INFLATION EXPECTATIONS, PRICE EQUATIONS, AND FED EFFECTS

By
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Abstract

This paper makes three main contributions. First, inflation expectation equations are estimated using quarterly time series data. Second, a price equation in level form is estimated that is consistent with the data, unlike Phillips-curve equations. Third, the case is considered in which an expectation variable in an inflation or price equation is not causal.

The results suggest that household inflation expectations are mostly affected by current and past inflation. The Fed through interest rates has a modest effect. In the estimated price equation a measure of the expected future price level is significant, although it may not be causal. Whether it is or not, the results show that the Fed's ability to affect inflation is modest since its effect on expectations is modest.

1 Introduction

Inflation expectations play an important role in macroeconomics, both in policy and research. The Fed stresses keeping expectations anchored to control inflation, and dealing with expectations in explaining inflation is an important part of empirical work. Two important questions in this area are 1) what determines expectations and 2) how do expectations affect actual inflation?

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There is a growing literature on examining inflation expectations, especially household expectations. Recent surveys include Binder (2017), D'Acunto et al. (2022), Coibion et al. (2020), Blinder et al. (2024), and D'Acunto et al. (2024). Two recent surveys of firm expectations are Candia et al. (2021) and Savignac et al. (2021). This literature suggests that inflation expectations are largely determined by agent's perceptions of current and past inflation. There is little evidence that expectations are anchored, nor that agents know much about macro events and monetary authorities' announcements and behavior. An early paper supporting the view that expectations of future inflation depend mostly on past inflation is Fuhrer (1997), which still appears to be the case.

The results in this paper show that time series regressions are consistent with the surveys. Inflation expectations depend primarily on current and past actual inflation. Real activity variables like the unemployment rate and the growth rate of real output are not significant in the expectation equations. However, the short-term interest rate is significant, although with a small coefficient estimate. The Fed through its interest rate policy does appear to have some effect on inflation expectations—a higher rate leading to lower expectations. Except in one case, in 2008, surprise Fed announcements are not significant in explaining expectations.

Inflation expectations play an important role in estimated Phillips-curve equations. Recent papers on the Phillips curve include Mavioeidis et al. (2014), Haxell et al. (2022), Beaudry et al. (2024), Furianetto et al. (2024), and Jorgensen et al. (2024). In a typical Phillips-curve specification the left hand side (LHS) variable is the rate of inflation and the right hand side (RHS) variables include expected future inflation, sometimes past inflation, a measure of resource utilization, and cost shock variables. I have long argued that these equations are off by a derivative. The LHS variable should be (in logs) the price level, not the change in the price level.[1] This is discussed below, and such an equation is estimated. It will be seen

[1] My first discussion of this was nearly 50 years ago in Fair (1976). The price equation used at that time is very similar to the price equation used in this paper.

that a variable measuring price level expectations is significant when added to the price equation.

A question that is generally not addressed in the literature is whether expectation variables are causal in inflation or price equations? The answer is generally implicitly assumed to be yes. One problem with the causal interpretation is that the expectations are usually household, not firm, expectations, and firms are the ones making price decisions. If firms are influenced by household expectations in their decision making process or if household expectations are a good proxy for firm expectations, this is support for the causal story.[2]

A non causal story is that households have information regarding firms' price decisions beyond the variables in the inflation or price equation being estimated. Say there is a supply chain problem that households know about but the equation does not, and the supply chain problem leads firms to raise prices more than otherwise. A household expectation variable would then be picking up the effects of the omitted supply chain variable. The expectation variable could thus be significant even if firms knew nothing about household expectations.

It will be seen that adding a price expectation variable to the price equation below lessens the effects of the other variables in the price equation, as would be expected whether the expectation variable is causal or not. It is thus difficult to test for causality. One can, however, examine the sensitivity of Fed effects on prices to the causality assumption by considering two cases. In the first case there is no expectation variable in the price equation, and in the second case there is. These two cases are considered in Section 4.

[2] It is shown below that the observations that are available for firm inflation expectations are not highly correlated with household inflation expectations.

2 Explaining Household Inflation Expectations

Equations are estimated in this section in which the LHS variable is a household inflation expectation variable for quarter t and the RHS variables include current and lagged values of actual inflation. The equations are estimated by two-stage least squares (2SLS) to account for possible endogenous RHS variables. I am unaware that such equations exist in the literature.

There is recent research examining the differences in expectations across households. See Minima et al. (2024), Gennaioli et al. (2024), and Binder et al. (2024). There are large differences across households and large differences among households, professional forecasters, and market determined expectations. Binder et al. (2024) even find differences between Republicans and Democrats. In this paper, however, a macro approach is taken: the median of household expectations is used in any given period. This allows expectation variables to be used in macro price equations, and it allows one to examine how the medians are affected over time by other macro variables.

The literature mentioned in the previous section suggest that current and past inflation may be all that households are influenced by. Other possible explanatory variables were added to the equations to see if they were significant. A number of measures of the real side of the economy were tried, including the unemployment rate, the reciprocal of the unemployment rate, and the growth rate of real GDP. None of these variables were significant, and so they have not been included in the estimates below.

The three-month Treasury bill rate, denoted as RS, was included to see if expectations might depend on actual Fed behavior as measured by the bill rate.[3] It will be seen that this variable is significant, with a negative coefficient estimate, implying, as might be expected, that inflation expectations fall when the Fed tightens. It might also be the case that Fed effects on expectations are even larger if

[3]The Fed controls the federal funds rate, but for all intents and purposes it also controls the three-month Treasury bill rate.

the decisions are surprises. This is tested by adding variables designed to measure surprises to see if they are significant. The construction of these variables is discussed below. It will be seen that only one significant surprise event could be found.

Data from three household surveys are used for the estimation: the median of the expected price change in the next 12 months from the Michigan (MICH) survey of consumer expectations, the average 12-month inflation expectation from the Conference Board (CONF) survey, and the median 1-year ahead expectation from the New York Federal Reserve (NYFR) survey. The surveys are monthly, and quarterly values were computed as the average of the three monthly values. Table 1 lists the variables used in the expenditure regressions.

As noted in the Introduction, it would be better to have data on firm inflation expectations since firms set prices. Quarterly data on firm inflation expectations are available from the Cleveland Federal Reserve beginning in the the second quarter of 2018. This is a survey of CEO's, asking for their predictions of the CPI for the next 12 months. Although the sample is not large enough to warrant estimation, it is interesting to compare the Cleveland data with the others. For the common sample period (2018.3–2024.1, 23 observations), the mean of the 23 inflation expectations are 3.83 Cleveland, 3.52 MICH, 4.95 CONF, and 3.80 NYFR. The correlation between the change in the Cleveland expectation and the change in another (for the sample period 2018.4–2024.1) is: 0.283 MICH, 0.087 CONF, and 0.521 NYFR. NYFR is clearly closest to Cleveland, but none are all that close. .

Table 1
Variable Notation for the Expectation Equations

$D20081$ = 1 in 2008.1; 0 otherwise.
$ECONF$ = Conference Board inflation expectations.
$EMICH$ = Michigan inflation expectations.
$ENYFR$ = New York Fed inflation expectations.
$PCORE$ = percentage change annual rate in core CPI.
$PCPI$ = percentage change annual rate in CPI—for Table 6.
$PENER$ = percentage change annual rate in energy component of CPI.
$PFOOD$ = percentage change annual rate in food component of CPI.
RS = three-month Treasury bill rate.

Extra FSR Notation

$LGOV!$ = log of real per capita government purchases of goods.
$LGOV2$ = log of real per capita government transfer payments.
LEX = log of real per capita exports.
T = time trend, 1 in 1954.1, 2 in 1954.2, etc.
UR = unemployment rate.

All data are quarterly.

Constructing Data on Fed Surprises

Most of the Fed announcements are not surprises. Actual Fed behavior is picked up in the expectations equations by the use of RS. But it could be that there is an additional effect if the Fed's announcement is a surprise. How to estimate surprises? For the work here an announcement was taken to be a surprise if it led to a large change in the S&P 500 stock price index in a few minutes after the announcement.

The announcements are made at 2:00 pm Eastern time. Large changes were identified using tick data on the S&P 500 E-mini futures between 1:55 pm and 2:15 pm. Every FOMC meeting from 2000 to the first quarter of 2024 was examined. The tick transactions were used to compute the average price per second. Using these observations, the percentage changes in the S&P 500 price index 5, 10, and

15 minutes after the 2:00 pm announceent were computed. An announcement was taken to be a surprise if at least one of the 5-, 10-, and 15-minute changes was greater than 0.75 percent in absolute value. The 0.75 value is the value used in Fair (2003) for similar purposes. It is about 7 times the standard deviation of the 5-minute changes for the data used in Fair (2003).

For a quarter in which a surprise took place, a dummy variable was constructed that was 1 in that quarter and 0 otherwise. There were a total of 11 surprises, listed in Table A in the Appendix. One quarter had two surprises, and so there were a total of 10 dummy variables. These variables lagged one quarter were added to the expectation equations to see if they were significant. If a dummy variable is significant, this says that the Fed's announcement had an independent effect on inflation expectations beyond just the value of RS itself.

The Estimated Inflation Expectation Equations

Estimates of three equations are presented in Table 2. As noted above, no significant effects could be found for real activity variables, and so none are included. Of the 10 dummy variables tried, only D20081 was significant. On March 18, 2008, the Fed lowered the federal funds rate by 75 basis points, which led to an increase in the S&P 500 of 0.83 percent after 15 minutes. According to the equations for MICH and CONF, this had a positive effect on expectations in the next quarter. (The sample period for NYFR does not include 2008.) Otherwise, there was no evidence that any of the surprises mattered.

The lagged dependent variable (LDV) is used in each equation to pick up partial adjustment effects. This specification assumes that it takes time for an inflation change to be fully reflected in expectations. The LDV coefficient estimates are 0.672, 0.770, and 0.633 for MICH, CONF, and NYFR, respectively. Three subsets of the CPI were used as explanatory variables: core ($PCORE$), food ($PFOOD$), and energy ($PENER$). These three variables are individually significant for

Table 2
Estimated Expectation Equationss

	LHS: $EMICH$		LHS: $ECONF$		LHS: $ENYFR$	
Var.	Est.	t-stat	Est.	t-stat	Est.	t-stat
cnst	0.471	4.98	0.847	5.39	0.711	4.51
LDV	0.672	12.09	0.770	17.84	0.633	8.06
$PCORE$	0.2076	4.14	0.0339	1.01	0.1276	3.23
$PFOOD$	0.0424	1.65	0.0394	2.52	0.0691	3.19
$PENER$	0.0027	0.57	0.0050	2.78	0.0076	2.82
RS	-0.0530	-2.95	-0.0374	-2.85	-0.0684	-2.73
$D20081_{-1}$	1.38	3.01	1.65	6.85		
SE	0.415		0.223		0.199	
R^2	0.934		0.910		0.973	
#obs	183		144		41	

Estimation method: 2SLS.
See Table 1 for notation.
LDV = lagged dependent variable.
MICH sample period: 1978.3–2024.1.
CONF sample period: 1988.2–2024.1.
FRNY sample period: 2014.1–2024.1.

Common First Stage Regressors

$PCORE_{-1}$, $PCORE_{-2}$, $PFOOD_{-1}$, $PFOOD_{-2}$, $PENER_{-1}$, $PENER_{-2}$, cmst, T. RS_{-1}, RS_{-2}, $1/UR_{-1}$, $1/UR_{-2}$, $LGOV1_{-1}$, $LGOV2_{-1}$, LEX_{-1}, $D20081_{-1}$

Added for MICH

$EMICH_{-1}$

Added for CONF

$ECONF_{-1}$

Added for NYFR

$ENYFR_{-1}$

NYFR. $PFOOD$ and $PENER$ are individually significant for CONF, although $PCORE$ is not significant. For MICH only $PCORE$ is significant.

RS is significant in each of the three equations, although its coefficient estimates are fairly small. For MICH the long run effect of a one percentage point change in RS is -0.16 percentage points ($-0.0530/(1.0 - 0.672$). For CONF it is also -0.16 percentage points ($-0.0374/(1.0 - 0.770$). and for NYFR it is -0.19 percentage points ($-0.0684/(1.0 - 0.633$).

The equations are estimated by 2SLS. The first stage regressors (FSRs) for each equation are listed at the bottom of Table 2. With the time series methodology used hee it is straightforward to account for simultaneity. All the FSRs are lagged at least one quarter and can be assumed to be uncorrelated with the error term in the equation. This would not be true if the error terms were serially correlated, but this is not he case. When the three equations are estimated under the assumption of first order serial correlation of the error term, the estimates of the serial correlation coefficient are not significant. For MICH the estimate of the serially correlation coefficient is -0.145 with a t-statistic of -1.51. For CONF it is -0.166 with a t-statistic of -1.77, and for NYFR it is -0.024 with a t-statistic of -0.14. The FSRs include three exogenous macro variables from my US model discussed in Section 4. They are two government spending variables and exports. These variables are lagged one quarter as a precaution against their possible endogeneity.

Overall, the equations strongly show that current and lagged inflation (through the LDV) explain much of the variation in median household inflation expectations. There are differential effects from core, food, and energy. Actual Fed behavior as reflected in RS has some effect, but it is modest. Only the Fed announcement in March 2008 appears to have extra effects.

3 Price Equations

No Expectation Variable

A widely cited price deflator in the media is the price deflator for personal consumption expenditures, PCE. This is the price deflator targeted by the Fed. If, however, one is interested in explaining the pricing behavior of agents in the U.S. economy, PCE is not appropriate because it includes import prices (as well as excluding export prices). The same is true of the consumer price index. Import prices reflect decisions of foreign agents and the behavior of exchange rates, which are not decision variables of domestic agents. The price deflator of the firm sector used here is the nonfarm price deflator from the National Income and Product Accounts, denoted PF. It reflects private, domestic decisions.

It is common in the literature to estimate price equations where the LHS variable is the rate of inflation. I have found, however, that the data do not support this specification. The dynamics are wrong. The data support price equations specified in (log) level form. In the price equation considered here, which is in log form, the LHS variable is $\log PF$. As noted in the Introduction, the RHS variables in typical Phillips-curve equations include expected future inflation, sometimes past inflation, a measure of resource utilization, and cost shock variables.

Ignoring expectations for the moment, the price level equation used here includes the lagged price level, a resource utilization variable, and cost shock variables. The resource utilization variable is the reciprocal of the unemployment rate. Phillips curves are usually specified using the level of the unemployment rate, but it seems likely that there is a nonlinear effect. The lower is the unemployment rate the larger is the effect on inflation or the price level from a decrease in the unemployment rate. I have found better results using the reciprocal. Also, no attempt is made to subtract some estimate of the natural rate of unemployment from the actual rate. The concept of a natural rate is murky, and it is subjective in what one chooses for the rate.

The two cost shock variables are the nominal wage rate inclusive of the employer social security tax rate and the price of imports. The wage rate variable has subtracted from it a measure of potential labor productivity.

This level specification is consistent with a theory in which the decision variable of a firm is the level of its price. If a firm's market share is a function of the ratio of its price to the average price of other firms, the objective of the firm is to choose the optimizing price level. There seems no good theoretical reason to have the firm decide on the change while ignoring the value of the lagged price level.

The estimated price equation is presented in the left half of Table 3. Notation is presented at the bottom of the table. The estimation period used here is shorter than the one I normally use because of the desire to incorporate the Michigan expectation variable in the second estimation. The period is 1978.3–2024.1 versus 1954.1–2024.1, which I normally use. Although the estimates are not presented in the table, 8 dummy variables are added to the equation to account for the pandemic. For each quarter between 2020.1 and 2021.4 a dummy variable was constructed that was 1 in that quarter and zero otherwise. The equation is estimated under the assumption of first order serial correlation of the error term. The estimate of the first order serial correlation coefficient is 0.201 with a t-statistic of 2.60.

The variables are all highly significant. Regarding the cost variables, the wage variable has a t-statistic of 4.10 and the price of imports has a t-statistic of 7.48. On the demand side, the reciprocal of the unemployment rate has a t-statistic of 6.99.

The time trend, T, is meant to pick up any trend effects on the price level not captured by the other variables. Adding the time trend to an equation like this is similar to adding the constant term to an equation specified in terms of changes rather than levels. The time trend will also pick up any trend mistakes made in constructing LAM, the measure of potential labor productivity.

Table 3
Estimated Price Equations: PF
LHS Variable is $\log PF$

	Base Equation		Expectation Added	
RHS Variable	Est.	t-stat	Est.	t-stat
cnst	-0.0557	-4.78	-0.0206	-1.81
T	0.000275	8.12	0.000101	2.35
$\log PF_{-1}$	0.872	61.85	0.113	0.75
$\log PF^e$			0.832	5.07
$\log[WF(1+D5G)/LAM]$	0.0531	4.10	0.0280	2.50
$\log PIM$	0.0423	7.48	0.0130	1.79
$1/UR$	0.000620	6.99	0.000326	3.63
RHO1	0.201	2.60	0.051	0.67
SE	0.00325		0.00305	
R^2	0.9999		0.9999	
#obs	183		183	

Estimation period is 1978.3–2024.1.
Eight dummy variables added, 2020.1–2021.4.

First Stage Regressors

cnst, T, $\log PF_{-1}$, $\log PF_{-2}$, $\log[[WF(1+D5G)/LAM]_{-1}$, $\log PIM_{-1}$, $1/UR_{-1}$, UR_{-1}, $LGOV1_{-1}$, $LGOV2_{-1}$, LEX_{-1}, 8 dummy variables, 2020.1–2021.4, plus 2021.4 lagged once

Added for second equation

$\log PF^e$, $\log PF^e_{-1}$

Extra notation not in Table 1

$D5G$ = federal employer social security tax rate.
LAM = potential output per worker hour.
PF = private non farm price deflator.
$PF^e = PF_{-1} \cdot EMICH_{-1}^{1/4}/100$.
WF = average hourly wage rate of workers in the firm sector.

The price of imports is a key explanatory variable in the equation. It rose substantially in the 1970's, which explains much of the inflation in this period. A common view in the literature is that price equations (in particular Phillips curves) "broke down" in the 1970's when there was stagflation. In fact, the high inflation in the 1970's is well explained by cost shocks, particularly oil price shocks, which are picked up here by the price of imports. Also, the relative price of imports fell in the 1980's, which is a factor leading to the falling inflation in the 1980's aside from aggregate demand effects. Volcker was help by favorable cost shocks during this period. Some of the importance of the price of imports is lost using the estimation that begins only in 1978.3 (rather than 1954.1) because the high inflation in the early 1970's is not captured. For the longer estimation period the coefficient of $\log PIM$ is 0.0538 (as opposed to 0.0423) with a t-statistic of 18.49.

The coefficient estimate of the lagged price level is 0.872 with a t-statistic of 61.85, or a standard error of 0.0141. The t-statistic for the hypothesis that the coefficient is equal to 1.0 is 9.08, which is a strong rejection of the equation in first difference form. This result is robust. When the one-quarter lagged values of the wage rate, the price of imports, and the unemployment rate are added to the equation (to allow them to be in change form), the coefficient estimate of the lagged price level is 0.879 with a t-statistic of 31.49 and a standard error of 0.0279. The t-statistic for the hypothesis that the coefficient is 1.0 is 4.34.

The equation is estimated by 2SLS under the assumption of first order serial correlation of the error term. Again, this is a straightforward procedure in this time series context. The FSRs are all lagged at least one quarter and can be assumed to be uncorrelated with the error term left after serial correlation is removed.

Expectation Variable Added

The variable $EMICH$ in Section 2 is the median expectation of inflation one year hence from the Michigan survey. Assume that this is a good proxy for the expectation one quarter hence. Then at the beginning of the quarter the expected price level for the quarter is $PF_{-1} \cdot EMICH_{-1}^{1/4}/100$. ($EMICH$ is at an annual rate, so it is raised to the $1/4$ power to put it at a quarterly rate.) Denote this variable PF^e. The equation in the right half of Table 3 is the same as that in the left half except that $\log PF^e$ is added. Two FSRs are also added: $\log PF^e$ and $\log PF^e_{-1}$.

Adding this variable lowers in absolute value the other coefficient estimates. The coefficient estimate of the lagged price level has fallen from 0.872 to 0.113. The coefficient estimate for $\log PF^e$ is 0.832 with a t-statistic of 5.07. The estimate of the serial correlation coefficient is now not significant. It is clear from these results that there is information in the expected price level not in the other explanatory variables in the equation. Whether this is causal has been discussed earlier.

The sum of the coefficient estimates of $\log PF_{-1}$ and $\log PF^e$ is 0.945, less than 1.0, which is consistent with the level specification. The hypothesis that the coefficients sum to 1.0 is rejected, with a t-statistic of 3.09. This is thus support for the price level specification.

Consumer Price Index

The current results are not due to the use of PF over CPI. Table 4 presents results using the log of the CPI, denoted $LCPI$, as the LHS variable. This table has has the same format as Table 3, where $LCPI$ replaces LPF everywhere. The two main results, that the expectation variable is highly significant and that the level specification is significant, are the same. Note that the coefficient estimate of the price of imports is lower for CPI than for PF since CPI includes import prices. The hypothesis that the coefficient of $LCPI_{-1}$ is 1.0 is rejected, with a t-statistic of 6.33. So the use of CPI also supports the level specification.

Table 4
Estimated Price Equations: CPI
LHS Variable is $\log CPI$

RHS Variable	Base Equation Est.	t-stat	Expectation Added Est.	t-stat
cnst	0.0903	2.66	0.0603	2.13
T	0.000287	5.09	0.000111	1.77
$\log CPI_{-1}$	0.876	44.59	0.076	0.34
$\log CPI^e$			0.859	3.64
$\log[WF(1+D5G)/LAM]$	0.0841	3.52	0.0546	2.68
$\log PIM$	0.0252	2.57	0.0042	0.42
$1/UR$	0.000390	2.61	0.000238	1.85
RHO1	0.345	4.15	0.169	1.93
SE	0.00439		0.00452	
R^2	0.9999		0.9999	
#obs	183		183	

Estimation period is 1978.3–2024.1.
Eight dummy variables added, 2020.1–2021.4.

First Stage Regressors

cnst, T, $\log CPI_{-1}$, $\log CPI_{-2}$, $\log[[WF(1+D5G)/LAM]_{-1}$, $\log PIM_{-1}$, $1/UR_{-1}$, UR_{-1}, $LGOV1_{-1}$, $LGOV2_{-1}$, LEX_{-1}, 8 dummy variables, 2020.1–2021.4, plus 2021.4 lagged once

Added for second equation

$\log CPI^e$, $\log CPI^e_{-1}$

Extra notation not in Tables 1 and 3

CPI = consumer price index.
$CPI^e = CPI_{-1} \cdot EMICH_{-1}^{1/4}/100$.

4 Estimated Fed Effects on Prices

This section uses my U.S. macroeconometric model, denoted the "US model," to estimate the effects of a change in RS, the three-month Treasury bill rate, on inflation. The latest discussion of the model is in Fair (2024). The price equation used in the model is the one in Table 3. There is also a wage equation in the model, estimated for the same period used in Table 3. Prices affect wages in the model and vice versa. The main feature of the model that is needed to know for the present results aside from the price equation in Table 3 is that an increase in RS has a negative effect on aggregate demand, which then has a positive effect on the unemployment rate. The increase in the unemployment rate then has a negative effect on PF and thus on inflation.

For the first experiment the equation in the left half of Table 3 is used. The period examined is 2022.1–2024.1, 9 quarters. The estimated residuals are added to the model's stochastic equations and taken to be exogenous. This results in a perfect tracking solution if the actual values of all the exogenous variables are used. Then RS is increased by 1.0 from its base (actual) value for each of the 9 quarters and the model is solved. (RS is exogenous for this experiment.) The difference between a predicted value and the actual value for a variable and quarter is an estimate of the effect of the increase in RS on the variable.

Table 5 presents the results for real GDP, the unemployment rate, and the rate of inflation as measured by the percentage change at an annual rate in PF. (Remember that the explanatory variable in the price equation is the reciprocal of the unemployment rate.) After 6 quarters real GDP is 0.40 percent lower, the unemployment is 0.17 percentage points higher, and inflation is 0.28 percentage points lower.

Table 5
Effects of a 1.0 Increase in RS from Baseline

	Base Equation			Expectation Added		
Qtr.	GDPR	UR	PPF	GDPR	UR	PPF
2022.1	0.01	0.01	0.02	0.04	0.01	0.01
2022.2	0.14	0.04	0.08	0.14	0.04	0.07
2022.3	0.23	0.08	0.15	0.23	0.08	0.13
2022.4	0.30	0.11	0.21	0.30	0.11	0.19
2023.1	0.35	0.14	0.27	0.35	0.14	0.24
2023.2	0.40	0.17	0.28	0.39	0.17	0.27
2023.3	0.43	0.18	0.27	0.42	0.18	0.29
2023.4	0.45	0.19	0.24	0.44	0.19	0.29
2024.1	0.47	0.20	0.23	0.46	0.19	0.30

GDPR = real GDP.
UR = unemployment rate.
PPF = percentage change in PF, annual rate.
Values are change from baseline, percentage points.
Absolute change for UR and PPF.
Percent change for GDPR.

The second experiment is the same as the first except the price equation in the right half of Table 3 is used. Two other equations are needed for this case. The first is an equation explaining $EMICH$, the Michigan survey of inflation expectations. For the work here the equation for $EMICH$ in Table 2 has been reestimated using the CPI rather than its three components. This equation is presented in Table 6. This equation is very similar to the one in Table 2. This change was made so that a price variable in the US model could be linked to the CPI. (The CPI is not in the US model.) The closest price variable in the model is the price deflator for domestic sales, denoted PD, and the equation in Table 7 links the percentage change in PD to the percentage change in CPI.

Table 6
$EMICH$ equation

	LHS: $EMICH$	
Var.	Est.	t-stat
cnst	0.442	5.16
$EMICH_{-1}$	0.744	16.19
$PCPI$	0.1606	5.27
RS	-0.0278	-2.53
$D20081_{-1}$	0.98	2.59
SE	0.375	
R^2	0.946	
#obs	183	

Estimation method: 2SLS.
See Table 1 for notation.
LDV = lagged dependent variable.
Sample period: 1978.3–2024.1.

First Stage Regressors

$PCPI_{-1}, PCPI_{-2}$, cmst. $T.RS_{-1}$,RS_{-2},$1/UR_{-1}$,$1/UR_{-2}$,$LGOV1_{-1}$,$LGOV2_{-1}$, LEX_{-1}, $D20081_{-1}$, $EMICH_{-1}$

In this second experiment the increase in RS has a negative effect on expectations (Table 6), which in turn has a negative effect on PF (second half of Table 3). This is in addition to the Fed's effects on current and past inflation in the $EMICH$ equation and its effects on past prices and the unemployment rate in the PF equation. The results are also presented in Table 5. The results from the two experiments are similar. The added RS effect on expectations is roughly offset by the smaller coefficient estimates in absolute value in the PF equation and the fact that the unemployment rate or other measures of resource utilization are not in the expectations equation.

Table 7
Estimated Link for PD to CPI

	LHS: $PCPI$	
Variable	Est.	t-stat
cnst	0.643	4.86
PPD	0.953	30.49
SE	1.51	
R^2	0.769	
#obs	281	

Estimation method: OLS.
$PCPI$ = percentage change in CPI, annual rate.
PD = price deflator for domestic sales in US model.
PPD = percentage change in PD, annual rate.
Sample period: 1954.1–2024.1.

For both experiments the Fed's ability of affect inflation is modest. There are two main reasons. The first is that in the model the Fed's ability to affect real output and the unemployment rate is modest. After 6 quarters real output is down about 0.40 percent and the unemployment rate is up about 0.17 percentage points from a one percentage point increase in RS. The slippage from real output to the unemployment rate is due to Okun's-Law type effects, which are in the model. The second is that the coefficient on the unemployment rate variable in the price equation is modest, especially in the price equation with the expectation variable added. In the second experiment the Fed directly affects expectations, but this effect is small. In order for the Fed to have a large effect on inflation it would need to have a large effect on expectations, which the data do not support.

5 Conclusion

This paper makes three main contributions. First, inflation expectation equations are estimated using quarterly time series data. Second, a price equation in level form is estimated that is consistent with the data, unlike Phillips-curve equations. Third, the case is considered in which an expectation variable in an inflation or price equation is not causal.

The results suggest that household inflation expectations are mostly affected by current and past inflation. The Fed through interest rates has a modest effect. There is little evidence that surprise Fed announcements matter. In the estimated price equation a measure of the expected future price level is significant. As just noted, this may or may not be causal.

The Fed's ability to affect prices is modest whether or not expectations are causal. If they are not, the Fed affects prices by affecting unemployment (and other measures of real activity) and past prices. If they are causal, the Fed affects expectations by affecting current and past inflation and through the value of the interest rate that it sets. Expectations then affect prices, with the Fed also affecting prices by affecting unemployment and past prices. In either case the effects are modest.

6 Appendix

Table A

Surprise Fed Announcements

Date	Quarter	Rate Change
03/18/2008	2008.1	-0.75
09/16/2008	2008.3	0
09/18/2013	2023.3	0
12/18/2013	2013.4	0
10/28/2015	2015.4	0
01/27/2016	2016.1	0
12/19/2018	2018.4	0.25
03/16/2022	2022.1	0.25
09/21/2022	2022.3	0.75
11/02/2022	2022.4	0.75
12/14/2022	2022.4	0.50

Surprise is change in S&P 500 of 0.75 percent or more within 15 minutes.

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