Were Fed's active monetary policy actions necessary?

Pang, Iris Ai Jao
Hong Kong University of Science and Technology

10. May 2010

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1. Introduction

Vector autoregression (VAR) has been used to analyze the effects of monetary policy by relating the variables of interest to the structural economic shocks. In the VAR framework, we can identify the effects of policy if we can identify the structural economic shocks. Dynamic policy effects can then be computed via the impulse response functions. The advantage of such an exercise is that we do not need to identify the dynamic structure of the economic model. However, there have been disagreements on how to identify these policy shocks appropriately (see Christiano, Eichenbaum, and Evans, 2000 for a survey of the alternatives).

The VARs usually employ only a few variables because of constraints arising from the degrees of freedom considerations. As mentioned in Bernanke, Boivin and Eliasz (2005) (hereafter BBE), the standard VAR usually contains only six to eight variables. However, as far as monetary policy is concerned, central banks in reality exploit hundreds of data series to make their decisions on monetary policies. The small number of variables in the VAR analysis cannot span the information set used by central banks. This leads to the problem of omitting variables that contain information about the structural economic shocks in the standard VAR analysis. Leeper, Sims, and Zha (1996) tried larger VARs through the use of Bayesian priors that contained thirteen and eighteen variables. However increasing the number of variables in a VAR creates low efficiency of estimation; moreover, using less than twenty variables is still unacceptably less than the hundreds of time series actually used by central banks. In short, the low dimension of the VAR is not practicable in the analysis of actual monetary policy dynamics.

The recent development of factor models provides a solution to this dimensionality problem of the VAR. In general, the idea of the factor model is to summarize the information embedded in a large dataset into a small number of factors and apply these factors to conventional econometric models. Stock and Watson (2002) developed a dynamic factor model which uses the principal components analysis to extract information from a large dataset. They applied the model in forecasting, and showed that forecasts based on dynamic factor models outperform the AR models, VAR models and leading indicator models. Bernanke and Boivin (2003) confirmed Stock and Watson's result that using large data sets can improve the accuracy of forecasts. They also improved the estimation of the U.S. Fed's policy reaction function using the large dataset.

BBE (2005) suggested a factor-augmented VAR model to incorporate a large amount of information in VAR without including too many variables. They combined the standard VAR with factor analysis. Two approaches were introduced, the two-step approach and the Bayesian method based on Gibbs sampling. The two approaches produced similar qualitative results. However the two-step approach tended to produce more reasonable impulse response functions. In the two-step approach, large amounts of information about the economy were first summarized by a small number

of estimated factors using the Stock and Watson (2002) method. These estimated factors were then used in the factor-augmented VAR. Consequently, this setup alleviates the dimensionality problem of the VAR analysis.

This paper applies the two-stage FAVAR developed by BBE (2005) to investigate the appropriateness of frequent monetary policy actions - adjusting the interest rate frequently and in a prolonged manner. There have often been claims that the Federal Reverse Bank cuts or raises the Fed Funds Rate too frequently. The concern is that that the Federal Reserve Bank had mistakenly first cut the interest rate too frequently and for too long a period, and then had overcompensated by increasing the interest rate too fast and too soon. To verify if such a claim is valid, assuming that the Federal Reserve Bank had shortened the time period of monetary policies and lengthened the period of a pause, we generate some hypothetical scenarios. We then compare the economic activities implied by the impulse response functions from our hypothetical scenarios with those that are generated from actual policies undertaken by the Fed during the time of Alan Greenspan (1987-2006). We find that a less active monetary policy approach could control inflation with less negative impact on real economic activities, and that the major economic variables would be less volatile in a 48-month horizon.

This paper is different from Bernanke and Boivin (2003)'s real-time expert system for monetary policy-making in two ways. First, the FAVAR had not been developed in the 2003 paper yet, but a pilot version of the model was used in the paper, which was called Factor Model plus Vector Autoregression (FM-VAR) by the authors. This was also a 2-step model, but in the second step the authors included the factors, inflation, unemployment, and the federal funds rate, in that order. The inclusion of the last three variables in the VAR is equivalent to treating these variables as independent factors without idiosyncratic errors. This is the key difference between the FM-VAR and the FAVAR. The treatment of inflation and unemployment as independent factors are unreasonable and unnecessary. In the FAVAR, these two variables are put in the first step as part of the large dataset to be extracted to factors, and the only observable variable is the federal funds rate. The FAVAR model will be described in details in Section 2. Second, although both the Bernanke and Bolvin (2003) and this paper are based on counterfactual monetary policy settings, the former focused on the comparison between machine generated monetary policy actions and actual monetary policies between January 1987 and December 1998. In contrast, our work focuses on whether active monetary policy actions are necessary. The investigation provides insights into the implementation of monetary policies not only for the U.S., but also for all central banks that control interest rates as their major monetary policy tool.

The rest of this paper is structured as follows. Section 2 describes the FAVAR model and estimation method. Section 3 describes the dataset and illustrates the framework of application, which includes descriptions of hypothetical monetary policy scenarios and explanations of why these particular scenarios are chosen. Section 4 applies the 2-step FAVAR model suggested by BBE (2005) to both hypothetical monetary policies and actual monetary policies. This section also reports the finding of comparisons of impulse response functions generated from the hypothetical scenarios and the actual monetary policies. In short, we find that major economic indicators are less volatile if the Federal Reserve Bank held a longer pause at a higher interest rate than if the Bank used an active monetary policy approach, and real economic activities are not affected in a serious manner. Inflation is still under control even if

the Federal Reserve Bank did not actively exert policy actions. Section 5 concludes.

2. FAVAR model

The FAVAR model was developed in BBE (2005). This section illustrates the model in detail. The main advantage of the model is that BBE makes use of Stock and Watson (2002b)'s dynamic factor model to summarize the information of a large dataset into several factors and include these factors in standard VAR settings. The model provides a solution to the dimension problem of the VAR analysis.

Since our study applies the two-step estimation method described in BBE (2005), in which the factors are estimated by principal components prior to the estimation of the factor-augmented VAR, the following only describes the estimation of the two-step approach. The Gibbs sampling method in BBE (2005) was not chosen because it suffers from the additional structure it imposes which was not empirically supported in the BBE paper, and it is time consuming.

2.1 The model

Let F_t be a $K\times1$ vector of unobservable factors which can summarize most of the information contained in X_t which is an $N\times1$ stationary time series variable observed for $t=1,\ldots,T_t$; Y_t is an $M\times1$ observable macroeconomic variable and is a subset of X_t.

F_t can be interpreted as factors that affect many economic variables. These factors can be extracted from observations on the large information set in X_t. The number of informational time series, N, is large and may be larger than T, the number of time periods, and is assumed to be much larger than $K+M$. It is further assumed that the information set is related to the unobserved factors, F_t, and the observable macroeconomic variables Y_t:

$$X_t^{'} = \Lambda^f F_t^{'} + \Lambda^y Y_t^{'} + \varepsilon_t^{'} \tag{1}$$

where Λ^f is an $N\times K$ matrix of factor loadings, Λ^y is $N\times M$, ε_t is an $N\times1$ vector of error terms that have mean zero and assumed to be weakly correlated. Equation (1) is the dynamic factor model developed by Stock and Watson (2002b). It implies that X_t is driven by both unobservable factors and observable macroeconomic variables, and therefore Y_t and F_t can be correlated. Since X_t can contain lagged values, F_t can be understood as containing arbitrary lags of fundamental factors. An advantage of the static representation of the dynamic factor model of equation (1) is that it can be estimated by the principal component method (Stock and Watson, 2002b).

The joint dynamics of (F_t, Y_t) are given by

$$\begin{bmatrix} F_t \\ Y_t \end{bmatrix} = B(L)\begin{bmatrix} F_{t-1} \\ Y_{t-1} \end{bmatrix} + e_t \tag{2}$$

where B(L) is a conformable lag polynomial of finite order d; e_t is an error term with mean zero and covariance matrix Σ.

If the terms in B(L) that relate Y_t to F_{t-1} are all zero, equation (2) is a standard VAR in Y_t; otherwise equation (2) is referred by BBE (2005) as a factor-augmented vector autoregression (FAVAR). If equation (2) is estimated as a standard VAR when the true system is a FAVAR, (that is, if the factors are omitted) then the estimates in the standard VAR system will be biased.

2.2 Estimation of the model

Since F_t is a vector of unobservable factors, equation (2) can only be estimated after F_t is derived. In this paper, we apply the two-step estimation procedure in BBE (2005).

It is reasonable to believe that information contained in X_t can be summarized into several categories. We call these categories common components, C_t. In the first step of the two-step approach, we extract the first $K+M$ principal components using all variables in X_t, and we get $\widehat{C_t}$. However, any of the linear combinations underlying $\widehat{C_t}$ could involve the policy instrument, which is part of Y_t. Therefore it would be invalid to estimate a VAR of $\widehat{C_t}$ and Y_t. We have to remove the dependence of $\widehat{C_t}$ on the policy instrument. This requires identifying variables in X_t that are not related to the policy shock.

Since fast-moving variables in the dataset X_t, are highly sensitive to policy shocks, fast structural shocks and contemporaneous information, such as financial news and economic data release, BBE (2005) argue that there is high collinearity between the fast-moving variables and any policy shock. The logic implies that information contained in the fast-moving variables should be accounted for by the policy shock. On the contrary, slow-moving variables, for example real estate prices and sales, are assumed to be unaffected within the month by the policy shock, and these variables are marked with an asterisk in the Appendix. X_t is therefore split into slow-moving variables, the policy shock and fast-moving variables.

As slow-moving variables are not related to the policy shock contemporaneously, the common components extracted from slow-moving variables, $\widehat{F_t^{slow}}$, are also not related to the policy shock contemporaneously.

We thus form $\widehat{C_t}$ such that

$$\widehat{C_t} = \beta^{slow}\widehat{F_t^{slow}} + \beta^{Y}Y_t + \upsilon_t \tag{3}$$

We then remove the dependence of $\widehat{C_t}$ on the policy instrument to get the factors, $\widehat{F_t}$, in equation (2) as

$$\widehat{F_t} = \widehat{C_t} - \widehat{\beta^{Y}}Y_t \tag{4}$$

where $\widehat{C_t}$ are principal components from X_t and $\widehat{\beta^{Y}}$ comes from the result of equation (3).

Factors, $\widehat{F_t}$, obtained in this way form a part of the space covered by $\widehat{C_t}$ that is not covered by Y_t, and therefore is now valid to be entered into VAR with Y_t. To identify unique factors against any rotation, restrictions are imposed on factors by $F'F/T = I$ [1].

In the second step, we estimate the FAVAR in equation (2) which consists of $\widehat{F_t}$ and Y_t.

Since the focus of this empirical work is to examine how monetary policy shocks affect the economy, the identification scheme in the VAR analysis focuses on identifying a single structural shock, that is the federal funds rate, $Y_{t.}$ The monetary policy shock is ordered last and is the only innovation in the model.

3. Application of FAVAR: Did the Fed overexert policy actions?

Figure 1 shows the movements of the Federal Funds Target Rate between October 1982 and October 2006. It includes the target rate under Alan Greenspan's chairmanship between August 11th 1987 and January 31st 2006. We can see that the Federal Reserve Bank moved the target Federal Funds Rates many times in one direction, and then "undid" the policy actions by going in the reverse direction after a pause. Many times in history, it is argued that that the Federal Reserve Bank had 'overdone' its policy actions. This study is to analyze whether the central bank had overexerted the monetary policy actions in the interest rate cycle.

We begin our analysis in June 1989 and end in January 1995. The period consists of an expansionary monetary policy, a pause, and then a contractionary monetary policy, i.e. period A-B, B-C and C-D in the Figure 1 respectively. The actual pause from B to C lasted for 16 months, after which the Federal Reserve Bank raised the Federal Funds Rate at a speed that was faster than the one it had used when it had cut the rate. After raising the Fed Funds Rate from the 3% level to the 6% level, the central bank cut the rate again at a much slower speed and intervening pauses pauses until September 1999. Since monetary policy mainly serves the purpose of stabilizing the economy in terms of the inflation rate and the unemployment rate, frequent policy actions and subsequent unwinding of actions might be inappropriate since the frequent policy actions may bring unnecessary volatility to the economy. Therefore, it is reasonable to suspect that the Federal Reserve Bank had overexerted the Federal Funds Rate cut before point B.

To see if this claim is valid we construct hypothetical scenarios of longer pauses around B and C and apply the settings to the FAVAR model described in Section 2. We then compare the impulse response of the monetary policy actions of these scenarios to the impulse responses of historical policy actions.

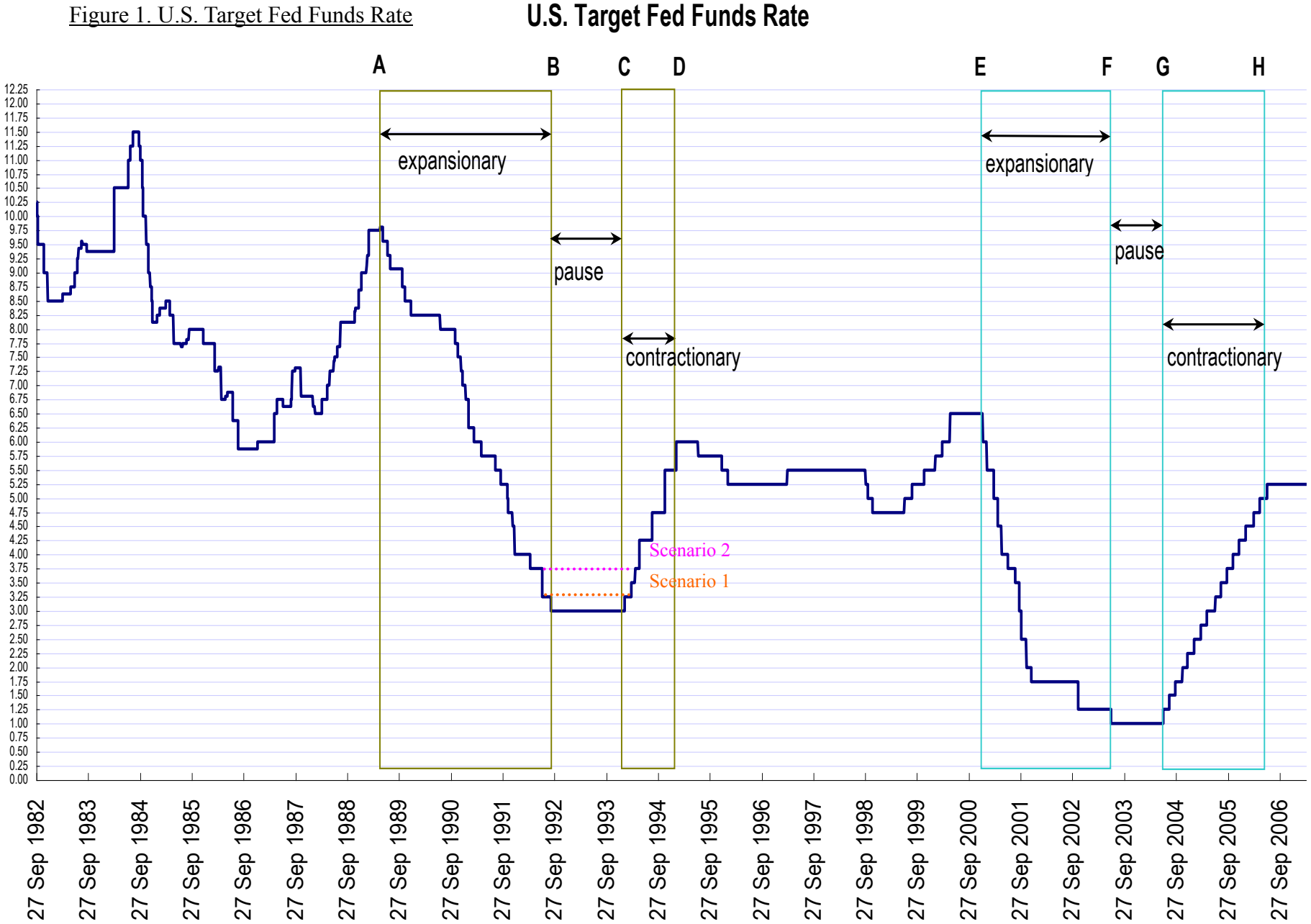
[1] We can impose restrictions on the factor loadings or the factors. Either approach provides the same common component and the same factor space.

3.1 Data

The dataset consists of monthly macroeconomic time series data from January 1975 to November 2006 for 120 variables in the U.S.. The data series are updated from the dataset used by BBE (2005) which ends in August 2001. The series are transformed to be stationary. The list of the series and their transformation are listed in Appendix A.

Among the variables, there are 67 variables representing real activity, 17 variables relating to inflation or price and 36 monetary variables. The real activity group consists of variables related to industrial production, capacity utilization, manufacturers' inventories, retail inventories, retail sales, real personal consumption, real personal income, new housing starts, employment and average working hours. The inflation or price group is composed of consumer price indices and producer price indices. The monetary variable group includes money aggregate variables, short-term and long-term interest rates and interest rate spreads, major exchange rates and outstanding credit.

Figure 1. U.S. Target Fed Funds Rate



3.2 The Choice of Hypothetical Scenarios

Since the purpose of this study is to analyze whether the Federal Reserve Bank overexerted monetary policy actions in the past, the hypothetical scenarios are constructed to undo the policy actions before the start of interest rate pause at point B. Two hypothetical scenarios are identified. Scenario 1 assumes the Federal Reserve Bank did not exert the last interest rate cut before the pause at point B. Scenario 2 pushes this further to assume the Federal Reserve Bank did not exert the last two interest rate cut before the pause.

Scenario 1 is a hypothetical setting depicting the scenario that the Federal Reserve Bank did not exert the last monetary policy action of the interest rate cut cycle in October 1992, and that it had started the pause of the Fed Funds Rate at 3.25% from September 1992 till March 1994; it then raised the Fed Funds Rate by 0.25% in April 1994. The corresponding historic monetary policy is that the Federal Reserve Bank held the Fed Funds Rate at 3.00% from October 1992 till February 1994, and then raised the rate by 0.25% in March and also in April. In short, Scenario 1 is a setting where the Federal Reserve Bank held the Fed Funds Rate constant for two more months at a rate that was 0.25% higher than it actually did.

Scenario 2 assumes that the Federal Reserve Bank undid the monetary policy actions between August 1992 and May 1994. The hypothetical setting is that the Federal Reserve Bank had paused the Fed Funds Rate at 3.75% from July 1992 till May 1994, then raised the Fed Funds Rate by 0.25% in June 1994. The corresponding historic monetary policy is that the Federal Reserve Bank cut the Fed Funds Rate by 0.5% and by 0.25% in August and October 1992 respectively, then paused until February 1994, and then raised the rate by 0.25% in April and also in May and by 0.5% in June 1994. However, in order to compare the results in Scenario 1 and Scenario 2, the shock after May 1994 is set at 0.25%.

4. Empirical results

4.1 Number of factors

To proceed to the FAVAR model stated above, it is important to know the number of factors to be incorporated in the VAR framework. Stock and Watson (2002a) suggested that the number of factors could be determined by an information criterion. Bai and Ng (2002) provided a criterion to determine the number of factors associated with the dataset, X_t only. However, BBE (2005) emphasized that the criterion developed by Bai and Ng (2002) did not address the issue of how many factors should enter in the VAR analysis in equation (2). In their paper, BBE (2005) tried different numbers of factors, specifically they tried K=1, 3, 5 and 7. They showed that there was no qualitative difference in the impulse response functions with K=5 and 7. Stock and Watson (2005) extended the dataset and provided another estimation method to FAVAR that incorporated Bai and Ng (2002)'s information criteria to determine the number of dynamic factors in X_t, and they found that the number of factors was 7. In addition to this finding they realized that there was little qualitative difference between their results and that in BBE in terms of the impulse response functions when BBE applied K= 5. Nevertheless, the information criteria developed by Bai and Ng

(2002) can only determine the number of factors in X_t but not in the VAR of equation (2).

In order to justify for the number of factors used in the FAVAR model, our study tries to use the conventional information criteria for standard VAR in the FAVAR. AIC, HQ and SC are reported in Table 1 below. In order to check for the robustness of these criteria we extend the candidates of K to K=1, 3, 5, 7, 9, 11, 13. As we can see from Table 1, AIC and HQ decrease with the number of factors, and therefore we cannot find the optimal number of factors using AIC and HQ. One of the reasons might be that AIC and HQ do not impose enough penalty to determine the optimal number of factors in the VAR in equation (2). On the contrary, using SC as the information criterion we find that the number of factors in equation (2) is 7. We therefore choose K=7 throughout the analysis.

Table 1. Information Criteria applied to FAVAR in equation (2)

K	AIC	HQ	SC
1	-1.0521	-0.8433	-0.5242
3	-5.2523	-4.4323	-3.1794
5	-7.9813	-6.1479	-3.3467
7	-11.7596	-8.5105	-3.5464
9	-14.5257	-9.4587	-1.7170
11	-17.2325	-9.9454	1.1885
13	-20.8133	-10.9038	4.2369

4.2 Empirical Results

We follow BBE (2005) in estimating the FAVAR. Using conventional information criteria, the models are estimated with thirteen lags, which, given the nature of monthly data is the same as the BBE (2005) model.

The following compares the impulse response functions of major economic activities in the hypothetical scenarios described in Section 3.2 with impulse response functions in the corresponding scenarios.

Figure 2 compares 20 impulse response functions of hypothetical and historical data in Scenario 1, and Figure 3 compares those in Scenario 2. These twenty variables are chosen to examine the impact of monetary policy on the entire economy.. In fact, we can compare all the 120 impulse response functions. The results of the study are shown below.

At first glance, as expected we see larger differences in the impulse response functions of the hypothetical and historical data in Figure 3 than in Figure 2. This is due to the assumption that the Federal Reserve Bank pursued a longer pause in the hypothetical situation under Scenario 2 than under Scenario 1.

If we look at Figure 2 and Figure 3 (the magnified graphs following each figure) we find that the impulse responses of real economic activities in the hypothetical situations are higher than those of historical monetary policy. These variables include industrial production, personal consumption, durable goods consumption, non-durable

goods consumption and housing starts. These results meet our expectation that real economic activities, in general, would be suppressed by tightening monetary policies, but are affected to a lesser extent under the hypothetical situation when there is no "over-exertion" of previous monetary policies.

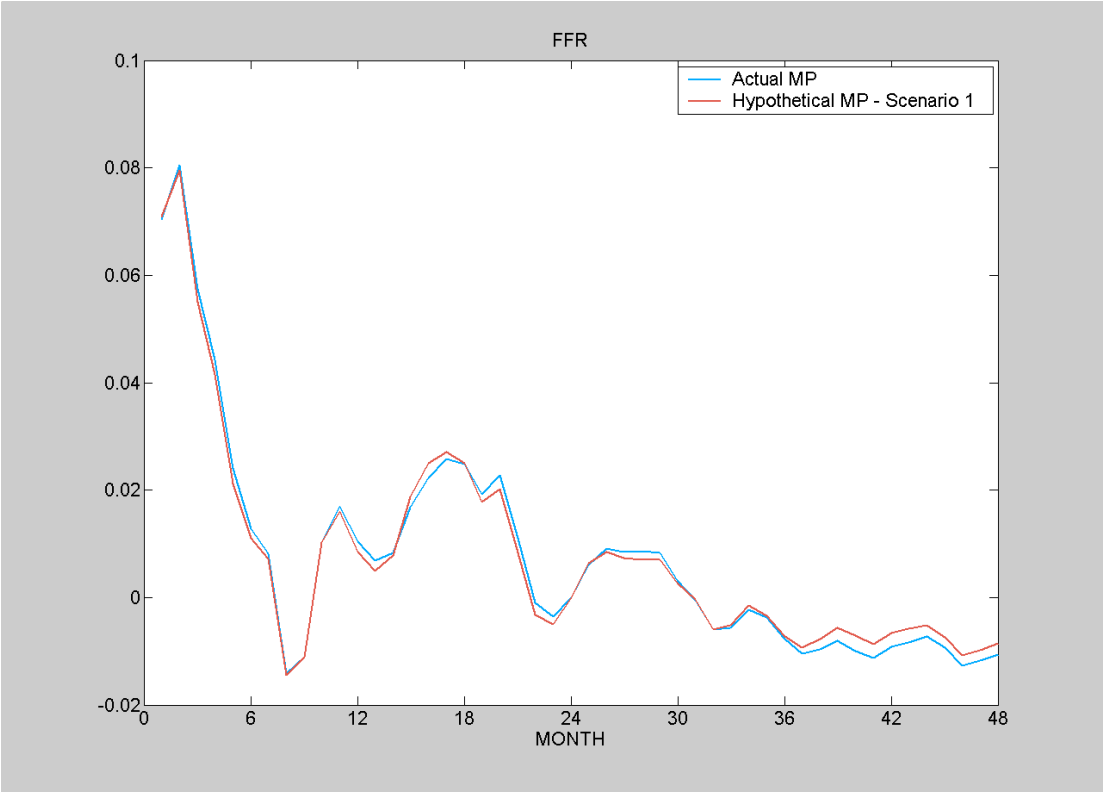
The impulse response of unemployment in the hypothetical situation is less volatile than that of the historical situation. There are a few more variables that show similar responses, for example, capacity utility rate, housing starts and the NAPM new orders index.

Although the CPI does fall with a short lag after the shock, it should be noted that the impulse responses of CPI, commodity price index and average hourly earnings are higher in the hypothetical situation than those of historical monetary policy.

Figure 3 shows that in Scenario 2, the average hourly earnings start to fall after 42 months in the hypothetical situation but only after 24 months in historical situation. It takes a longer period to bring the wage rate down under the hypothetical tightening of monetary policy with a longer pause and a higher level of the Fed Funds Rate, compared to active monetary policy. This implies that a non-active monetary policy approach may not be appropriate to fight cost-push inflation which is usually caused by higher expected wage in the near future.

Overall the impulse response functions are in accordance with the implications of macroeconomic theory. The lower prices and lower levels of real economic activities under the historical situation might be the result of a few tightening policy actions before the shock, and therefore the responses of the CPI and industrial production reflect the accumulated effects of these tightening policies. Therefore, by comparing the hypothetical non-active monetary policy situation with the historical active monetary policy situation, we can say that the Federal Reserve Bank over-exerted policy actions in the past. Using the FAVAR our study shows that inflation would still have been under control even if the Federal Reserve Bank had not actively cut the Federal Funds Rate. However, inflation would not have gone down as much under the non-active monetary policy. We show that the costs of an active monetary policy approach are that some real economic activities are more adversely affected and other variables become more volatile.

Figure 2. Comparison of Impulse Response Functions of Historical Monetary Policy and Scenario 1 (FFR, Industrial Production).



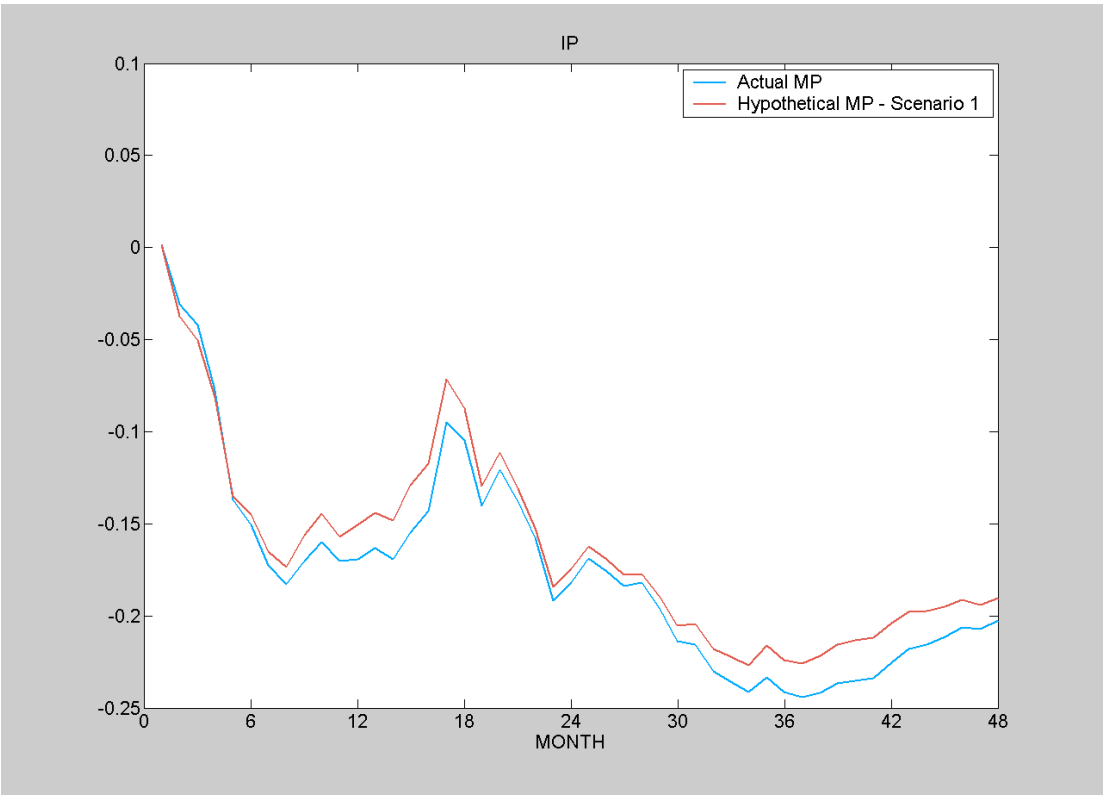


Figure 2 (continued). Comparison of Impulse Response Functions of Historical Monetary Policy and Scenario 1 (CPI, 3M Treasury Bills).

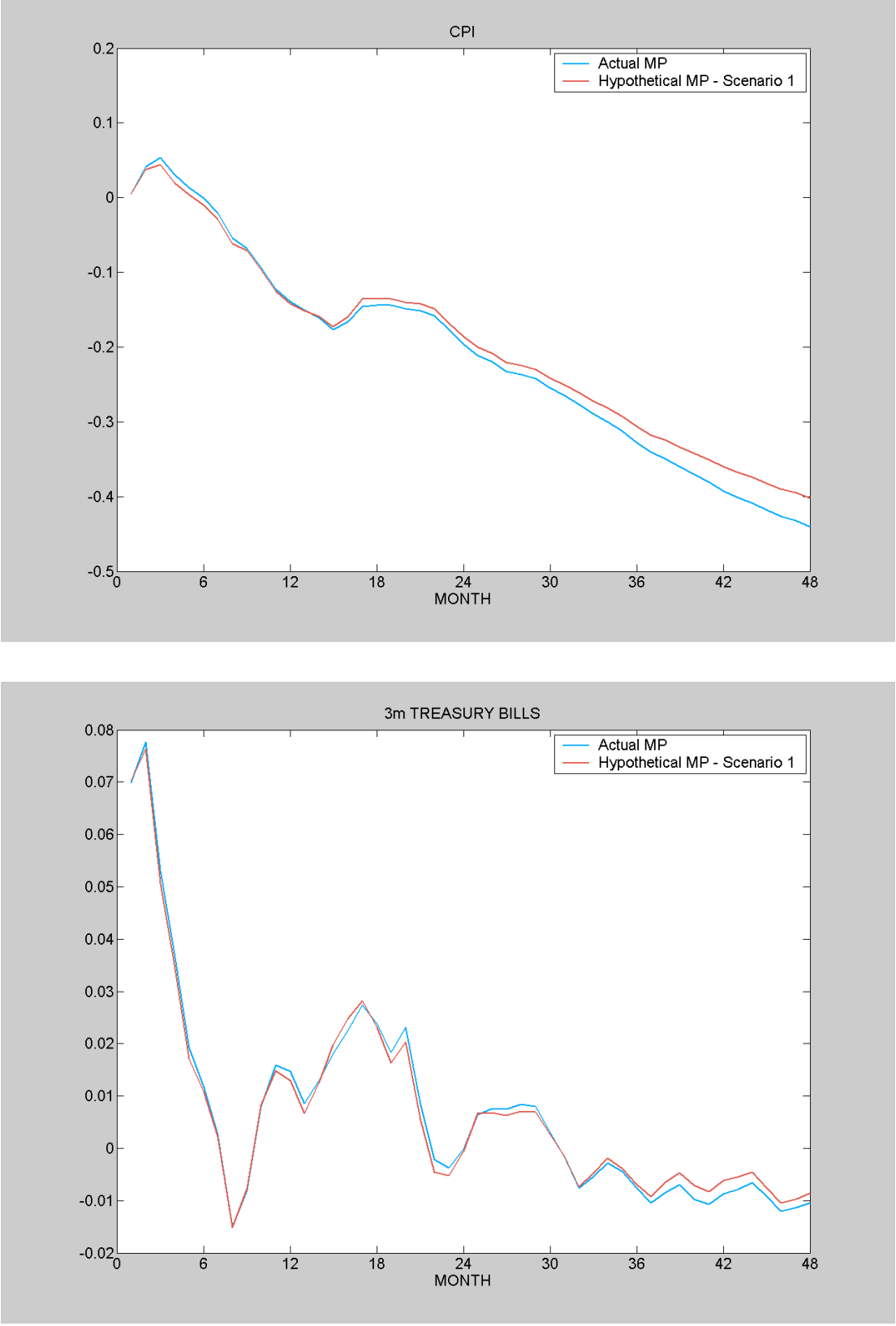
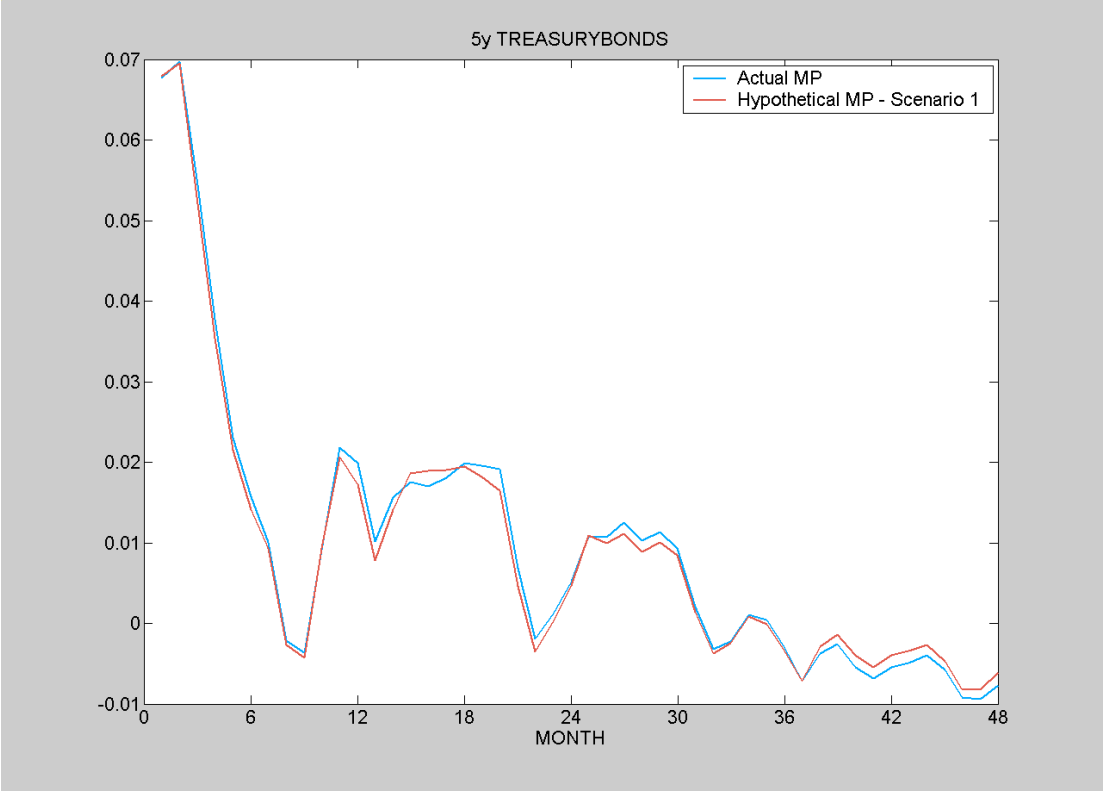


Figure 2 (continued). Comparison of Impulse Response Functions of Historical Monetary Policy and Scenario 1 (5-yr Treasury Bonds, Monetary Base).



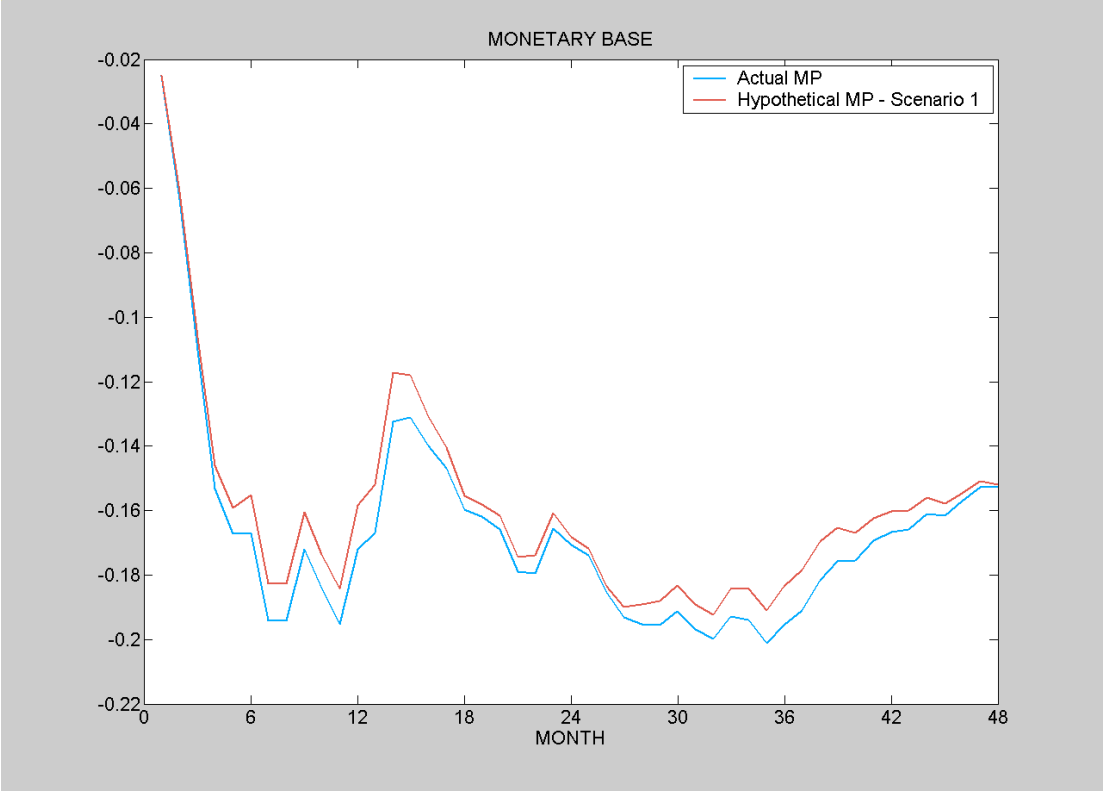
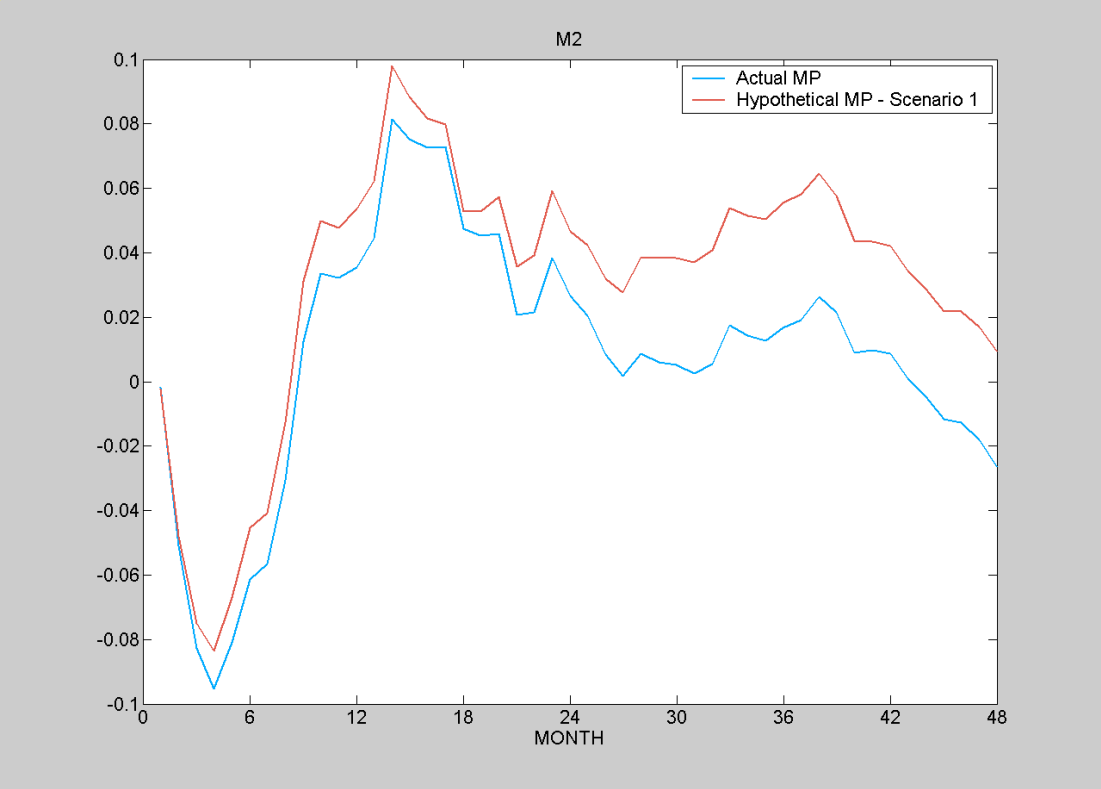


Figure 2 (continued). Comparison of Impulse Response Functions of Historical Monetary Policy and Scenario 1 (M2, Yen/USD Exchange Rate).



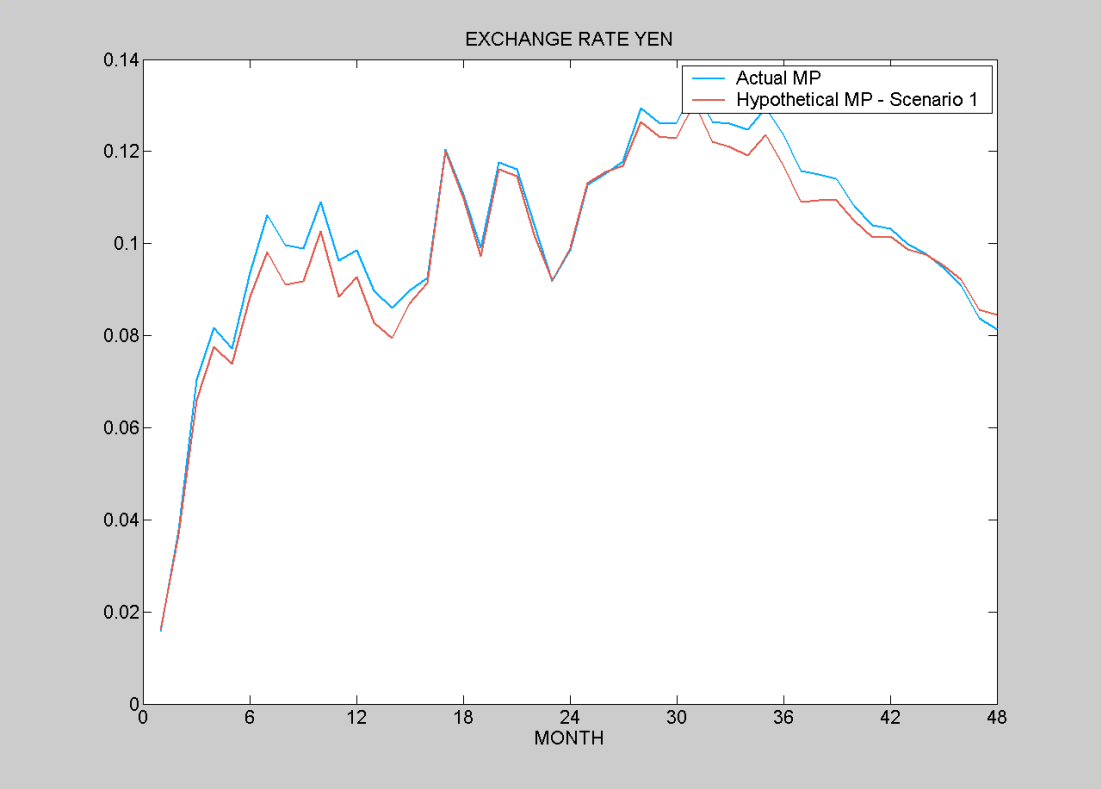
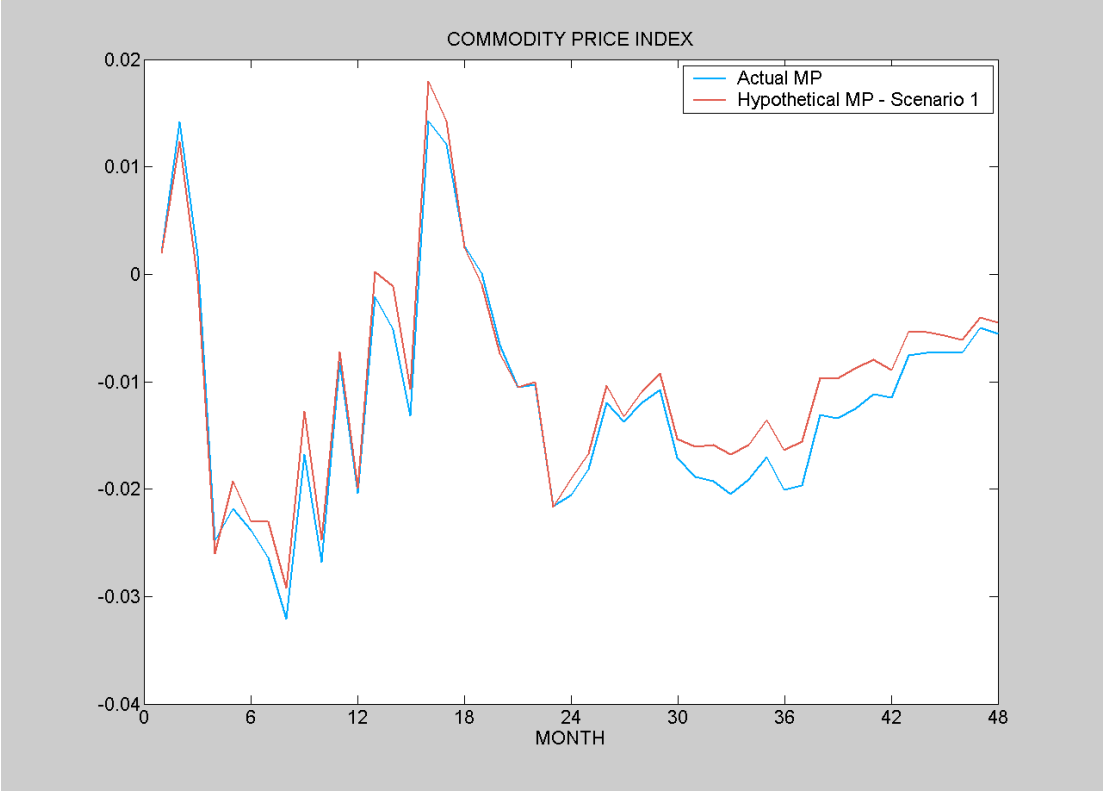


Figure 2 (continued). Comparison of Impulse Response Functions of Historical Monetary Policy and Scenario 1 (Commodity Price Index, Capacity Utilization Rate).



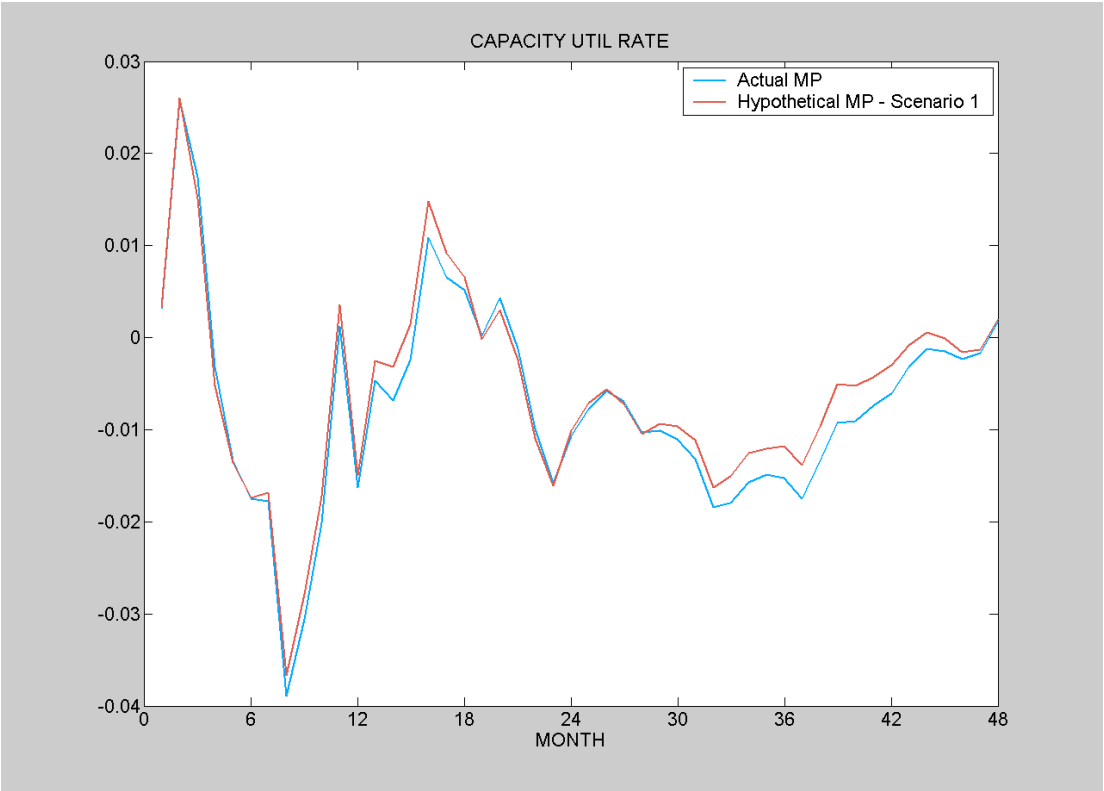


Figure 2 (continued). Comparison of Impulse Response Functions of Historical Monetary Policy and Scenario 1 (Personal Consumption, Durable Consumption).

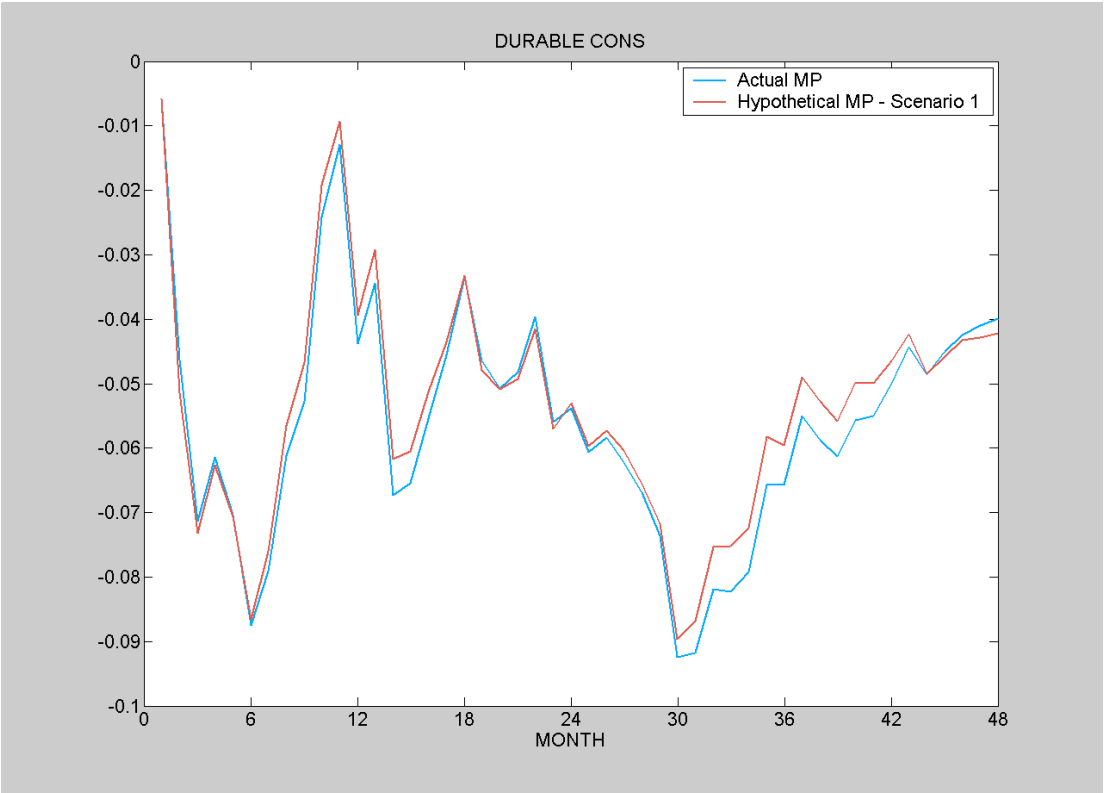
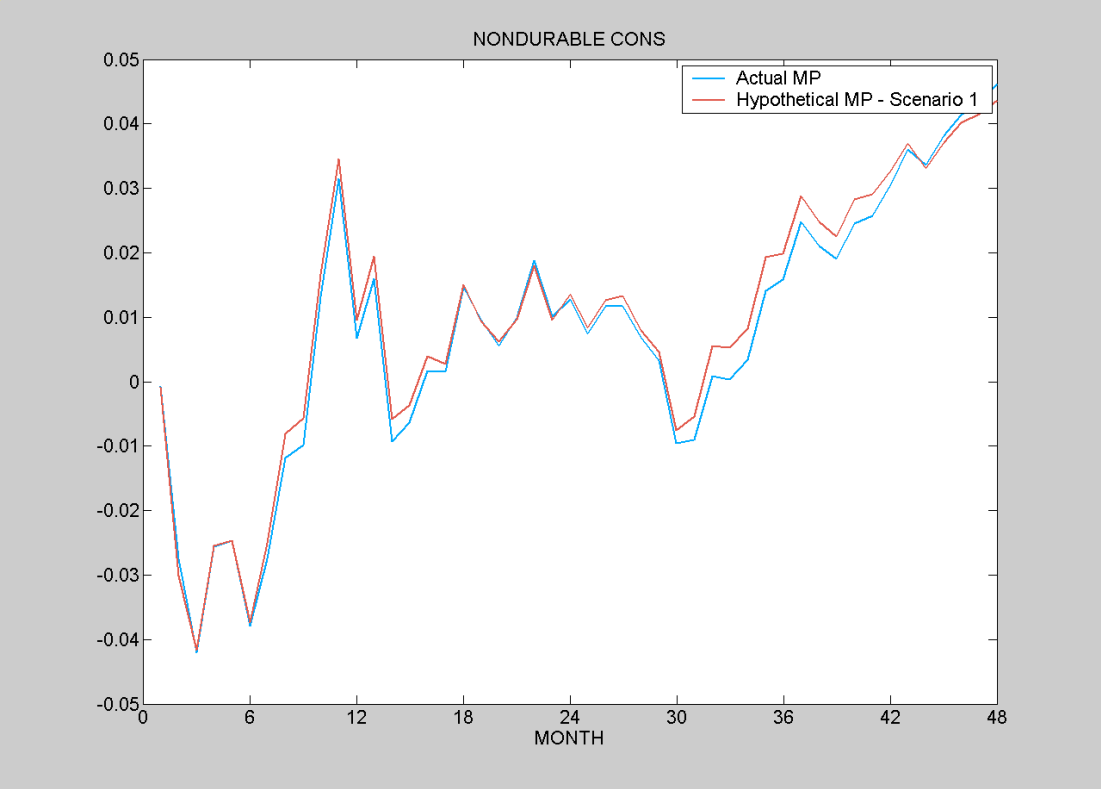


Figure 2 (continued). Comparison of Impulse Response Functions of Historical Monetary Policy and Scenario 1 (Non-Durable Consumption, Unemployment).



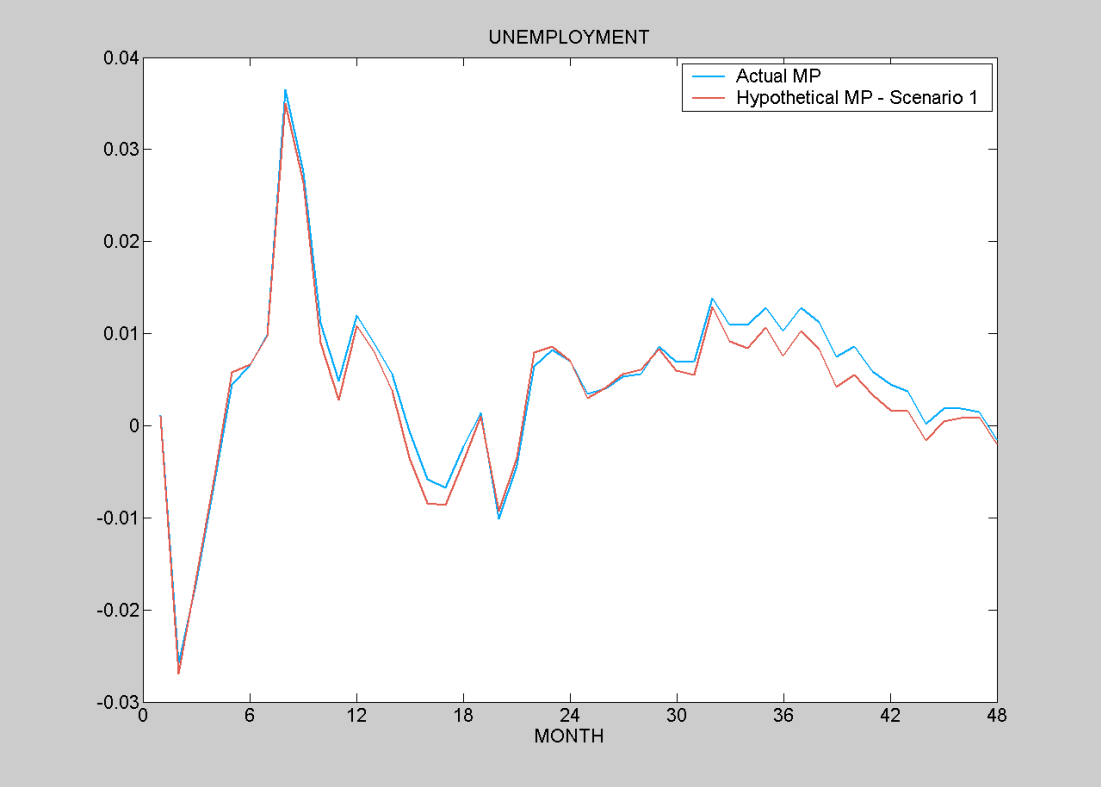
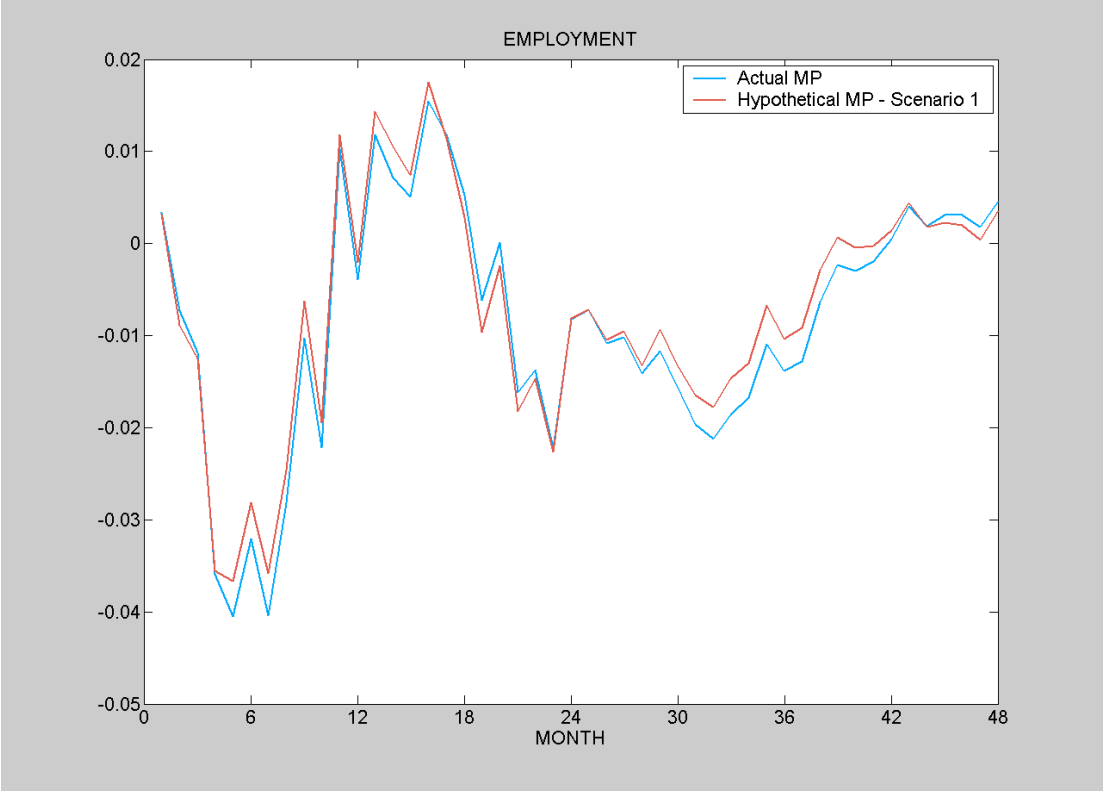


Figure 2 (continued). Comparison of Impulse Response Functions of Historical Monetary Policy and Scenario 1 (Employment, Average Hourly Earnings).



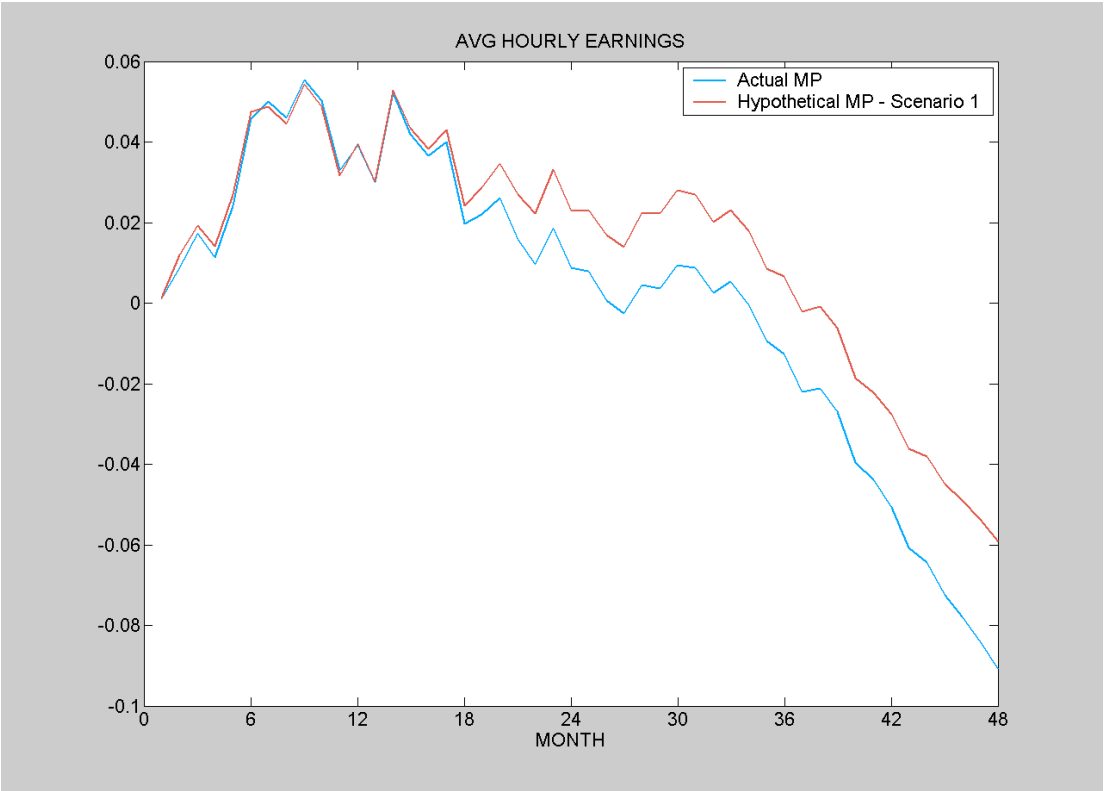
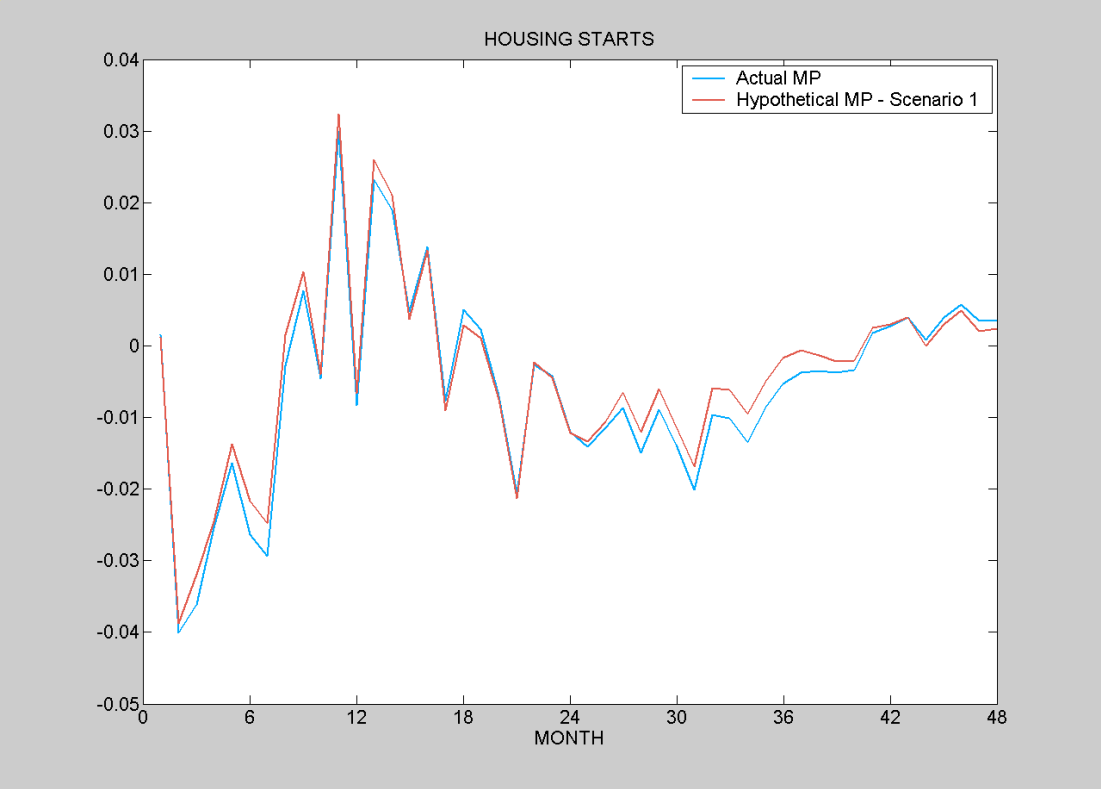


Figure 2 (continued). Comparison of Impulse Response Functions of Historical Monetary Policy and Scenario 1 (Housing Starts, New Orders).



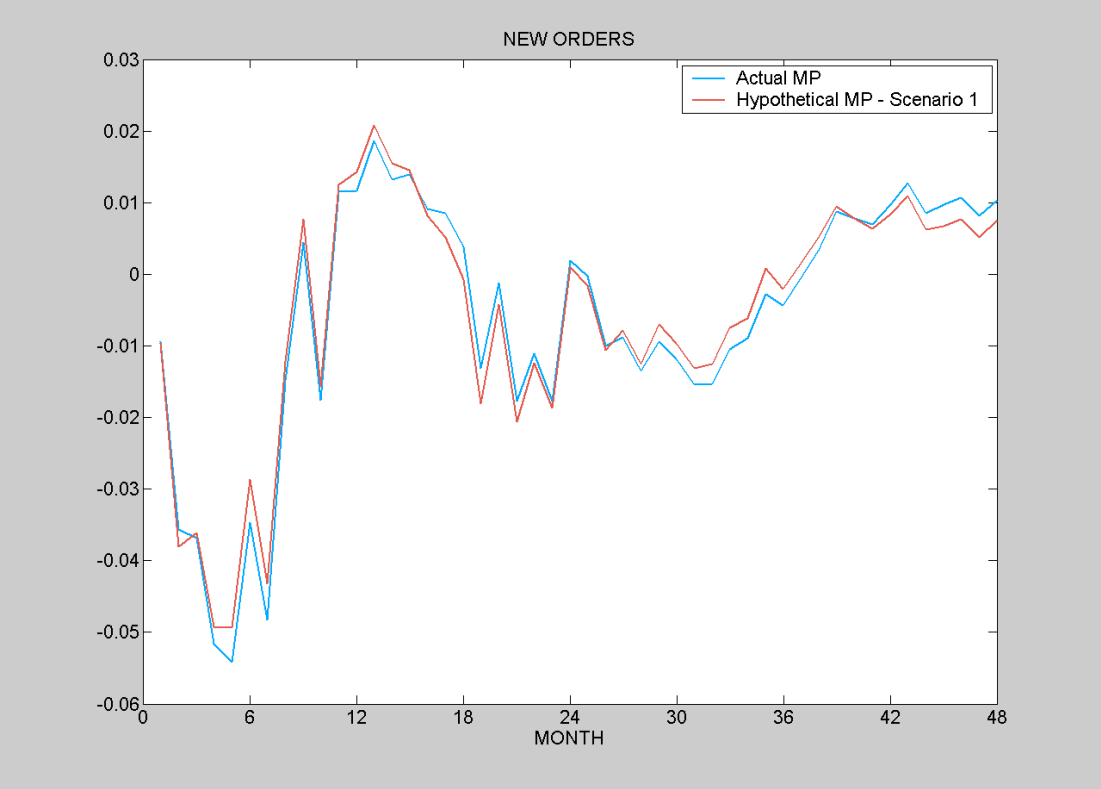
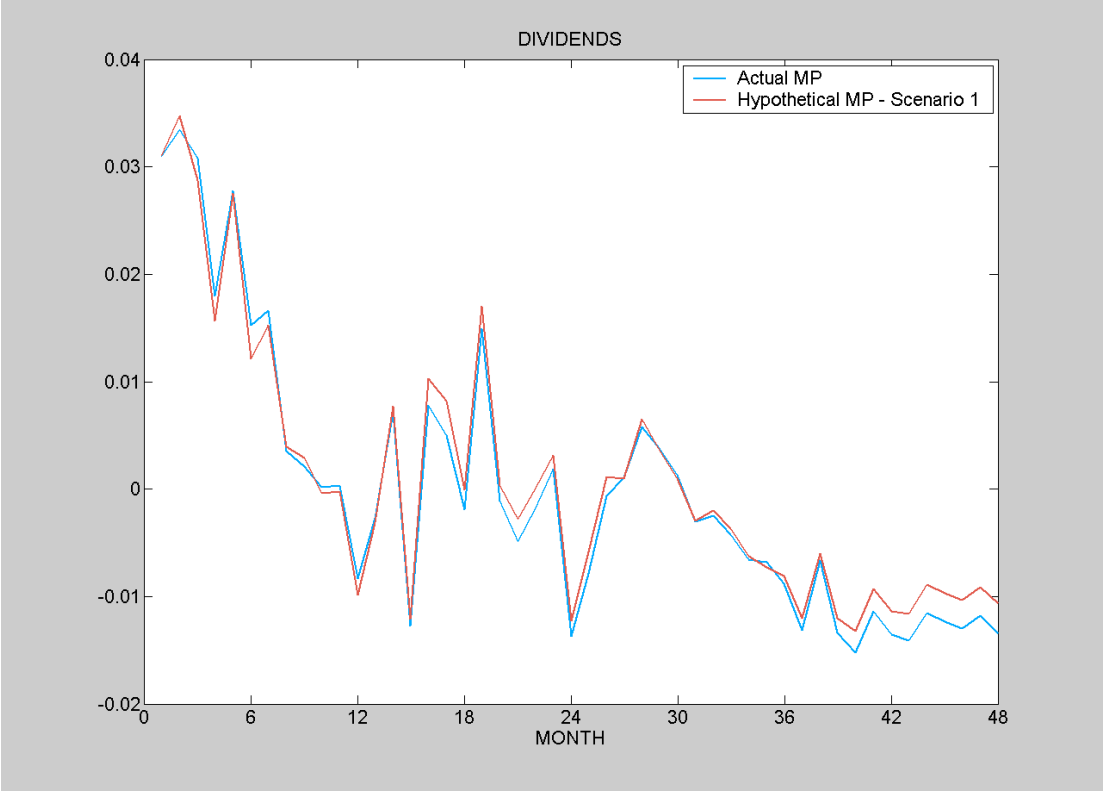


Figure 2 (continued). Comparison of Impulse Response Functions of Historical Monetary Policy and Scenario 1 (Dividends, Consumer Expectation).



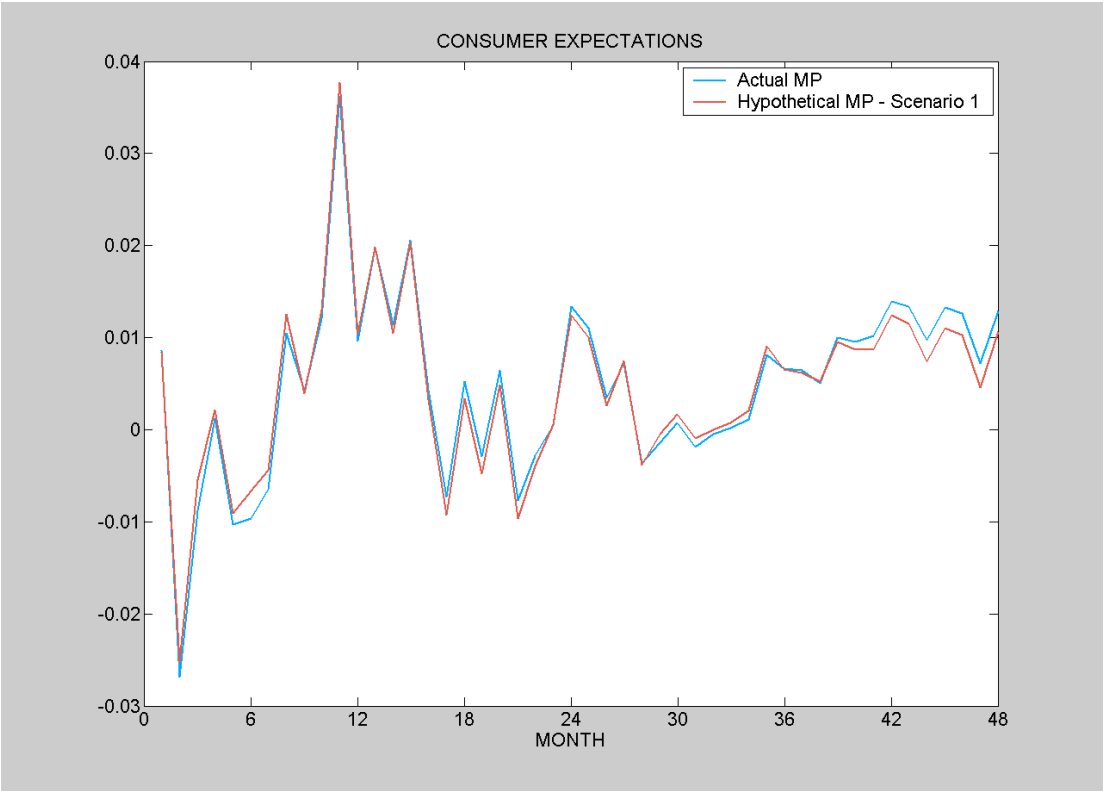
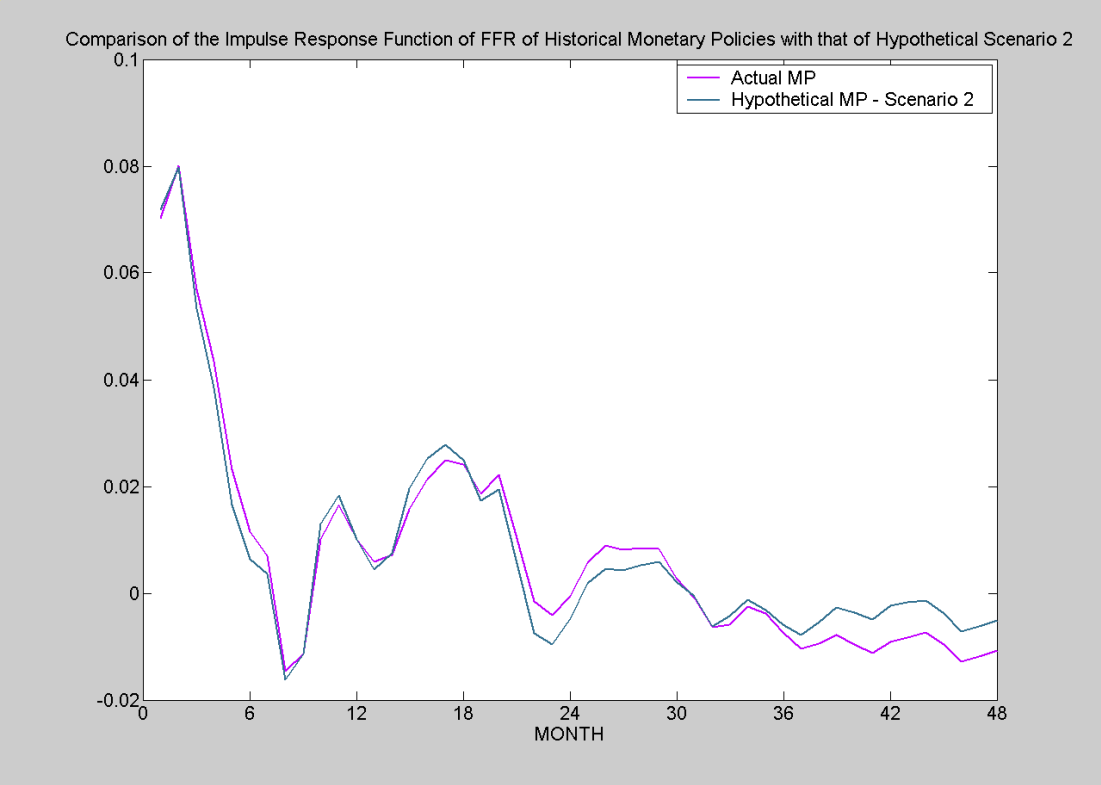


Figure 3. Comparison of Impulse Response Functions of Historical Monetary Policy and Scenario 2 (FFR, Industrial Production).



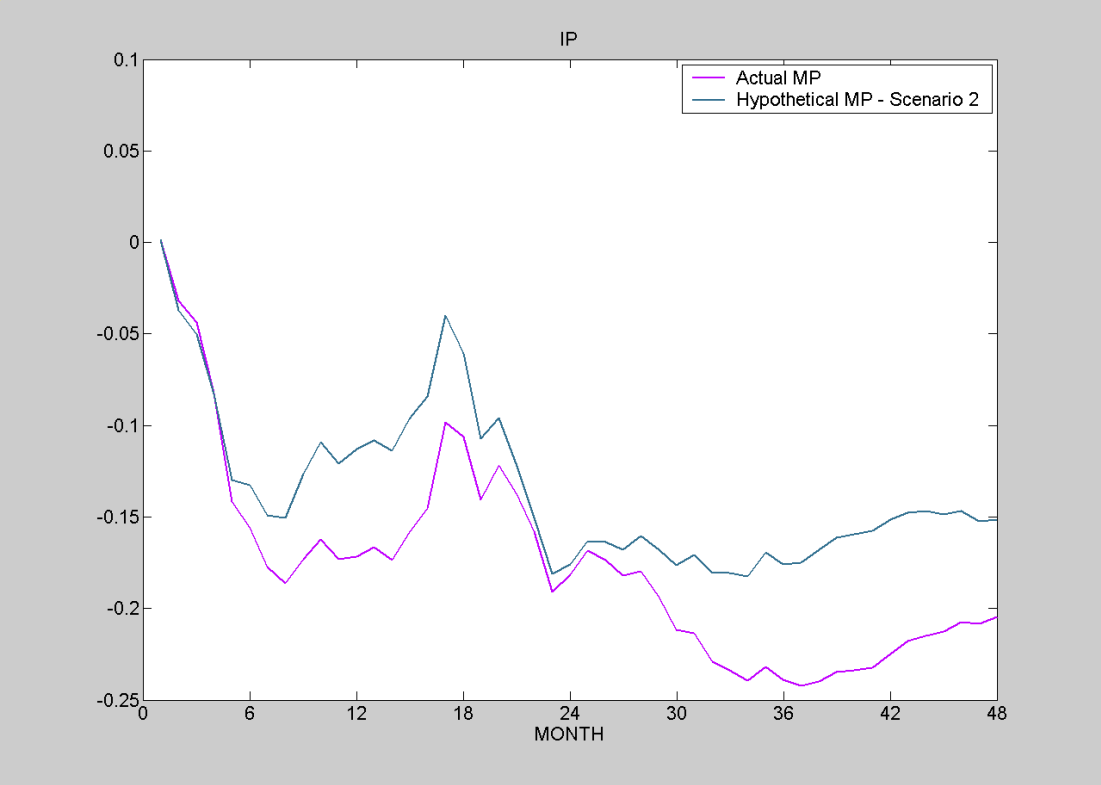
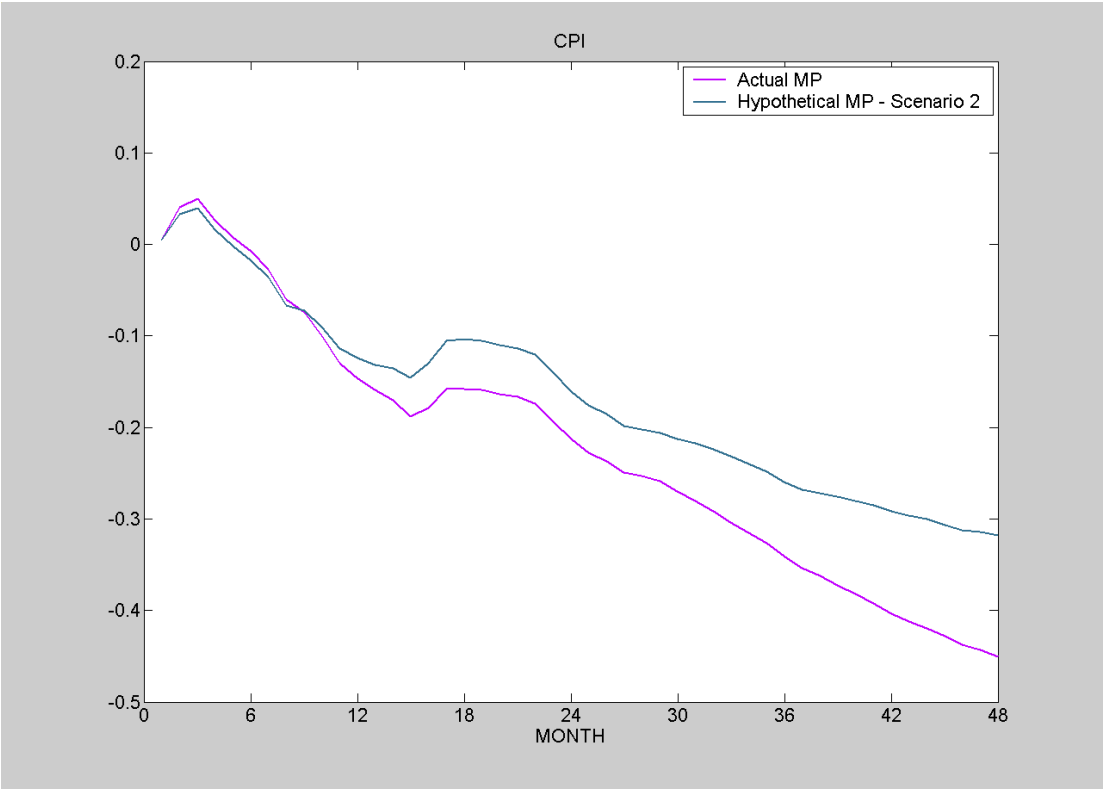


Figure 3 (continued). Comparison of Impulse Response Functions of Historical Monetary Policy and Scenario 2 (CPI, 3M Treasury Yield).



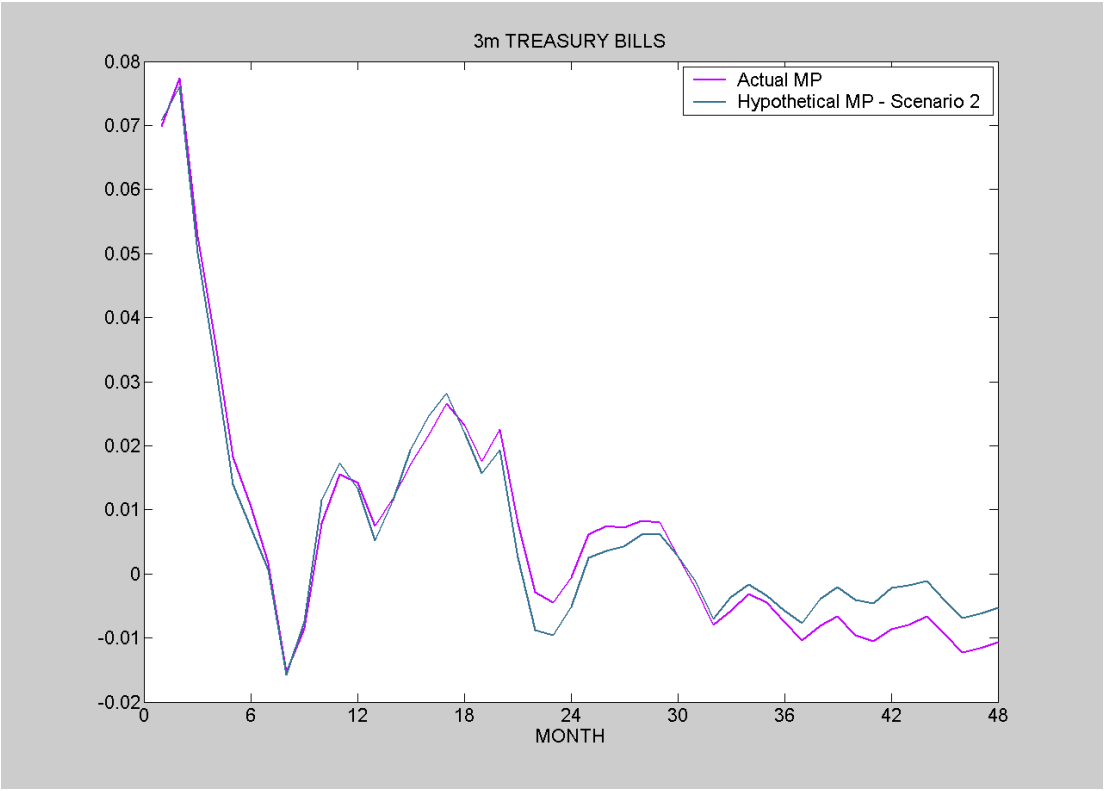
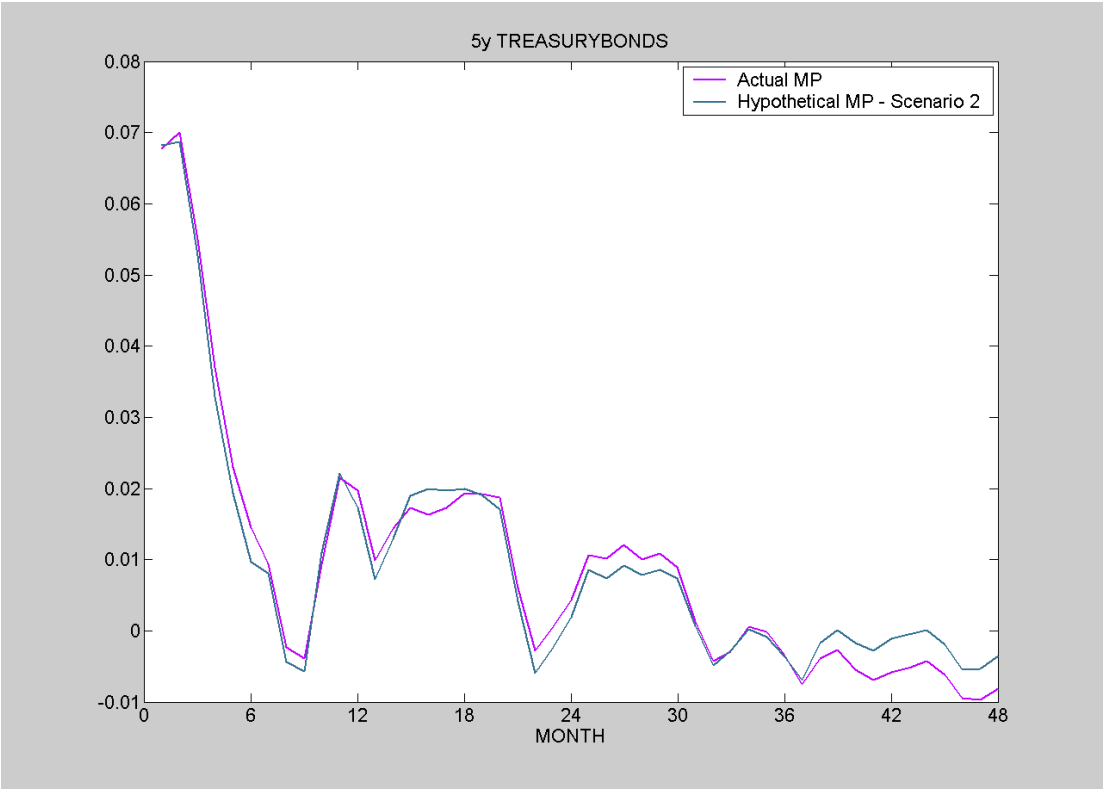


Figure 3 (continued). Comparison of Impulse Response Functions of Historical Monetary Policy and Scenario 2 (5yr Treasury Yield, Monetary Base).



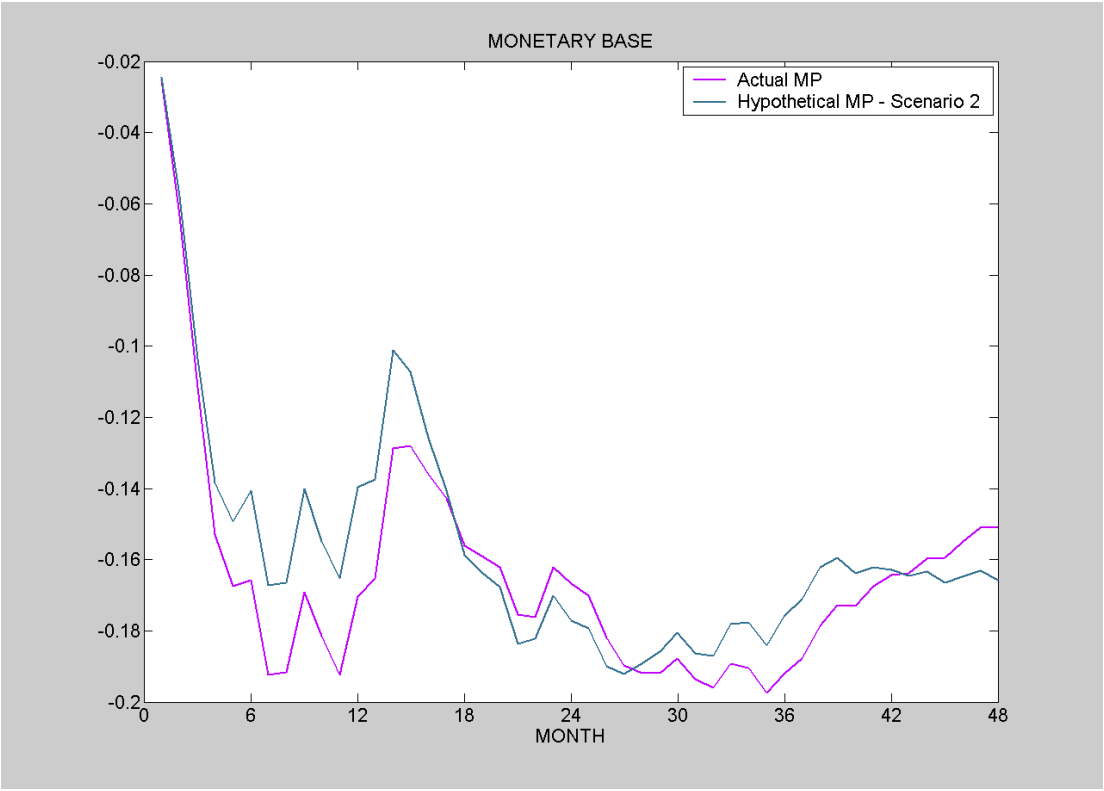
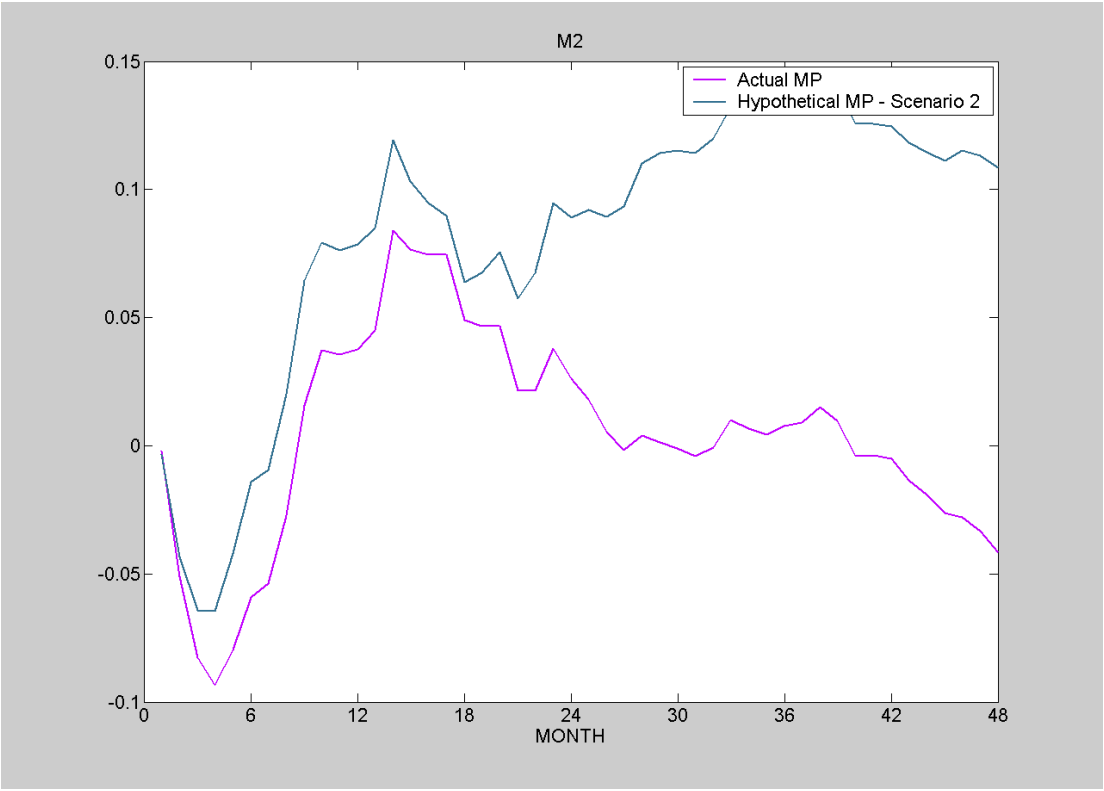


Figure 3 (continued). Comparison of Impulse Response Functions of Historical Monetary Policy and Scenario 2 (M2, Yen/USD Exchange Rate).



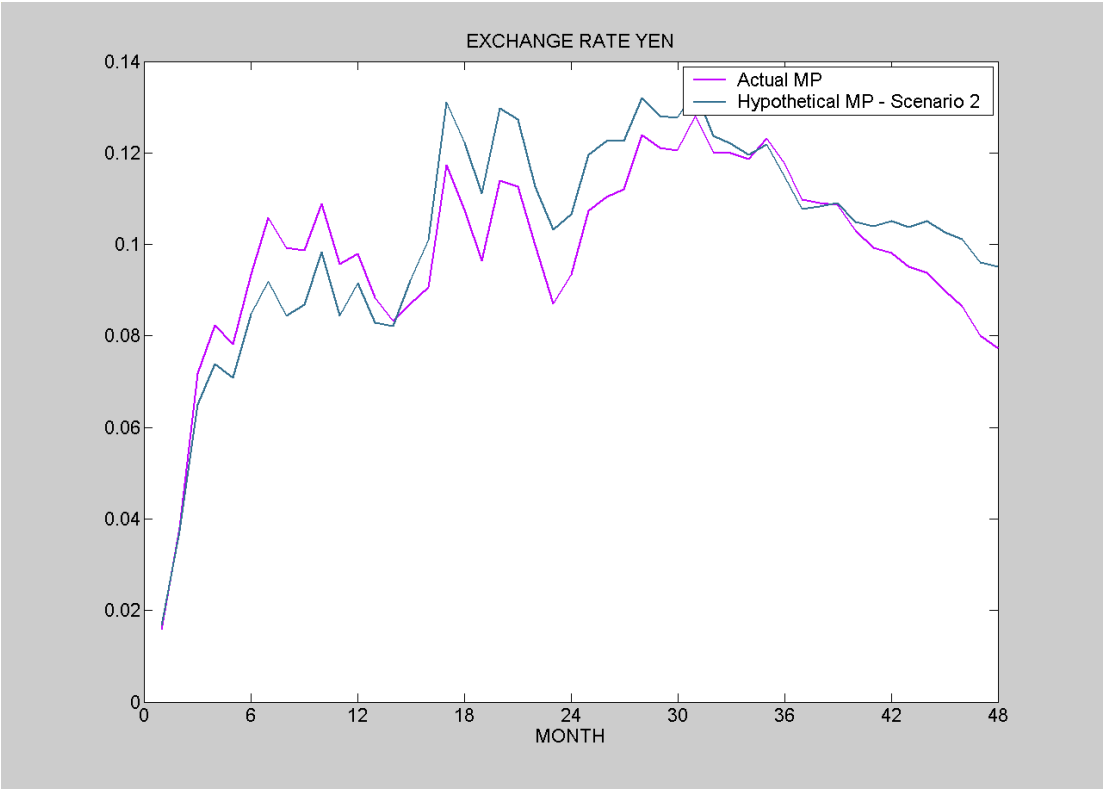
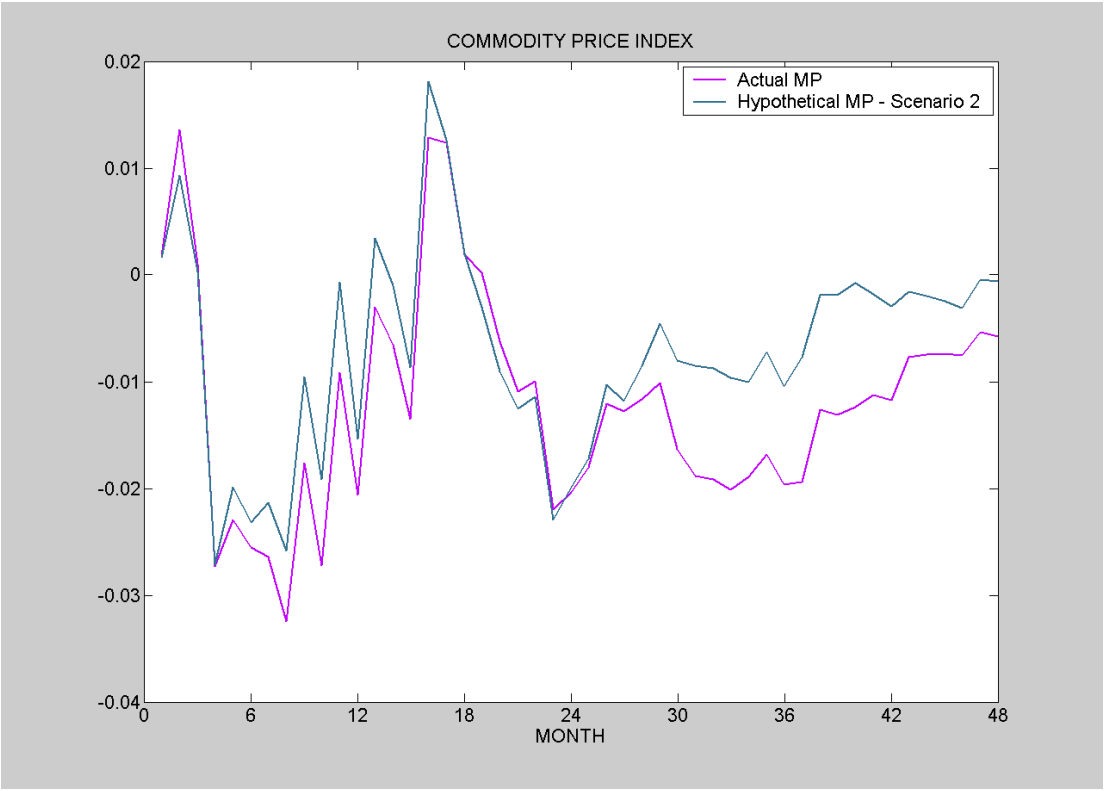


Figure 3 (continued). Comparison of Impulse Response Functions of Historical Monetary Policy and Scenario 2 (Commodity Price Index, Capacity Utilization Rate).



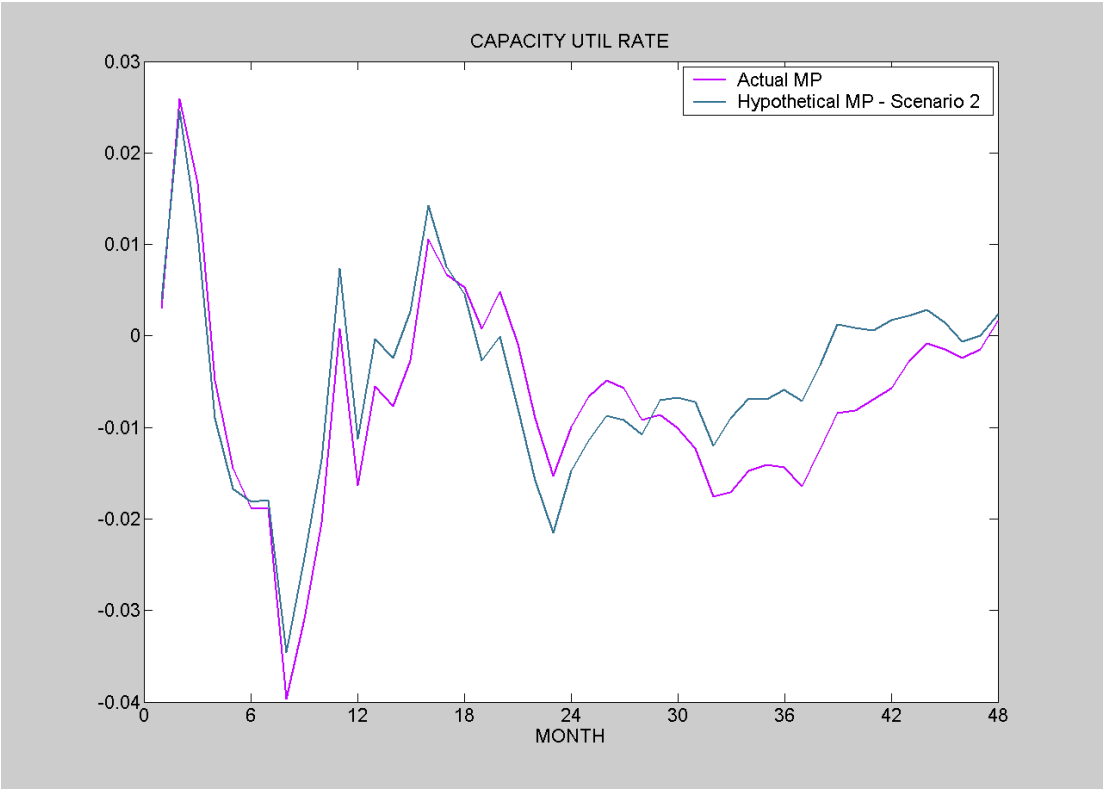
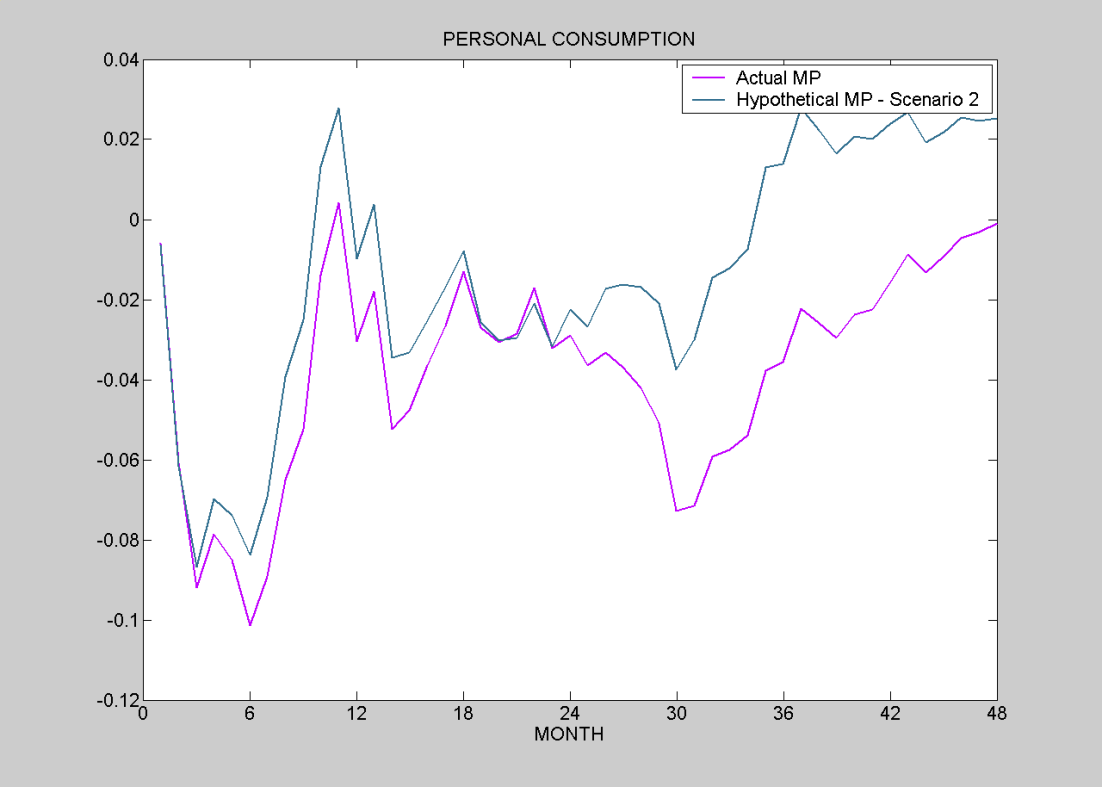


Figure 3 (continued).Comparison of Impulse Response Functions of Historical Monetary Policy and Scenario 2 (Personal Consumption, Durables Consumption).



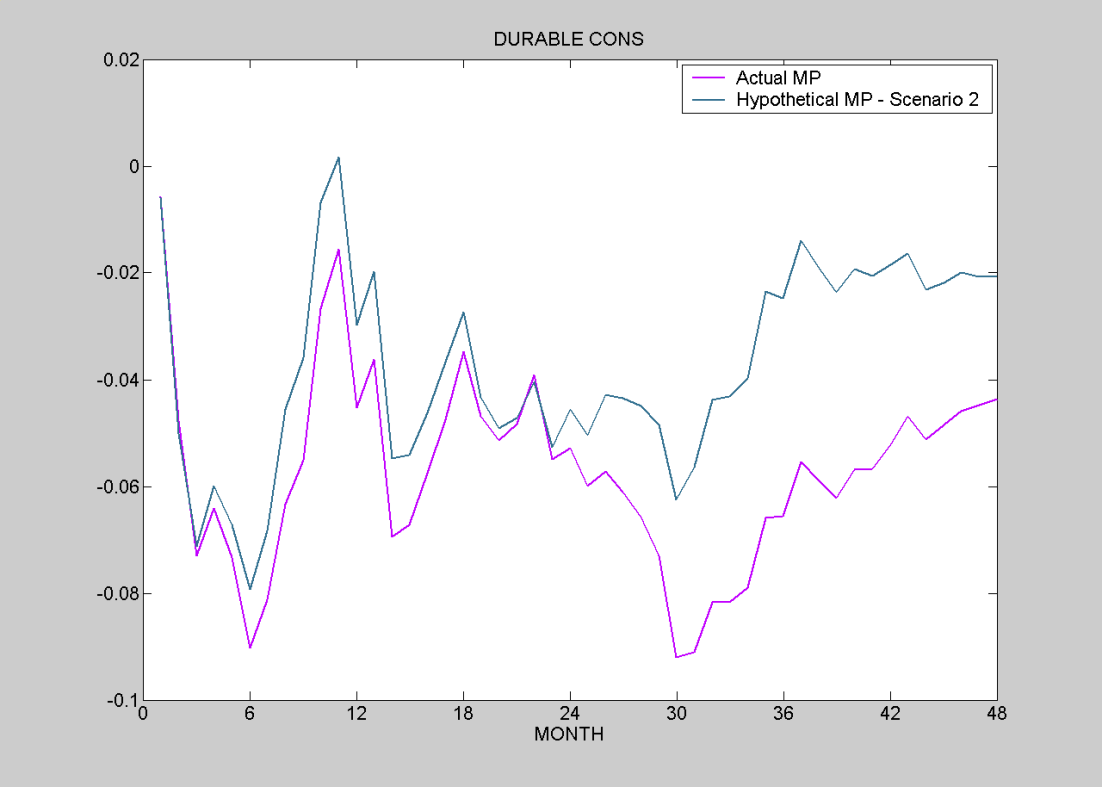
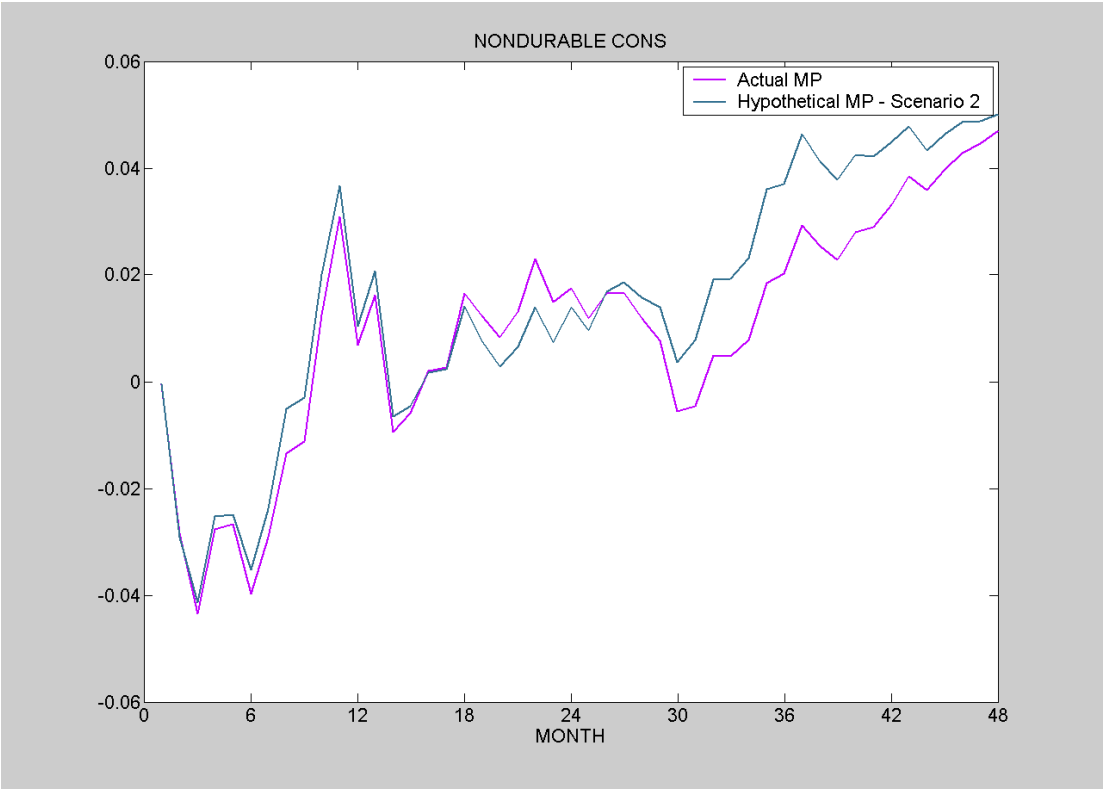


Figure 3 (continued). Comparison of Impulse Response Functions of Historical Monetary Policy and Scenario 2 (Non-Durables Consumption, Unemployment).



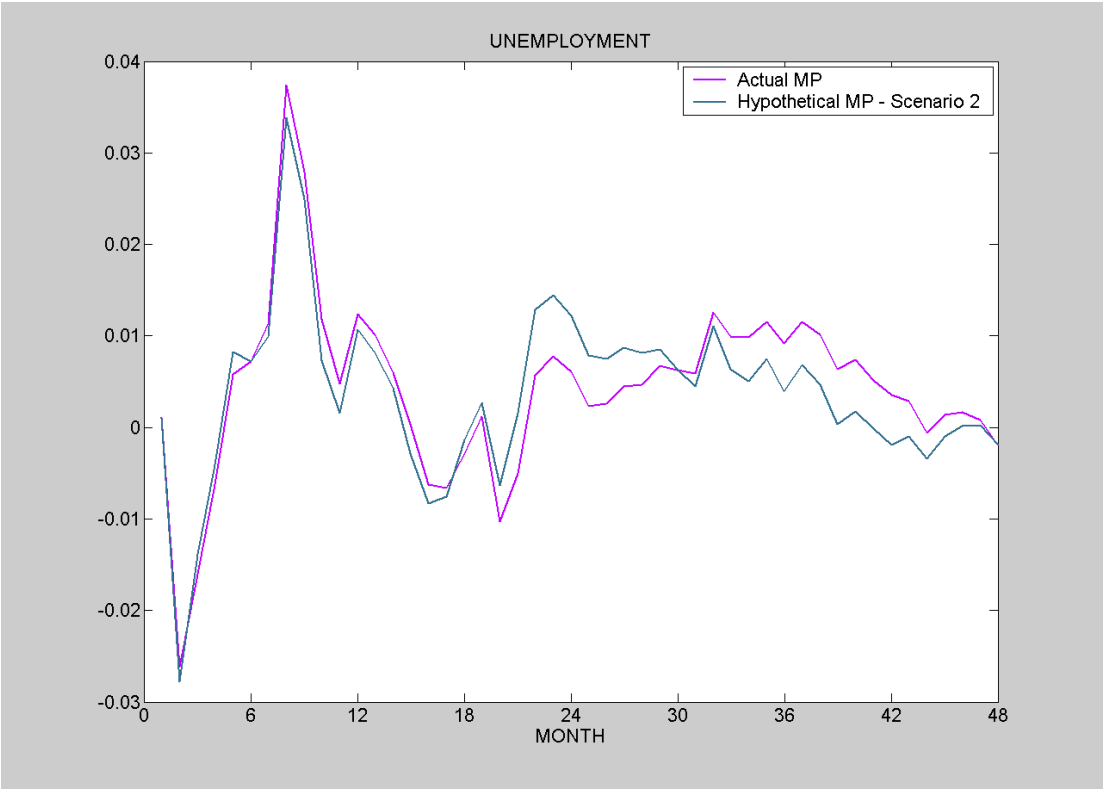
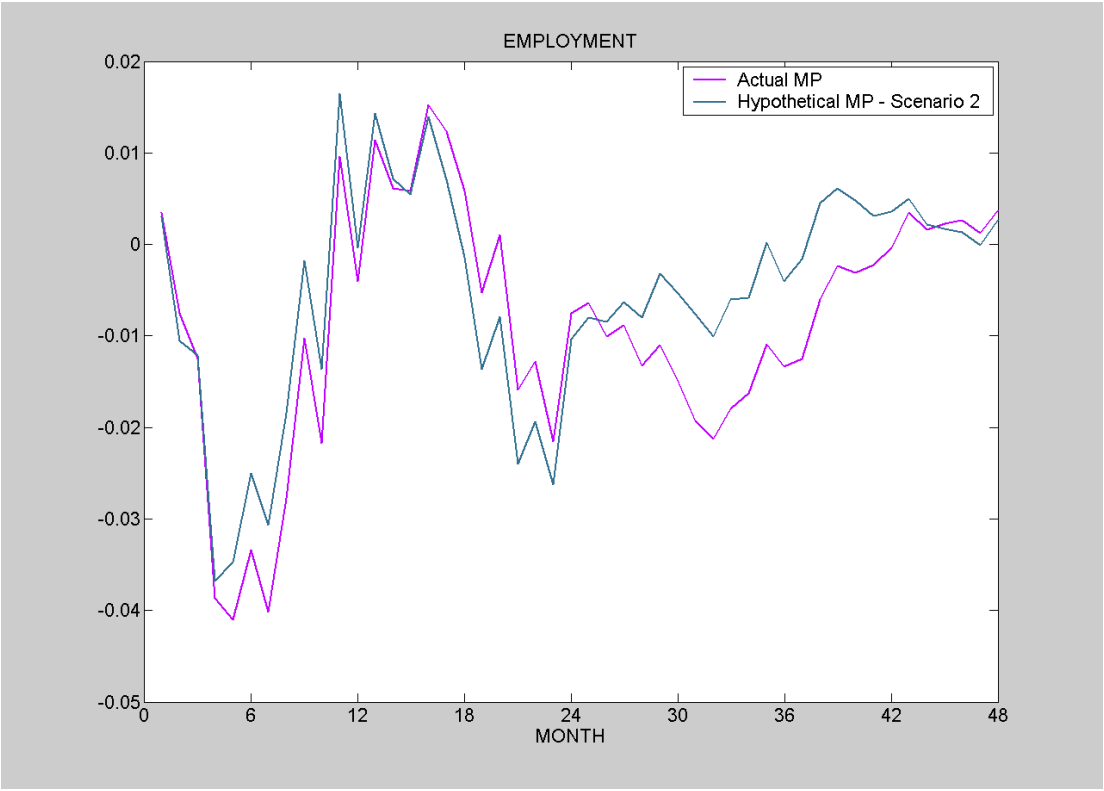


Figure 3 (continued). Comparison of Impulse Response Functions of Historical Monetary Policy and Scenario 2 (Employment, Average Hourly Earnings).



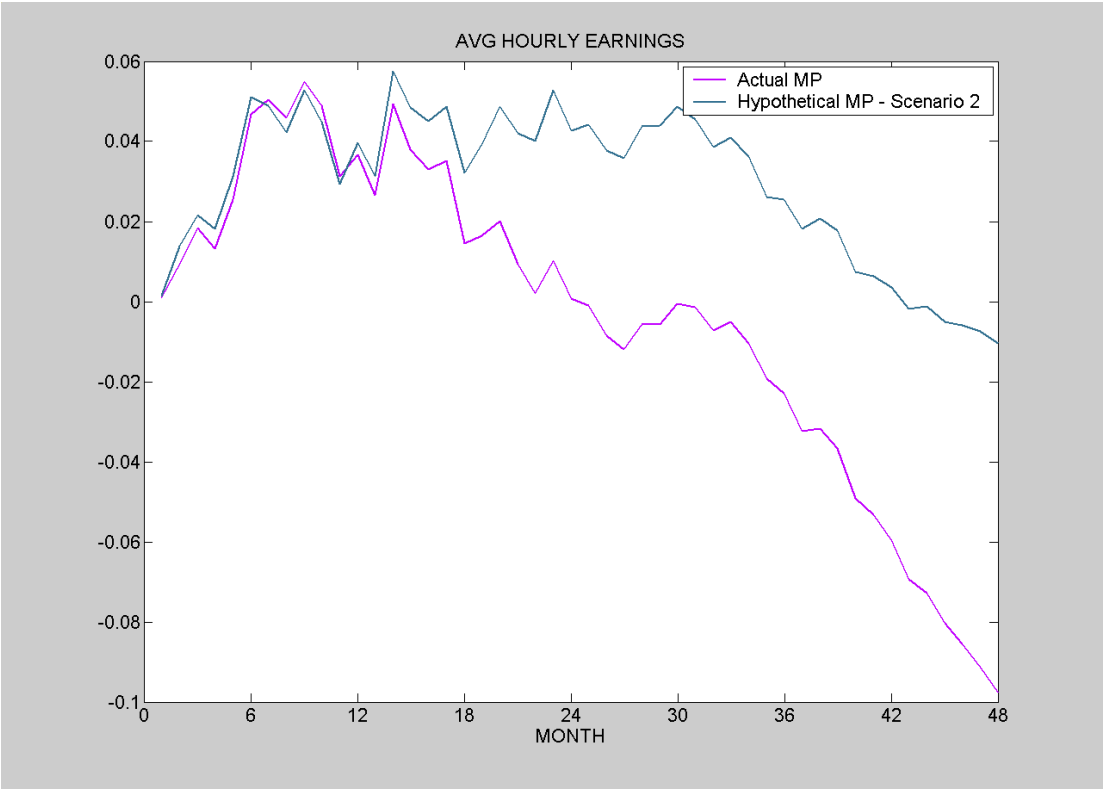
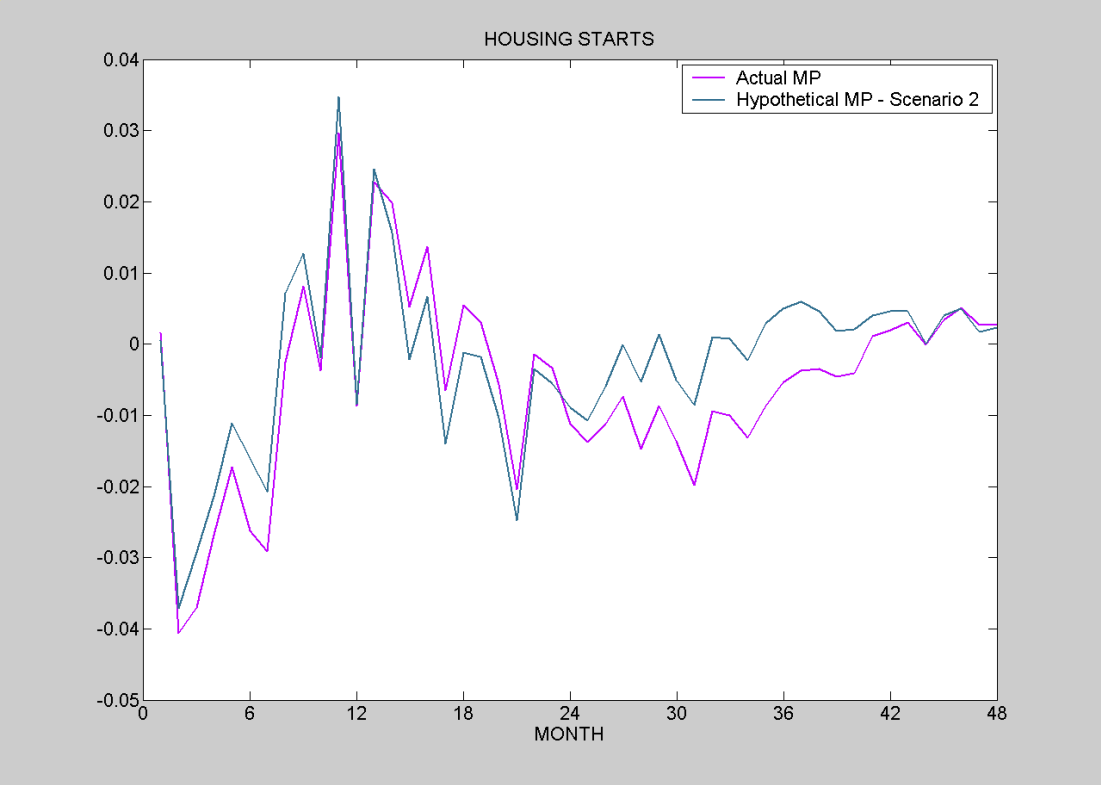


Figure 3 (continued). Comparison of Impulse Response Functions of Historical Monetary Policy and Scenario 2 (Housing Starts, New Orders).



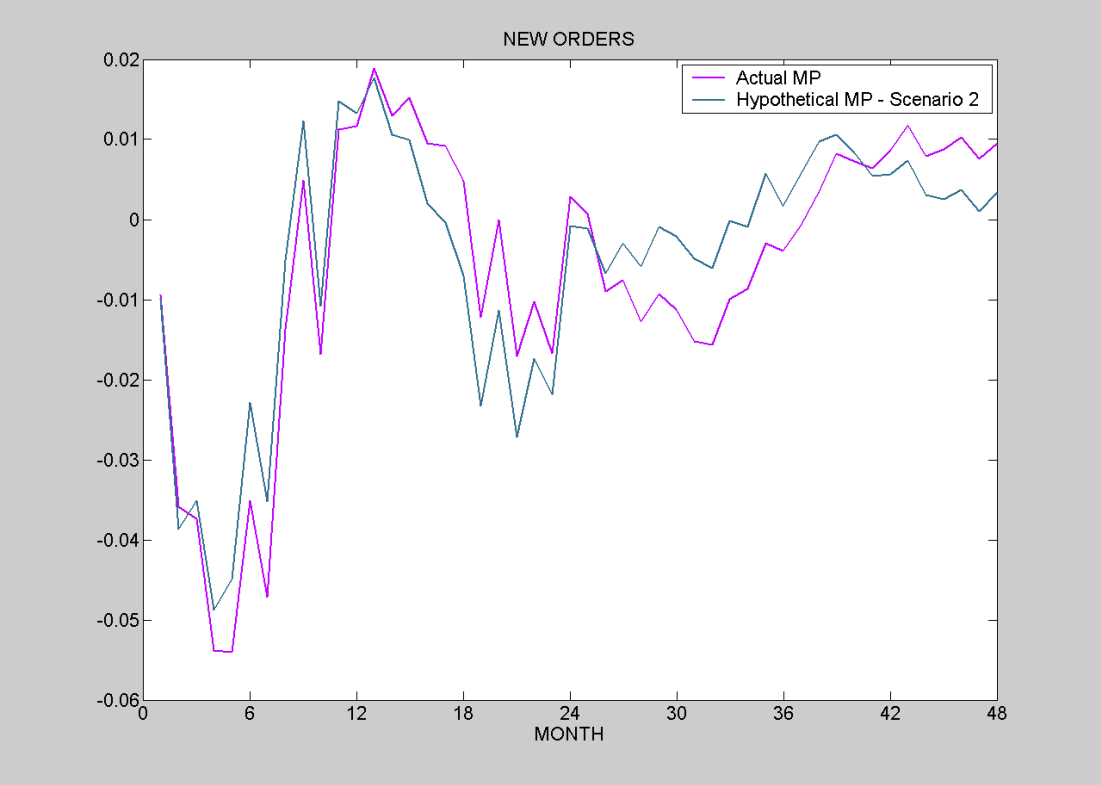
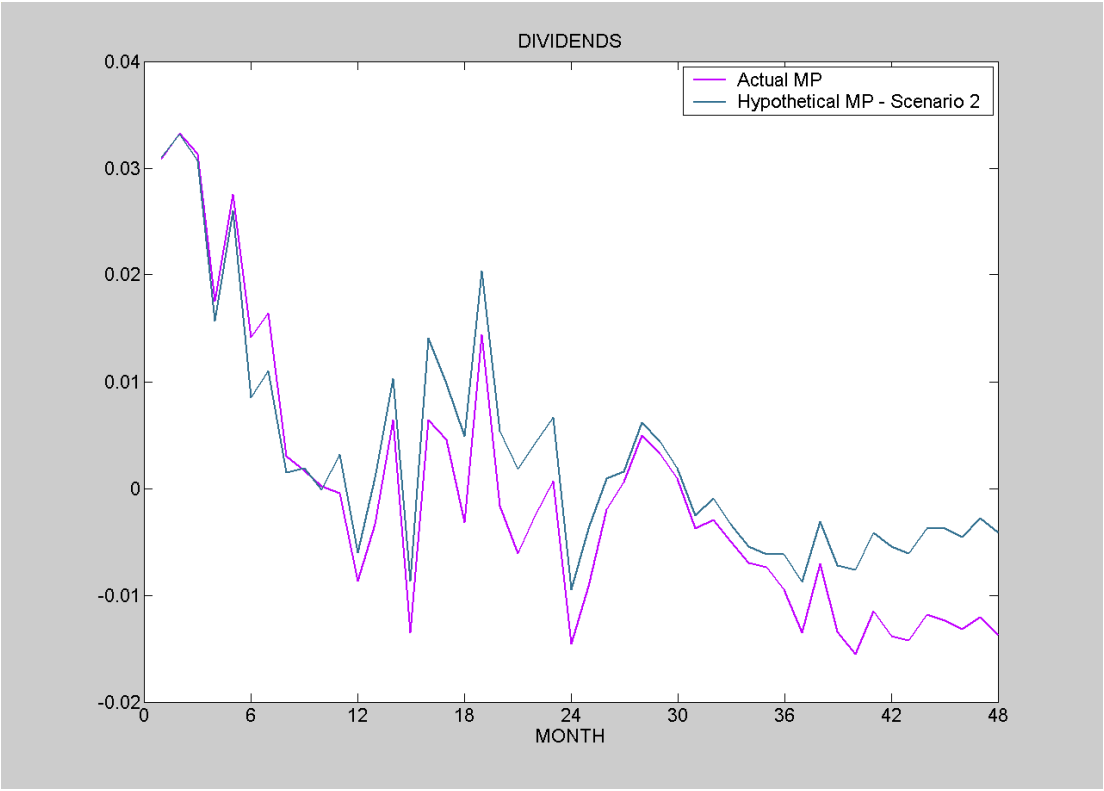
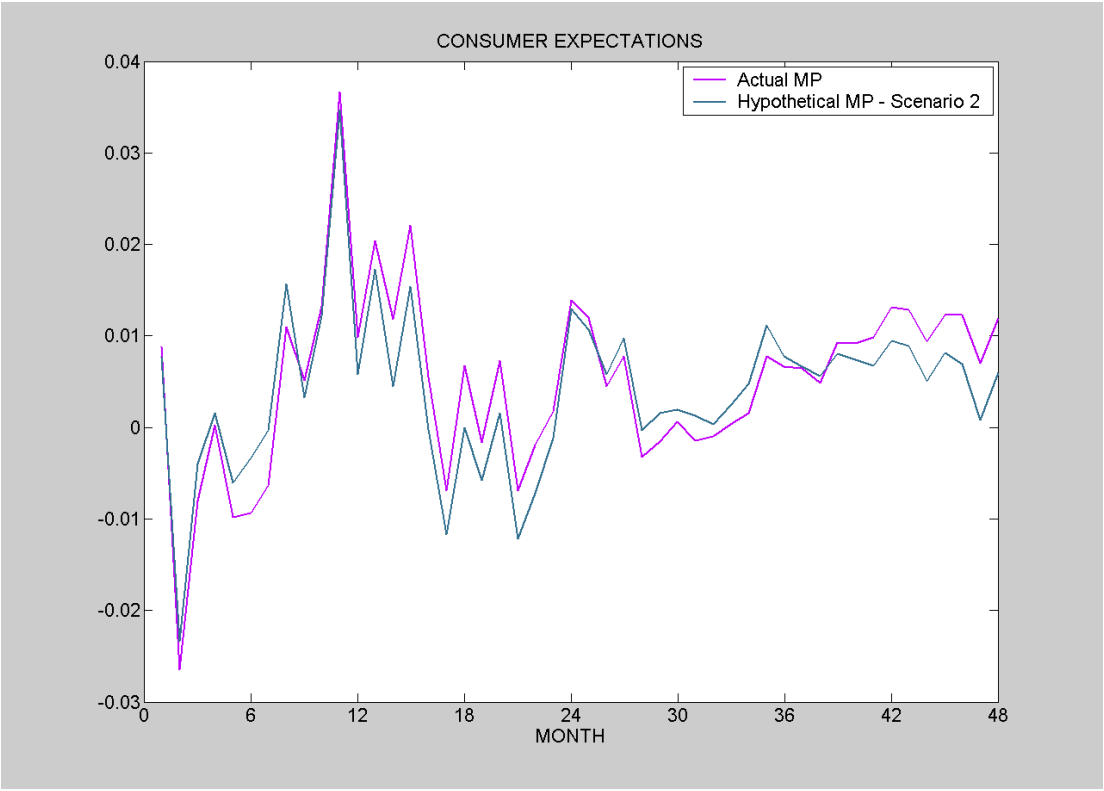


Figure 3 (continued). Comparison of Impulse Response Functions of Historical Monetary Policy and Scenario 2 (Dividends, Consumer Expectations).





5. Conclusion

This study investigates whether active monetary policy actions are necessary. We construct hypothetical monetary policy actions where the Federal Reserve Bank held the Fed Funds Rate stationary at a higher level than the actual historical active monetary policy actions.

The extra information generated by the FAVAR allows us to look at the effect of a monetary policy shock on more than a hundred impulse response functions of economic variables. This leads to a better understanding of the dynamics of monetary policy actions on interest rates, the financial sector and the real activities of the economy.

Using FAVAR with a large dataset, this study finds that a less active monetary policy would also control inflation but would produce a less negative impact on real economic activities, and that major economic variables would be less volatile in a 48-month horizon. However, the wage rate seems to be more sticky under the non-active monetary policy approach, and might not be appropriate for curbing cost-push inflation. This provides insights into the implementation of monetary policies not only for the U.S., but also for other central banks tha use the manipulation of the interest rates as their major monetary policy tool.

However, the identification of factors in the FAVAR model is still to be developed and would be important for future research.

Appendix A -Data Description

All series are downloaded from Jean Boivin website, http://neumann.hec.ca/pages/jean.boivin/mypapers/BBE_Ddisk.zip. The transformation codes are: 1 – no transformation; 2 – first difference; 4 – logarithm; 5 – first difference of logarithm. An asterisk, '*', denotes the assumption of slow-moving variable in the estimation.

Real output and income

1	IPP*	1959:01-2001:08	5	INDUSTRIAL PRODUCTION: PRODUCTS, TOTAL (1992=100,SA)
2	IPF*	1959:01-2001:08	5	INDUSTRIAL PRODUCTION: FINAL PRODUCTS (1992=100,SA)
3	IPC*	1959:01-2001:08	5	INDUSTRIAL PRODUCTION: CONSUMER GOODS (1992=100,SA)
4	IPCD*	1959:01-2001:08	5	INDUSTRIAL PRODUCTION: DURABLE CONS. GOODS (1992=100,SA)
5	IPCN*	1959:01-2001:08	5	INDUSTRIAL PRODUCTION: NONDURABLE CONS. GOODS (1992=100,SA)
6	IPE*	1959:01-2001:08	5	INDUSTRIAL PRODUCTION: BUSINESS EQUIPMENT (1992=100,SA)
7	IPI*	1959:01-2001:08	5	INDUSTRIAL PRODUCTION: INTERMEDIATE PRODUCTS (1992=100,SA)
8	IPM*	1959:01-2001:08	5	INDUSTRIAL PRODUCTION: MATERIALS (1992=100,SA)
9	IPMD*	1959:01-2001:08	5	INDUSTRIAL PRODUCTION: DURABLE GOODS MATERIALS (1992=100,SA)
10	IPMND*	1959:01-2001:08	5	INDUSTRIAL PRODUCTION: NONDUR. GOODS MATERIALS (1992=100,SA)
11	IPMFG*	1959:01-2001:08	5	INDUSTRIAL PRODUCTION: MANUFACTURING (1992=100,SA)
12	IPD*	1959:01-2001:08	5	INDUSTRIAL PRODUCTION: DURABLE MANUFACTURING (1992=100,SA)
13	IPN*	1959:01-2001:08	5	INDUSTRIAL PRODUCTION: NONDUR. MANUFACTURING (1992=100,SA)
14	IPMIN*	1959:01-2001:08	5	INDUSTRIAL PRODUCTION: MINING (1992=100,SA)
15	IPUT*	1959:01-2001:08	5	INDUSTRIAL PRODUCTION: UTILITIES (1992-=100,SA)
16	IP*	1959:01-2001:08	5	INDUSTRIAL PRODUCTION: TOTAL INDEX (1992=100,SA)
17	IPXMCA*	1959:01-2001:08	1	CAPACITY UTIL RATE: MANUFAC.,TOTAL(% OF CAPACITY,SA) (FRB)
18	PMI*	1959:01-2001:08	1	PURCHASING MANAGERS' INDEX (SA)
19	PMP*	1959:01-2001:08	1	NAPM PRODUCTION INDEX (PERCENT)
20	GMPYQ*	1959:01-2001:08	5	PERSONAL INCOME (CHAINED) (SERIES #52) (BIL 92$,SAAR)
21	GMYXPQ*	1959:01-2001:08	5	PERSONAL INC. LESS TRANS. PAYMENTS (CHAINED) (#51) (BIL 92$,SAAR)

Employment and hours

22	LHEL*	1959:01-2001:08	5	INDEX OF HELP-WANTED ADVERTISING IN NEWSPAPERS (1967=100;SA)
23	LHELX*	1959:01-2001:08	4	EMPLOYMENT: RATIO; HELP-WANTED ADS:NO. UNEMPLOYED CLF
24	LHEM*	1959:01-2001:08	5	CIVILIAN LABOR FORCE: EMPLOYED, TOTAL (THOUS.,SA)
25	LHNAG*	1959:01-2001:08	5	CIVILIAN LABOR FORCE: EMPLOYED, NONAG.INDUSTRIES (THOUS.,SA)
26	LHUR*	1959:01-2001:08	1	UNEMPLOYMENT RATE: ALL WORKERS, 16 YEARS & OVER (%,SA)
27	LHU680*	1959:01-2001:08	1	UNEMPLOY.BY DURATION: AVERAGE(MEAN)DURATION IN WEEKS (SA)
28	LHU5*	1959:01-2001:08	1	UNEMPLOY.BY DURATION: PERS UNEMPL.LESS THAN 5 WKS (THOUS.,SA)

29	LHU14*	1959:01-2001:08	1	UNEMPLOY.BY DURATION: PERS UNEMPL.5 TO 14 WKS (THOUS.,SA)
30	LHU15*	1959:01-2001:08	1	UNEMPLOY.BY DURATION: PERS UNEMPL.15 WKS + (THOUS.,SA)
31	LHU26*	1959:01-2001:08	1	UNEMPLOY.BY DURATION: PERS UNEMPL.15 TO 26 WKS (THOUS.,SA)
32	LPNAG*	1959:01-2001:08	5	EMPLOYEES ON NONAG. PAYROLLS: TOTAL (THOUS.,SA)
33	LP*	1959:01-2001:08	5	EMPLOYEES ON NONAG PAYROLLS: TOTAL, PRIVATE (THOUS,SA)
34	LPGD*	1959:01-2001:08	5	EMPLOYEES ON NONAG. PAYROLLS: GOODS-PRODUCING (THOUS.,SA)
35	LPMI*	1959:01-2001:08	5	EMPLOYEES ON NONAG. PAYROLLS: MINING (THOUS.,SA)
36	LPCC*	1959:01-2001:08	5	EMPLOYEES ON NONAG. PAYROLLS: CONTRACT CONSTRUC. (THOUS.,SA)
37	LPEM*	1959:01-2001:08	5	EMPLOYEES ON NONAG. PAYROLLS: MANUFACTURING (THOUS.,SA)
38	LPED*	1959:01-2001:08	5	EMPLOYEES ON NONAG. PAYROLLS: DURABLE GOODS (THOUS.,SA)
39	LPEN*	1959:01-2001:08	5	EMPLOYEES ON NONAG. PAYROLLS: NONDURABLE GOODS (THOUS.,SA)
40	LPSP*	1959:01-2001:08	5	EMPLOYEES ON NONAG. PAYROLLS: SERVICE-PRODUCING (THOUS.,SA)
41	LPTU*	1959:01-2001:08	5	EMPLOYEES ON NONAG. PAYROLLS: TRANS. & PUBLIC UTIL. (THOUS.,SA)
42	LPT*	1959:01-2001:08	5	EMPLOYEES ON NONAG. PAYROLLS: WHOLESALE & RETAIL (THOUS.,SA)
43	LPFR*	1959:01-2001:08	5	EMPLOYEES ON NONAG. PAYROLLS: FINANCE,INS.&REAL EST (THOUS.,SA
44	LPS*	1959:01-2001:08	5	EMPLOYEES ON NONAG. PAYROLLS: SERVICES (THOUS.,SA)
45	LPGOV*	1959:01-2001:08	5	EMPLOYEES ON NONAG. PAYROLLS: GOVERNMENT (THOUS.,SA)
46	LPHRM*	1959:01-2001:08	1	AVG. WEEKLY HRS. OF PRODUCTION WKRS.: MANUFACTURING (SA)
47	LPMOSA*	1959:01-2001:08	1	AVG. WEEKLY HRS. OF PROD. WKRS.: MFG.,OVERTIME HRS. (SA)
48	PMEMP*	1959:01-2001:08	1	NAPM EMPLOYMENT INDEX (PERCENT)

Consumption

49	GMCQ*	1959:01-2001:08	5	PERSONAL CONSUMPTION EXPEND (CHAINED) - TOTAL (BIL 92$,SAAR)
50	GMCDQ*	1959:01-2001:08	5	PERSONAL CONSUMPTION EXPEND (CHAINED) - TOT. DUR. (BIL 96$,SAAR)
51	GMCNQ*	1959:01-2001:08	5	PERSONAL CONSUMPTION EXPEND (CHAINED) - NONDUR. (BIL 92$,SAAR)
52	GMCSQ*	1959:01-2001:08	5	PERSONAL CONSUMPTION EXPEND (CHAINED) - SERVICES (BIL 92$,SAAR)
53	GMCANQ*	1959:01-2001:08	5	PERSONAL CONS EXPEND (CHAINED) - NEW CARS (BIL 96$,SAAR)

Housing starts and sales

54	HSFR	1959:01-2001:08	4	HOUSING STARTS: NONFARM(1947-58);TOT.(1959-)(THOUS.,SA
55	HSNE	1959:01-2001:08	4	HOUSING STARTS: NORTHEAST (THOUS.U.)S.A.
56	HSMW	1959:01-2001:08	4	HOUSING STARTS: MIDWEST(THOUS.U.)S.A.
57	HSSOU	1959:01-2001:08	4	HOUSING STARTS: SOUTH (THOUS.U.)S.A.
58	HSWST	1959:01-2001:08	4	HOUSING STARTS: WEST (THOUS.U.)S.A.
59	HSBR	1959:01-2001:08	4	HOUSING AUTHORIZED: TOTAL NEW PRIV HOUSING (THOUS.,SAAR)
60	HMOB	1959:01-2001:08	4	MOBILE HOMES: MANUFACTURERS' SHIPMENTS (THOUS.OF UNITS,SAAR)

Real inventories, orders and unfilled orders

61	PMNV	1959:01-2001:08	1	NAPM INVENTORIES INDEX (PERCENT)
62	PMNO	1959:01-2001:08	1	NAPM NEW ORDERS INDEX (PERCENT)

63	PMDEL	1959:01-2001:08	1	NAPM VENDOR DELIVERIES INDEX (PERCENT)
64	MOCMQ	1959:01-2001:08	5	NEW ORDERS (NET) - CONSUMER GOODS & MATERIALS, 1992 $ (BCI)
5	MSONDQ	1959:01-2001:08	5	NEW ORDERS, NONDEFENSE CAPITAL GOODS, IN 1992 DOLLARS(BCI)
Stock prices				
66	FSNCOM	1959:01-2001:08	5	NYSE COMMON STOCK PRICE INDEX: COMPOSITE (12/31/65=50)
67	FSPCOM	1959:01-2001:08	5	S&P'S COMMON STOCK PRICE INDEX: COMPOSITE (1941-43=10)
68	FSPIN	1959:01-2001:08	5	S&P'S COMMON STOCK PRICE INDEX: INDUSTRIALS (1941-43=10)
69	FSPCAP	1959:01-2001:08	5	S&P'S COMMON STOCK PRICE INDEX: CAPITAL GOODS (1941-43=10)
70	FSPUT	1959:01-2001:08	5	S&P'S COMMON STOCK PRICE INDEX: UTILITIES (1941-43=10)
71	FSDXP	1959:01-2001:08	1	S&P'S COMPOSITE COMMON STOCK: DIVIDEND YIELD (% PER ANNUM)
72	FSPXE	1959:01-2001:08	1	S&P'S COMPOSITE COMMON STOCK: PRICE-EARNINGS RATIO (%,NSA)
Exchange rates				
73	EXRSW	1959:01-2001:08	5	FOREIGN EXCHANGE RATE: SWITZERLAND (SWISS FRANC PER U.S.$)
74	EXRJAN	1959:01-2001:08	5	FOREIGN EXCHANGE RATE: JAPAN (YEN PER U.S.$)
75	EXRUK	1959:01-2001:08	5	FOREIGN EXCHANGE RATE: UNITED KINGDOM (CENTS PER POUND)
76	EXRCAN	1959:01-2001:08	5	FOREIGN EXCHANGE RATE: CANADA (CANADIAN $ PER U.S.$)
Interest rates				
77	FYFF	1959:01-2001:08	1	INTEREST RATE: FEDERAL FUNDS (EFFECTIVE) (% PER ANNUM,NSA)
78	FYGM3	1959:01-2001:08	1	INTEREST RATE: U.S.TREASURY BILLS,SEC MKT,3-MO.(% PER ANN,NSA)
79	FYGM6	1959:01-2001:08	1	INTEREST RATE: U.S.TREASURY BILLS,SEC MKT,6-MO.(% PER ANN,NSA)
80	FYGT1	1959:01-2001:08	1	INTEREST RATE: U.S.TREASURY CONST MATUR. ,1-YR.(% PER ANN,NSA)
81	FYGT5	1959:01-2001:08	1	INTEREST RATE: U.S.TREASURY CONST MATUR., 5-YR.(% PER ANN,NSA)
82	FYGT10	1959:01-2001:08	1	INTEREST RATE: U.S.TREASURY CONST MATUR.,10-YR.(% PER ANN,NSA)
83	FYAAAC	1959:01-2001:08	1	BOND YIELD: MOODY'S AAA CORPORATE (% PER ANNUM)
84	FYBAAC	1959:01-2001:08	1	BOND YIELD: MOODY'S BAA CORPORATE (% PER ANNUM)
85	SFYGM3	1959:01-2001:08	1	Spread FYGM3 - FYFF
86	SFYGM6	1959:01-2001:08	1	Spread FYGM6 - FYFF
87	SFYGT1	1959:01-2001:08	1	Spread FYGT1 - FYFF
88	SFYGT5	1959:01-2001:08	1	Spread FYGT5 - FYFF
89	SFYGT10	1959:01-2001:08	1	Spread FYGT10 - FYFF
90	SFYAAAC	1959:01-2001:08	1	Spread FYAAAC - FYFF
91	SFYBAAC	1959:01-2001:08	1	Spread FYBAAC - FYFF
Money and Credit quantity aggregates				
92	FM1	1959:01-2001:08	5	MONEY STOCK: M1 (BIL$,SA)
93	FM2	1959:01-2001:08	5	MONEY STOCK:M2 (BIL$, SA)
94	FM3	1959:01-2001:08	5	MONEY STOCK: M3 (BIL$,SA)
95	FM2DQ	1959:01-2001:08	5	MONEY SUPPLY -M2 IN 1992 DOLLARS (BCI)

96	FMFBA	1959:01-2001:08	5	MONETARY BASE, ADJ FOR RESERVE REQUIREMENT CHANGES(MIL$,SA)
97	FMRRA	1959:01-2001:08	5	DEPOSITORY INST RESERVES:TOTAL,ADJ FOR RES. REQ CHGS(MIL$,SA)
98	FMRNBA	1959:01-2001:08	5	DEPOSITORY INST RESERVES:NONBOR. ,ADJ RES REQ CHGS(MIL$,SA)
99	FCLNQ	1959:01-2001:08	5	COMMERCIAL & INDUST. LOANS OUSTANDING IN 1992 DOLLARS (BCI)
100	FCLBMC	1959:01-2001:08	1	WKLY RPLG COM. BANKS: NET CHANGE COM & IND. LOANS(BIL$,SAAR)
101	CCINRV	1959:01-2001:08	5	CONSUMER CREDIT OUTSTANDING NONREVOLVING G19

Price indexes

102	PMCP	1959:01-2001:08	1	NAPM COMMODITY PRICES INDEX (PERCENT)
103	PWFSA*	1959:01-2001:08	5	PRODUCER PRICE INDEX: FINISHED GOODS (82=100,SA)
104	PWFCSA*	1959:01-2001:08	5	PRODUCER PRICE INDEX:FINISHED CONSUMER GOODS (82=100,SA)
105	PWIMSA*	1959:01-2001:08	5	PRODUCER PRICE INDEX:INTERMED MAT.SUP & COMPONENTS(82=100,SA)
106	PWCMSA*	1959:01-2001:08	5	PRODUCER PRICE INDEX:CRUDE MATERIALS (82=100,SA)
107	PSM99Q*	1959:01-2001:08	5	INDEX OF SENSITIVE MATERIALS PRICES (1990=100)(BCI-99A)
108	PUNEW*	1959:01-2001:08	5	CPI-U: ALL ITEMS (82-84=100,SA)
109	PU83*	1959:01-2001:08	5	CPI-U: APPAREL & UPKEEP (82-84=100,SA)
110	PU84*	1959:01-2001:08	5	CPI-U: TRANSPORTATION (82-84=100,SA)
111	PU85*	1959:01-2001:08	5	CPI-U: MEDICAL CARE (82-84=100,SA)
112	PUC*	1959:01-2001:08	5	CPI-U: COMMODITIES (82-84=100,SA)
113	PUCD*	1959:01-2001:08	5	CPI-U: DURABLES (82-84=100,SA)
114	PUS*	1959:01-2001:08	5	CPI-U: SERVICES (82-84=100,SA)
115	PUXF*	1959:01-2001:08	5	CPI-U: ALL ITEMS LESS FOOD (82-84=100,SA)
116	PUXHS*	1959:01-2001:08	5	CPI-U: ALL ITEMS LESS SHELTER (82-84=100,SA)
117	PUXM*	1959:01-2001:08	5	CPI-U: ALL ITEMS LESS MEDICAL CARE (82-84=100,SA)

Average hourly earnings

118	LEHCC*	1959:01-2001:08	5	AVG HR EARNINGS OF CONSTR WKRS: CONSTRUCTION ($,SA)
119	LEHM*	1959:01-2001:08	5	AVG HR EARNINGS OF PROD WKRS: MANUFACTURING ($,SA)

Miscellaneous

120	HHSNTN	1959:01-2001:08	1	U.OF MICH. INDEX OF CONSUMER EXPECTATIONS(BCD-83)