 15 year period is near zero (-0.05%) and the average error in any direction (the absolute predictive error) is only 0.6%. Note also that in most years, the predicted error falls well within the RMS error expected by the predictive model and in all cases falls within the 95% confidence limits of approximately +/- 1.5% . The R Squared column reflects the degree of fit of the model to the data leading up to that year (1.0 would indicate a 100% fit).

Considering the simplified nature of this analysis using only public data, the predictions are stunningly accurate. It is an exceptionally strong validation of the approach used to measure effectiveness of a federal agency in the presence of external factors.

Conclusion

No doubt the Fed has very sophisticated econometric models to predict changes in inflation, and this simple analysis is not intended to supplant them. What the example has shown, however, is that the approach described in the paper can reliably be used to assist managers in measuring the effectiveness of their programs, and despite a program's complexity, there may be fewer driving forces behind the programmatic results than expected. Determining what those driving forces are and the relative strength of each puts program managers in a very strong position to better allocate their scarce resources.