DIFFERENT PRICE INDICES AND THE IMPLICATION FOR THE FEDERAL RESERVE REACTION FUNCTION: AN EMPIRICAL STUDY

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ABSTRACT

This paper demonstrates the importance of properly measuring inflation when estimating Federal Reserve reaction functions. Based on static Taylor rule type reaction functions the median consumer price index (MCPI) is a better measure of information on monetary inflation than either the consumer price index (CPI) or the GDP chain-type price index (CTPI) or several other common measures of inflation. The issue is important when attempting to assess the stance of monetary policy; the Federal Reserve's goal of maintaining price stability must account for movements in the overall price-level and not changes in relative price.

JEL classification: E50, E52, E31
Keywords: Federal Reserve, Reaction Function, Median Consumer Price Index

INTRODUCTION

This paper examines the implications of using different price indices in the estimation of Federal Reserve reaction functions. The use of different indices generates different reactions by the Federal Reserve to inflation based on the time period being analyzed. Taking the two main goals of the Federal Reserve as given, which are to promote economic growth and maintain price stability, it is critical when attempting to determine the stance of monetary policy to understand the implications from the use of different measures of inflation. Mismeasuring price level changes may lead to faulty conclusions about the stance of monetary policy, in particular the Federal Reserve's stance on inflation. The price indices examined

in this paper include the Consumer Price Index (CPI), the consumer price index less food and energy (CPILF), the Gross Domestic Product chain-type price index (CTPI), the GDP deflator (DEF), the personal consumption expenditures index (PCE), the personal consumption expenditures index less food and energy (PCELF), and the Median Consumer Price Index (MCPI).

The first six indices are familiar to economists; the seventh may be somewhat less familiar. The MCPI is a measure of inflation calculated by the Cleveland Federal Reserve Bank. Bryan and Pike (1991) provide a brief explanation of the calculation of the MCPI and rationale for using the MCPI to estimate the rate of inflation.

"The median of a set of data is the value of the middle observation when all items are arranged in either ascending or descending order of magnitude. In effect the median consumer price change is the CPI less everything but the price change that lies in the middle of the continuum. Since only the order, not the values, of the various price changes is used in its calculation, the median is a central tendency statistic that is largely independent of the data's distribution. The median also has the intuitively appealing property of lying closer to the majority of price changes than does any alternative measure." (Bryan & Pike, 1991)

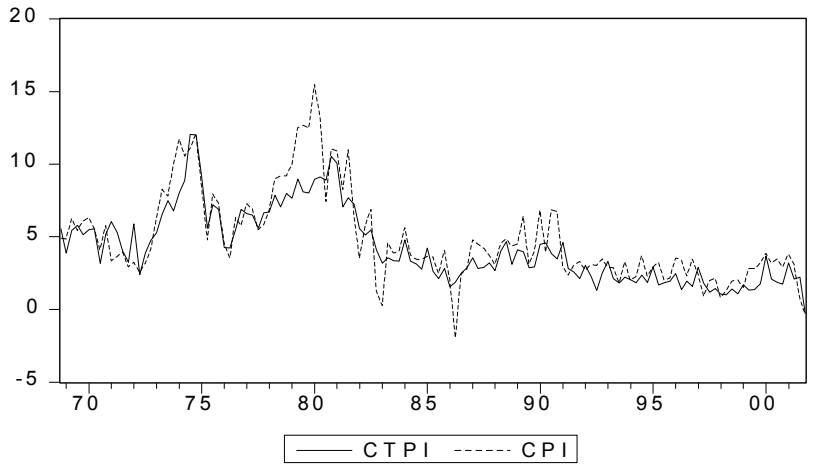
A more rigorous discussion of the median price index as a measure of monetary inflation, or a "trimmed means estimator of inflation" can be found in Bryan, Cecchetti, and Wiggins (1997). The authors find that the trimmed means estimators yield an efficient estimator of core inflation which is twenty-three percent more efficient than the standard mean CPI.

The Consumer Price Index (CPI) as the measure of inflation in the U.S. economy is probably one of the most often cited pieces of economic information. Everything from Social Security benefits to union contracts depend upon the consumer price index, through the use of cost of living adjustments. The case has been made that the CPI overstates the rate of inflation therefore it may not be the most appropriate measure of monetary inflation or the price level in the economy (The reasons why the CPI may overstate inflation are outside the scope of this paper, see Wynne and Sigalla (1993) or Shapiro and Wilcox (1996) for a detailed discussion of the issues). However, based on the underlying implications for the CPI, it remains an important measure of macroeconomic performance.

The GDP deflator index is often used as an alternative to the CPI when estimating the rate of inflation. The inflation rate as measured by the GDP chain-type price index tends to be lower than that measured by the CPI. In fact, the inflation rate as measured by the CPI exceeds that from the GDP chain-type price

index in 95 of the 133 quarters (or over seventy-percent of the time) from 1968 Q4 through 2001 Q4. The GDP chain-type price index is the broadest measure of the price level, in that, it includes goods and services not captured by the CPI, including investment goods. Both the CPI and the GDP chain-type price index appear as measures of inflation in the reaction function literature with varying degrees of significance, for example Judd and Rudebusch (1998). Figure 1 shows a plot of the CPI and GDP chain-type price indices from 1968 Q4 through 2001 Q4 using quarterly data.

Figure 1: Consumer Price Index and GDP chain-type price index, 1968.4 -2001.4



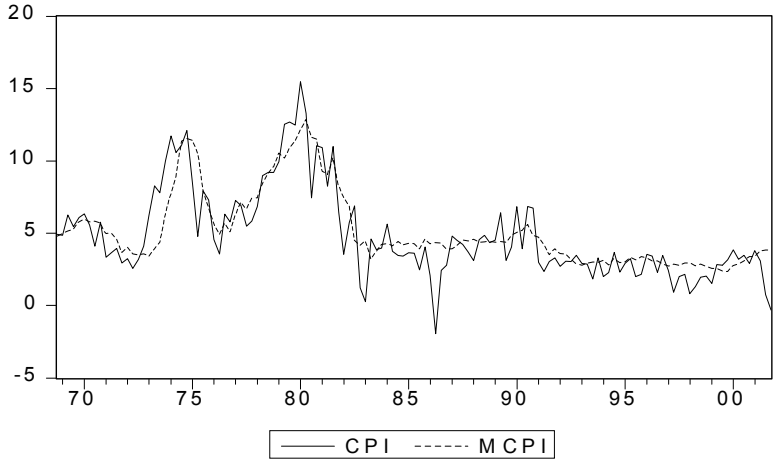
The use of the CPI as the measure of inflation is troublesome because in addition to measuring changes in the overall price level (inflation) the CPI also tends to measure changes in relative price movements. The issue addressed in this paper is whether or not there exists a measure of inflation that is "better" than either the CPI or CTPI, or other popular measures of inflation including the PCE, for determining the stance of monetary policy. The answer according to Bryan and Pike (1991) is yes. As demonstrated by Bryan and Pike, the MCPI is more closely related to changes in the money supply than the CPI, which indicates that it is a better measure of monetary inflation and is less affected by relative price changes.

"Distinguishing between inflation and relative price movements is also important for the conduct of monetary policy. Without a clear distinction between the two, policymakers may inadvertently react to relative price changes and thereby

complicate the economy's adjustment to a new set of prices. By not reacting to changes in the inflation rate, they might allow unnecessary price level fluctuations." (Bryan & Pike, 1991)

Figure 2 plots inflation measured form the CPI and the MCPI from 1968.4 through 2001.4. From the Figure we see that the MCPI is less volatile than the CPI particularly from the mid-1980s through 2001. Table 1 provides descriptive statistics for inflation based on the seven price indices being examined. The table indicates that for the entire sample inflation as measured by the CTPI or the PCELF are on average lower than either the CPI or MCPI and they both also have smaller standard deviations. Table 1 also shows that during both periods the CPI and CTPI have minimums which indicate deflation, whereas the minimum inflation rate based on the MCPI is approximately 2.3 percent.

Figure 2: Inflation measured by the MCPI and CPI, 1968.4 - 2001.4



According to Brunner (1994) and Hetzel (2000) this latter period represents a regime shift at the Federal Reserve where inflation began to receive greater attention and the role of monetary growth was de-emphasized. This also represents a period where the federal funds rate became the primary tool of monetary policy. Table 2 provides the correlation matrix between the different price indices and the federal funds rate. The results indicate that over the whole sample the CPILF has the highest correlation with the federal funds rate and the CTPI has the lowest correlation with the federal funds rate. During the more recent time period the MCPI has the highest correlation with the federal funds rate followed by the GDP

deflator and the GDP chain-type price index, the latter two represent much broader measures of inflation than does the CPI. Interestingly, during this more recent time-period the CPI has the lowest correlation with the federal funds rate, (0.472), of the seven price indices.

Table 1A: Summary Statistics for inflation, based on price indices, 1969.1-2001.4							
	CPI	CPILF	CTPI	DEF	MCPI	PCE	PCELF
Mean	4.883	4.926	4.287	4.286	5.186	4.331	4.242
Median	3.859	4.224	3.561	3.575	4.372	3.758	3.947
Standard Dev.	3.117	2.728	2.529	2.531	2.569	2.621	2.210
Minimum	-1.952	1.372	-0.255	-0.255	2.362	0.241	0.840
Maximum	15.479	14.522	12.049	11.795	12.863	11.738	11.032
Count	133	133	133	133	133	133	133
Table 1B: Summary Statistics for inflation, based on price indices, 1982.1-2001.4							
	CPI	CPILF	CTPI	DEF	MCPI	PCE	PCELF
Mean	3.190	3.543	2.689	2.689	3.770	2.838	3.059
Median	3.147	3.414	2.604	2.636	3.744	2.674	3.034
Standard Dev.	1.546	1.204	1.143	1.146	0.938	1.327	1.370
Minimum	-1.952	1.372	-0.255	-0.255	2.362	0.241	0.840
Maximum	6.887	7.334	5.577	5.551	7.476	6.211	6.354
Count	80	80	80	80	80	80	80

Table 2A: Correlation Matrix, 1969.1-2001.4								
	FFR	CPI	CPILF	CTPI	DEF	MCPI	PCE	PCELF
FFR	1.0000							
CPI	0.6491	1.0000						
CPILF	0.7082	0.8876	1.0000					
CTPI	0.6128	0.8857	0.8575	1.0000				
DEF	0.6150	0.8836	0.8545	0.9949	1.0000			
MCPI	0.6521	0.8503	0.9139	0.8851	0.8813	1.0000		
PCE	0.6260	0.9445	0.8437	0.9336	0.9279	0.8596	1.0000	
PCELF	0.6529	0.8035	0.8814	0.9076	0.9004	0.8916	0.9073	1.0000

Table 2B: Correlation Matrix, 1982.1-2001.4								
	FFR	CPI	CPILF	CTPI	DEF	MCPI	PCE	PCELF
FFR	1.0000							
CPI	0.4724	1.0000						
CPILF	0.6793	0.6697	1.0000					
CTPI	0.7040	0.6556	0.7473	1.0000				
DEF	0.7032	0.6571	0.7511	0.9977	1.0000			
MCPI	0.7599	0.4300	0.7767	0.7087	0.7053	1.0000		
PCE	0.6223	0.8118	0.6782	0.8154	0.8103	0.6267	1.0000	
PCELF	0.6733	0.4056	0.7400	0.7690	0.7629	0.7695	0.8014	1.0000

DATA AND METHODOLOGY

All data are quarterly and cover 1968.4 through 2001.4. The starting point for the data represents the beginning of the median consumer price index series available from the Cleveland Federal Reserve Bank. The data covering real gross domestic product, the consumer price index, the gross domestic product chain-type price index, and the federal funds rate are from the St. Louis Federal Reserve Bank (The internet source for the St. Louis Federal Reserve Bank, Federal Reserve Economic Data is http://www.stls.frb.org/fred/index.html). Data for the median consumer price index are from the Cleveland Federal Reserve Bank, where the series is maintained (The internet source for the Median Consumer Price Index at the Cleveland Federal Reserve bank is http://www.clev.frb.org/Research/index.htm#data). Following convention annualized growth rates for inflation and GDP are calculated according to:

$$\pi_{i,t} = 400*(ln(P_t) - ln(P_{t-1}))$$

and

$$y_t = 400*(ln(GDP_t) - ln(GDP_{t-1}))$$

The quarterly data on the MCPI were provided by researchers at the Cleveland Federal Reserve Bank.

The reaction function to be estimated is given by the following:

$$FFR_t = c + \eta FFR_{t-1} + \alpha y_t + \beta \pi_{i,t}.$$

Where FFR_t is the current federal funds rate, FFR_{t-1} is the federal funds rate from the previous quarter, y_t is the growth rate of real GDP, $\pi_{i,t}$ is the inflation rate based on the three different indices, and c is a constant. The rationale for including the lagged federal funds rate is to capture potential interest rate smoothing by the Fed. The coefficients to be estimated are c, η, α, and β. This reaction function differs from the standard "Taylor rule" reaction function, estimated by Taylor (1993) in that rather than using output gaps and inflation gaps, the estimation is based on the growth rates of real GDP and inflation. This alternative estimation has the advantage of not having to determine the Federal Reserve's inflation target or possible issues with determining potential GDP and has been used in several empirical papers including McNees (1986) and Perez (2000). Federal Reserve reaction functions similar to the one above have been estimated in a variety of settings, for example Bernanke and Blinder (1992), Brunner (1994), Balke and Emery (1994), Christiano, Eichenbaum, and Evans (1996), and Rudebusch (1998).

RESULTS

The reaction function above is estimated over two time periods, 1968.4, after accounting for the lagged federal funds rate, through 2001.4 and also the more recent time period 1982.1 through 2001.4, which represents a relatively stable period of monetary policy. Table 3 provides the results of the estimation from 1968.4 through 2001.4. Over the whole sample there are only minor differences between the estimations. Based on the results, the federal funds rate reacts least strongly to inflation measured from by the MCPI than from the other two measures of inflation. However, both inflation and real GDP growth have significant and positive effects on the FFR in all seven equations. In addition, the adjusted R-squared for the CPI equation and the standard error of regression from the CPI equation indicate that the CPI provides a slightly better fit than inflation measured by the other indices. There are very small differences in the response to the growth rate of GDP among the seven estimations. Therefore, the conclusion for the entire sample is that the choice of the price index is relatively unimportant and that the differences in the Federal Reserve reaction functions based on the indices are negligible. Figure 3 plots the actual federal funds rate over this time period against

the fitted federal funds rate from the MCPI regression, the plot appears to show a very good fit based on the MCPI.

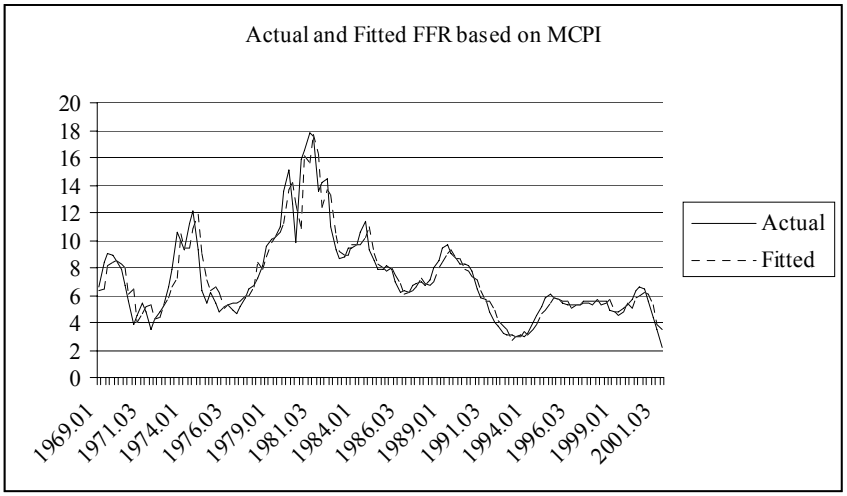
Table 3: Reaction functions estimated over 1969.1 – 2001.4.

Dependent variable is the federal funds rate. Standard errors are in parentheses ( ), and p-values are in brackets [ ].

Equation	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Constant	-0.273 (0.282) [0.336]	-0.300 (0.286) [0.297]	-0.307 (0.295) [0.301]	-0.303 (0.295) [0.305]	-0.386 (0.305) [0.209]	-0.308 (0.289) [0.289]	-0.312 (0.300) [0.300]
FFR(t-1)	0.887 (0.037) [0.000]	0.874 (0.041) [0.000]	0.916 (0.038) [0.000]	0.915 (0.039) [0.000]	0.918 (0.041) [0.000]	0.903 (0.038) [0.000]	0.917 (0.041) [0.000]
GDP Growth	0.096 (0.027) [0.001]	0.097 (0.028) [0.001]	0.098 (0.028) [0.001]	0.098 (0.028) [0.001]	0.104 (0.029) [0.000]	0.096 (0.028) [0.001]	0.097 (0.029) [0.001]
CPI	0.160 (0.035) [0.000]						
CPILF		0.185 (0.044) [0.000]					
CTPI			0.140 (0.045) [0.002]				
DEF				0.141 (0.045) [0.002]			
MCPI					0.125 (0.048) [0.010]		
PCE						0.162 (0.042) [0.000]	

Table 3: Reaction functions estimated over 1969.1 – 2001.4.							
Dependent variable is the federal funds rate. Standard errors are in parentheses ( ), and p-values are in brackets [ ].							
Equation	(1)	(2)	(3)	(4)	(5)	(6)	(7)
PCELF							0.142 (0.055) [0.011]
Adj. R-Square	0.894	0.891	0.885	0.885	0.883	0.889	0.883
SE of Reg.	1.019	1.031	1.060	1.060	1.072	1.041	1.072
AIC	2.906	2.930	2.984	2.983	3.006	2.949	3.007

Figure 3: Actual and fitted FFR based on inflation from the MCPI, 1969 Q1 – 2001



To determine whether or not the regression equations estimated are stationary, an augmented Dickey-Fuller test (ADF) is performed on the residuals for each equation. The results of the ADF tests are presented in Table 4. For each of the equations the null hypothesis of a unit root in the residuals is rejected at the 1-percent significance level. This implies that the relationships described in Table 3 are not spurious and perhaps there is a long-run cointegrating relationship among the FFR output and prices.

Table 4: Results of ADF tests on the residuals from the estimated equations, 1968.4 – 2001.4		
Equation	Test Statistic	1 Percent Critical Value
CPI	-4.037	-2.582
CPILF	-3.996	-2.582
CTPI	-3.909	-2.582
DEF	-3.895	-2.582
MCPI	-4.226	-2.582
PCE	-3.984	-2.582
PCELF	-3.925	-2.582

Based on the plot of the inflation rates from Figures 1 and 2, and also the descriptive statistics in Table 1, the period from 1982 through 2001 represents a period of more stable prices than the entire sample. The stability of this period may be attributable to a shift in the monetary policy targets, from monetary aggregates to the federal funds rate. To determine whether or not the Federal Reserve has reacted differently to inflation in the post 1982 regime, as suggested by Brunner (1994), the Federal Reserve reaction functions are re-estimated using the more stable sample period, 1982 Q1 through 2001 Q4. The results of these estimations are presented in Table 5.

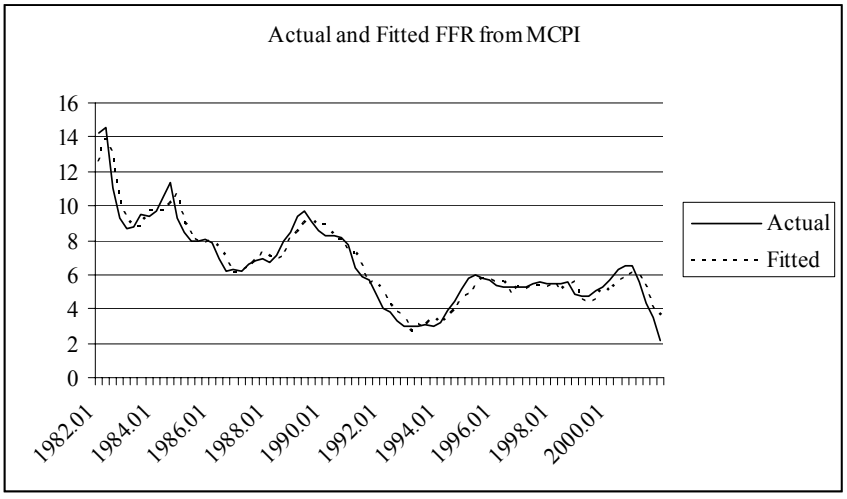
Table 5: Reaction functions estimated over 1982.1 – 2001.4.							
Dependent variable is the federal funds rate. Standard errors are in parentheses ( ), and p-values are in brackets [ ].							
Equation	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Constant	-0.201 (0.248) [0.421]	-0.243 (0.267) [0.366]	-0.208 (0.248) [0.405]	-0.205 (0.249) [0.411]	-0.827 (0.375) [0.030]	-0.137 (0.247) [0.582]	-0.067 (0.249) [0.788]
FFR(t-1)	0.920 (0.032) [0.000]	0.907 (0.039) [0.000]	0.890 (0.040) [0.000]	0.891 (0.040) [0.000]	0.858 (0.045) [0.000]	0.914 (0.037) [0.000]	0.944 (0.041) [0.000]

Table 5: Reaction functions estimated over 1982.1 – 2001.4.							
Dependent variable is the federal funds rate. Standard errors are in parentheses ( ), and p-values are in brackets [ ].							
Equation	(1)	(2)	(3)	(4)	(5)	(6)	(7)
GDP Growth	0.080 (0.028) [0.005]	0.082 (0.028) [0.004]	0.092 (0.028) [0.002]	0.092 (0.028) [0.002]	0.114 (0.030) [0.000]	0.083 (0.028) [0.004]	0.082 (0.028) [0.005]
CPI	0.108 (0.052) [0.040]						
CPILF		0.132 (0.081) [0.110]					
CTPI			0.191 (0.089) [0.034]				
DEF				0.188 (0.089) [0.039]			
MCPI					0.340 (0.129) [0.010]		
PCE						0.109 (0.069) [0.121]	
PCELF							0.015 (0.076) [0.845]
Adj. R-Square	0.931	0.930	0.932	0.931	0.933	0.930	0.927
SE of Reg.	0.639	0.647	0.638	0.639	0.629	0.647	0.647
AIC	1.992	2.014	1.989	1.990	1.961	2.016	2.048

The results of the estimation over the more recent time period indicate that the only statistically significant inflation rate at the 1-percent level in the Federal

Reserve reaction function is the rate of inflation as measured by the MCPI. The inflation variable is not significant at the ten-percent level in three of the regressions, including the CPILF, PCE, and PCELF. These results are interesting in that the CPILF and the PCELF have been touted as better measures of inflation that the CPI or the CTPI. The regression equation estimated with the MCPI as the measure of inflation has a highest adjusted R-squared value, the smallest standard error of regression, and the minimum AIC, indicating that the MCPI provides a better fit for the data. The MCPI regression is also the only equation where the intercept is statistically significant, therefore the response of the federal funds rate is smaller for both GPD growth and inflation. Figure 4 plots the actual federal funds rate with the fitted federal funds rate from the MCPI equation and inflation from the MCPI appears to give a very good fit for the data.

Figure 4: Actual and fitted FFR based on inflation from the MCPI, 1982 Q1 – 2001



Results of augmented Dickey-Fuller tests are presented in Table 6. Based on the ADF tests, the null hypothesis of a unit root can be rejected for all three equations. These results imply that the estimated regression equations are stationary.

Table 6: Results of ADF tests on the residuals from the estimated equations, 1982.1 – 2001.4		
Equation	Test Statistic	1 Percent Critical Value
CPI	-3.942	-2.593
CPILF	-4.572	-2.593
CTPI	-4.768	-2.593
DEF	-4.789	-2.593
MCPI	-4.559	-2.593
PCE	-5.027	-2.593
PCELF	-4.917	-2.593

CONCLUDING REMARKS

This paper has demonstrated the importance of properly measuring inflation when estimating Federal Reserve reaction functions. The results indicate that the median consumer price index (MCPI) is a better measure of information on monetary inflation during the stable monetary regime from the early 1980s through the early 2000s, than either the consumer price index (CPI) or the GDP chain-type price index (CTPI), or several other measures of inflation including the CPI less food, the personal consumption expenditures index (PCE) and the PCE less food, based on estimated reaction functions. Over a longer period, from the late 1960s through the 2000s there appeared to be little difference in reaction functions based on inflation from the different price indices. The issue is important when attempting to assess the stance of monetary policy, because the Federal Reserve's goal of maintaining price stability must account for the fact that the CPI may be measuring relative price movements rather than overall price-level changes.

This paper suggests that the MCPI perhaps best represents the information being used by the Federal Reserve when setting monetary policy. This is likely due to the fact that the MCPI is less affected by relative price movements than the CPI or the CTPI and is more closely related to monetary inflation, or changes in the overall price-level. Further research should examine the MCPI in dynamic Taylor rules as the results presented in this paper are based on the estimation of static Federal Reserve reaction functions.

REFERENCES

Balke, N.S. & K.M. Emery (1994). The federal funds rate as an indicator of monetary policy: Evidence from the 1980s. Federal Reserve Bank of Dallas *Economic Review*, 1-15.

Bernanke, B.S. & A.S. Blinder (1992). The federal funds rate and the channels of monetary transmission. *American Economic Review*, 82(4), 901-921.

Brunner, A.D. (1994). The federal funds rate and the implementation of monetary policy: Estimating the Federal Reserve's reaction function. *International Finance Discussion Paper* No. 266, Board of Governors of the Federal Reserve System.

Bryan, M.F., S.G. Cecchetti, & R.L. Wiggins II (1997). Efficient inflation estimation. National Bureau of Economic Research, Inc. NBER Working Papers: 6183.

Bryan, M.F. & C.J. Pike (1991). Median price changes: an alternative approach to measuring current monetary inflation. *Economic Commentary*, Federal Reserve Bank of Cleveland, December.

Christiano, L, M. Eichenbaum & C. Evans (1996). The effects of monetary policy shocks: Evidence from the flow of funds. *Review of Economics and Statistics*, 78, 16-34.

Hetzel, R.L. (2000). The Taylor rule: Is it a useful guide to understanding monetary policy? Federal Reserve Bank of Richmond *Economic Quarterly*, 86(2), 1-33.

McNees, S.K. (1986). Modeling the Fed: A forward-looking monetary policy reaction function. *New England Economic Review*, Nov./Dec., 3-8.

Perez, S.J. (2000). Revised or real-time data: What should be used to characterize the FOMC's information set? Washington State University manuscript, August.

Rudebusch, G. D. (1998). Do measures of monetary policy in a VAR make sense? *International Economic Review*, 39(4), 907-931.

Shapiro, M. & D. Wilcox (1996). Mismeasurement in the Consumer Price Index: An evaluation. *NBER Macroeconomics Annual*, 11, 93-154.

Taylor, J. B. (1993). Discretion versus policy rules in practice. *Carnegie-Rochester Conference Series on Public Policy*, 39, 195-214.

Wynne, M.A. & F. Sigalla (1993). A survey of measurement biases in prices indexes. Federal Reserve Bank of Dallas, Research Paper No. 9340, October.

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