Sticky Prices: The Impact of Regulation

by

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Abstract

This paper finds that approximately one-third of the items in the CPI are governed by price regulations that can slow and add noise to the response of prices to changes in cost or demand conditions. Consequently, regulation is a possible partial explanation of sticky prices in the overall rate of inflation, and delayed response to changes in the money supply. A survey is used to decompose the CPI into freely-determined and regulated sub-components. Evidence is provided that prices in the regulated sector of the economy respond approximately two quarters after prices in the freely-determined sector, thereby contributing a source of stickiness in overall inflation and in the response of inflation to monetary policy.

Key words: Price stickiness; Money supply; Granger causation; Impulse response.

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1. Introduction

Recognition of the importance of sticky prices for business cycles and for the real effects of monetary policy has stimulated a large body of research on why prices do not respond immediately to the forces of supply and demand.[1] Recently, Blinder (1994) reviewed the evidence and the numerous theoretical microeconomic rationales for sticky prices, listing twelve categories of theories why prices may be sticky.[2] The microeconomic foundations are related to the theory of the firm, making these theories consistent with decision-making in a market setting. Indeed, Blinder explicitly focuses his survey of why prices are sticky in the "private, non-farm, for-profit, unregulated" sector. Our paper represents a departure from this earlier emphasis by considering the part of the economy that has not yet explicitly been the subject of study of why prices respond slowly, namely the sector consisting of items that are subject to some form of price regulation.

Consideration of price regulation focuses attention on several of the causes of price stickiness that have previously been studied. Gordon (1990) argued for the need to consider the institutional process that is required to change prices, which in the regulated sector could involve a rate review agency. For example, local telephone and electric power rates involve public hearings and eventual decisions by regulators. Similarly, Blinder's (1994) survey respondents identified a source of stickiness that fits into a regulatory framework, namely, hierarchical delays. These delays due to bureaucracy can cause prices to respond slowly and erratically to market forces. In our research, we study the price stickiness that comes about from inertia in price adjustment in regulated parts of the

[1] This research is surveyed by Gordon (1981, 1990) in which the need to provide a rational explanation of market disequilibrium is emphasized. On the importance of price stickiness for business cycles and for the real effects of money also see Barrow (1977), Hall (1986), Mankiw (1994), and Rotemberg and Woodford (1996).

[2] For more details of the theories of price stickiness see Allen (1988), Ball and Romer (1991), Bils (1989), Blanchard (1983), Blinder (1982), Carlton (1990), Kashyap (1990), Mankiw (1985), Okun (1981), Rotemberg (1982) and Shapiro (1988).

economy such as utilities, public transportation, education, communication, residential property taxes, and other important components of the overall CPI.

We surveyed experts in the area of regulation in order to distinguish between freely-determined and regulated components of the U.S. CPI, and establish that regulation provides a potentially important source of price stickiness in the economy as a whole. We show that against the benchmark of inflation in the free market sector - as opposed to some unmeasured Walrasian benchmark - there is significant inertia in aggregate price adjustments due to regulation.[3] This inertia is in addition to the stickiness in price adjustments that has already been well established in the "private, non-farm, for-profit, unregulated" segment of the economy. The evidence presented in this paper takes on particular relevance when it is recognized that, according to the survey conducted for this paper, approximately one third of the United States' CPI basket consists of items that are subject to some degree of price regulation. [4]

Section 2 explains how we decomposed the CPI into a freely-determined component and a regulated component. Section 3 compares the inflation sub-components to each other and to the overall CPI, clearly establishing that regulated inflation is stickier than that of the free-market economy. Stickiness is investigated using Granger causation and impulse response functions. Section 4 uses the same procedures to consider the role of regulation for the lag between changes in the money supply and changes in inflation. Section 5 concludes by relating the stickiness in regulated prices to the theories that have been advanced to explain price inertia.

2. Construction of the Inflation Sub-indices

[3] Blinder (1994) emphasizes the difficulty in judging price stickiness when the benchmark is "either unmeasurable in principle, or unmeasured in practice". In our paper the benchmark is measurable in principle, and measured in practice.

[4] The classifications for the period studied, 1967-1996, and the weights of items for 1986, are shown in the appendix.

In order to construct the free market and the regulated sub-indices, a survey was sent to a set of economists we identified as experts in the field of price regulation. [5] Six of the seven experts to whom we mailed the survey responded.[6] Each expert was asked to classify individual items or groups of items in a detailed listing of categories in the United States CPI according to whether their prices are regulated, freely-determined, or "mixed". A fourth category "do not know" was included in case a respondent was not sure of an opinion. Respondents were asked to consider a price as freely determined if in their opinion, throughout the post WWII period and throughout the United States, the price of the good or service (item) could respond readily to market forces within a calendar quarter. Respondents were to consider an item as regulated if in their opinion, the price of a good or service could not respond to market forces within a quarter. Items were to be considered as mixed if the respondent felt that the item had changed categories between freely determined and regulated during the period under consideration, or if the item is/was regulated in some states but not in others. Respondents were told to ignore the wage-price freeze/control period. Our survey enabled us to construct a product-level partition of the CPI, a partition that has been considered preferable to other partitions, such as those using standard industry classification codes (see Ohanian, Stockman, and Killian (1995)).

A simple majority rule was used to classify items. On the basis of the responses and the number of items classified as mixed, it was decided to combine the mixed items with those identified as regulated, making this category one for which there is some price regulation, in contrast to the freely-determined category. To the extent that there is some price flexibility in the mixed items in certain locations or time periods, including them as regulated should reduce the distinction between regulated and freely-determined inflation categories. Therefore, any distinction that is nevertheless observed between our two

[5] The survey approach taken parallels that used in an earlier paper by Dexter, Levi and Nault (1993).
[6] The experts that responded were Dennis J. Aigner, Alan S. Blinder, Paul Kleindorfer, Paul MacAvoy, Sam Peltzman and Murray Weidenbaum.

inflation sub-component series is despite the flexibility contained in the regulated category. When the mixed and regulated items were aggregated there was a very clear distinction between the categories: in the vast majority of cases, there was consensus or only a single disagreement among the six experts. This can be seen from the summary of survey responses, available from the authors on request. With the entire CPI included by combining the mixed and regulated categories, approximately one third of the weight of the CPI was found to consist of items subject to some degree of price regulation.[7]

Prices and weightings of the various items are based upon data available in CITIBASE that provides data from 1967. For used car prices where CITIBASE data is absent, information is obtained from the *Monthly Labor Review*. In order to accommodate the re-weightings of the CPI basket in December 1977 and December 1986, and to handle the change in home ownership costs in December 1981 that splits the middle period into two sub-periods, our data are divided into four time periods. Construction is based upon seasonally unadjusted data. The constructed sub-category price indexes are then seasonally adjusted using multiplicative seasonal factors.[8] The details of the classification of all of the items in the CPI, and the explanation of the construction of our price indices, are available from the authors.

3. Regulated versus Freely-Determined Inflation

3.1. Comparison of the Inflation Series

Figure 1 compares the constructed freely-determined and regulated inflation series, and shows that they differ substantially. The two parts of Figure 2 indicate that the deviations are larger for the regulated inflation series versus the overall CPI than for the freely-determined series versus the overall CPI. Table 1 provides summary statistics of

[7] The actual proportion of the CPI in the regulated/mixed category varies from 30 percent in the first sub-period basket, and increases to 34 percent in the fourth and last sub-period basket.
[8] All our results hold with similar statistical significance if the price indices are not deseasonalized.

the constructed regulated and freely-determined inflation series, and inflation in the overall CPI. The table shows that over the almost 30 years of inflation data, regulated inflation is higher on average than freely-determined inflation, and more variable. Table 2 shows that the correlation between the regulated and freely-determined inflation series is 0.56739.

TABLE 1: SUMMARY STATISTICS ON INFLATION SERIES, 1967:1 - 1996:4

	Freely-Determined	**Regulated**	**Overall CPI**
Mean	0.051421	0.055381	0.052738
Median	0.042940	0.047026	0.043446
Maximum	0.143739	0.206691	0.155022
Minimum	-0.004516	-0.066691	-0.014623
Std. Dev.	0.030888	0.042531	0.030873
Skewness	1.092243	1.168947	1.058178
Kurtosis	3.726807	5.604550	3.817667

TABLE 2: CORRELATIONS BETWEEN INFLATION SERIES, 1967:1 - 1996:4

	Freely-Determined	**Regulated**	**Overall CPI**
Freely-Determined	1.000000		
Regulated	0.567389	1.000000	
Overall CPI	0.930181	0.829142	1.000000

Not surprisingly, this is substantially lower than the correlations of both series with the overall CPI that contains each sub-index. The tables make it clear that the inflation series we have constructed are different from each other and also differ from overall CPI inflation.

3.2. Stationarity of the Inflation Series

Our principal interest in the inflation series we have constructed is in whether regulated inflation exhibits more stickiness than freely-determined inflation. Our first test of stickiness of regulated inflation against the benchmark of freely-determined inflation considers Granger Causality, which is a test of precedence.[9] In order to use Granger Causality and other comparisons of the series we must check whether our inflation series are stationary. A simple albeit crude test of stationarity is to examine the correlograms, which are provided in Figure 3. For each inflation series the autocorrelations decay roughly monotonically to zero over a three-year period, consistent with stationary. However, to more precisely study the stationarity of the series, we carried out the augmented Dickey-Fuller (ADF) test for the presence of unit roots. The presence of a unit root could not be rejected at any reasonable significance level for freely-determined inflation and for overall inflation. For regulated inflation, the presence of a unit root can be rejected at the 5% significance level, but not at the 1% level. We conclude that stationarity cannot be supported, certainly for freely-determined and overall inflation.

Because we wish to perform Granger Causality tests involving the relationship of the series to each other, we also checked whether the nonstationary series are cointegrated. Using the Johansen cointegration test, we found that our freely-determined and regulated inflation series are indeed cointegrated.[10]

[9] A companion paper examines stickiness in the context of the inflation-transmission mechanism. That paper shows that freely-determined prices respond more quickly to capacity constraints in the economy than do regulated prices. See Dexter, Levi and Nault (1999).

3.3. Stationarity of Accelerations of Prices

The fact that the inflation series exhibit nonstationarity, and that the freely-determined and regulated inflation series are cointegrated, requires that we follow the standard practice of taking the next level of differencing. In our context this means first differences of inflation. Figure 4 is a plot of *changes* in freely-determined and regulated inflation, showing that the series differ markedly and that changes in regulated inflation are more volatile than changes in freely-determined inflation. The two parts of Figure 5 shows that the regulated series differs more than does the freely-determined series from overall inflation. The summary statistics on changes of inflation are given in Table 3. We see that the standard deviation of the regulated series is twice that of changes in overall inflation, and substantially larger than that of changes in freely-determined inflation. The fact that the standard deviation of changes in overall inflation is less than that of either sub-index is because the sub-indices are themselves negatively covariable, as indicated in Table 4. Greater volatility is also demonstrated by the range of changes in regulated inflation versus the other series. Changes in the inflation rates of the two sub-indices are clearly very different.

The ADF tests for stationarity of changes in inflation indicate that all of the series are stationary even at the 1% significance level. Therefore, in the remainder of the paper we work with changes in inflation rather than with inflation.

3.4. Stickiness of Regulated versus Freely-Determined Changes in Inflation

The Granger Causality test allows us to evaluate which series of changes in inflation precedes another. Stickiness in the regulated sector would suggest that prices adjust more rapidly in the unregulated sector, followed by an adjustment in the regulated sector. Thus, earlier adjustments in the unregulated sector contain information relevant for predicting

[10] The results of the ADF tests and the Johansen cointegration test are available from the authors.

subsequent adjustment in the regulated sector, presumably because the unregulated sector responds more rapidly to changes in the economic environment. It would also suggest that the freely-determined series precedes the overall CPI series, and that the overall CPI series precedes the regulated series.

TABLE 3: SUMMARY STATISTICS ON CHANGES IN INFLATION SERIES, 1967:2 - 1996:4.

	Freely-Determined	**Regulated**	**Overall CPI**
Mean	8.01E-05	0.000170	0.000112
Median	0.001260	-0.001022	0.000979
Maximum	0.058097	0.108042	0.041902
Minimum	-0.070587	-0.136096	-0.064130
Std. Dev.	0.022233	0.037340	0.018914
Skewness	-0.561205	0.052163	-0.587603
Kurtosis	4.041720	4.491909	4.011038

TABLE 4: CORRELATIONS BETWEEN CHANGES IN INFLATION SERIES, 1967:2 - 1996:4

	Freely-Determined	**Regulated**	**Overall CPI**
Freely-Determined	1.000000		
Regulated	-0.071859	1.000000	
Overall CPI	0.756924	0.595251	1.000000

We apply the Granger Causality test for lags of one quarter, a half-year and a full year to our two series of changes in inflation, and for changes in inflation in the overall CPI. The results of these tests are displayed in Table 5. The table shows that for a lag of one quarter at the 1% significance level, changes in freely-determined inflation Granger cause changes in regulated inflation, but not vice versa. Furthermore, at the 5% significance level, with a lag of one quarter, changes in freely-determined inflation Granger cause changes in overall inflation, but not vice versa. Also, at the 1% level, changes in overall inflation Granger cause changes in regulated inflation, but not vice versa. Essentially, at the 5% level, or just slightly higher, we have bi-directional Granger causation between the three series, but comparing the relative probabilities, it appears that the order of time precedence is that changes in freely-determined inflation precede overall inflation which in turn precedes regulated inflation. This is what one would expect if regulated sector prices are responding slowly relative to freely-determined prices, with both being included in the overall CPI. Similar time precedence of the three series of changes in inflation are obtained, at different significance levels, for the Granger causality tests using a half-year lag. As we would expect, when Granger Causality tests are applied for longer lags (e.g., four quarters) the Granger Causality becomes even more bi-directional. Specifically, at the 5% level with a full year lag, Granger Causality cannot be rejected for any of the precedence tests. Nonetheless, for all the tests, the precedence of changes in freely-determined inflation over changes in regulated inflation is more statistically significant than that of the reverse direction of Granger causation. All of these results are consistent with the view that regulation is a cause of price stickiness in the overall CPI.

3.5. Impulse Responses

Further evidence of the sequential relationship between changes in freely-determined inflation and changes in regulated inflation is provided by considering impulse response functions. Figures 6 and 7 show the impulse response functions of regulated to freely-

determined changes in inflation, and freely-determined to regulated changes in inflation, using unrestricted vector autoregression (VAR) with 1, 2, 4 and 8 period lags, including

TABLE 5: PAIRWISE GRANGER CAUSALITY TESTS: 1967:1 - 1996:4.

Variables Subject to Granger Test

Changes in freely-determined inflation (ΔFree Inf)
Changes in regulated inflation (ΔRegulated Inf)
Changes in overall inflation (ΔCPI Inf)

Lag: 1 Quarter Null Hypothesis:	**Obs**	**F-Statistic**	**Prob**
ΔRegulated Inf does not Granger Cause ΔFree Inf	117	4.44201	
0.03726			
ΔFree Inf does not Granger Cause ΔRegulated Inf		10.1932	
0.00182			
ΔCPI Inf does not Granger Cause ΔFree Inf	117	3.77619	
0.05445			
ΔFree Inf does not Granger Cause ΔCPI Inf		5.26798	
0.02355			
ΔCPI Inf does not Granger Cause ΔRegulated Inf		117	9.49468
0.00258			
ΔRegulated Inf does not Granger Cause ΔCPI Inf			5.54415
0.02025			

Lag: 2 Quarters Null Hypothesis:	**Obs**	**F-Statistic**	**Prob**
ΔRegulated Inf does not Granger Cause ΔFree Inf	116	2.59814	
0.07893			
ΔFree Inf does not Granger Cause ΔRegulated Inf		4.30348	
0.01585			
ΔCPI Inf does not Granger Cause ΔFree Inf	116	2.49184	
0.08738			
ΔFree Inf does not Granger Cause ΔCPI Inf		3.17506	
0.04561			
ΔCPI Inf does not Granger Cause ΔRegulated Inf		116	3.99844
0.02105			
ΔRegulated Inf does not Granger Cause ΔCPI Inf			3.21634
0.04387			

Lag: 4 Quarters Null Hypothesis:	**Obs**	**F-Statistic**	**Prob**
ΔRegulated Inf does not Granger Cause ΔFree Inf	114	3.46161	
0.01066			
ΔFree Inf does not Granger Cause ΔRegulated Inf		3.76453	
0.00667			
ΔCPI Inf does not Granger Cause ΔFree Inf	114	3.24982	
0.01480			
ΔFree Inf does not Granger Cause ΔCPI Inf		2.60172	
0.04016			

ΔCPI Inf does not Granger Cause ΔRegulated Inf	114	3.44722
0.01090		
ΔRegulated Inf does not Granger Cause ΔCPI Inf		2.58931
0.04093		

an intercept. The order of inclusion of variables in the VAR is the order of impulse as shown in the figures. That is, for the response for regulated inflation to impulses in freely-determined inflation, freely-determined inflation is included first, implying innovations come from freely-determined inflation, and vice versa for the response of freely-determined inflation.

Figures 6 and 7 both show that regulated changes in inflation follows freely-determined changes in inflation, with a significant positive response at two quarters. This reinforces the Granger Causality results above. Furthermore, for shorter lags, one and two periods, changes in freely-determined inflation do not respond to changes in regulated inflation. However, Figure 7 shows that over the longer lags of four and eight periods, there is a significant negative response at five quarters. This is consistent with the negative covariance between the two changes in inflation shown in Table 4. It is also consistent with inflation data for Canada, where more rapid inflation in the regulated sector is eventually associated with less rapid inflation in the freely-determined sector. Budget-constrained spenders, faced with paying more for regulated items, appear to eventually restrain their spending on other items. (See Dexter, Levi and Nault (1993)).

4. Inflation and the Money Supply

If the regulated sector involves price changes that are for example, bureaucratically determined and hence not directly related to conditions in the economy, then the response of inflation in the regulated sector to an inflationary stimulus, such as the money supply, will be noisier than the response of freely-determined inflation. If, in addition, regulated sector price changes are delayed, any response in inflation in the regulated sector that does occur will also involve a longer lag. That is, the response of changes in regulated inflation to changes in the money supply will be noisier and occur later. To investigate these issues, we again study Granger Causation and VAR-based impulse response

functions, this time between money and inflation, rather than between the different inflation series themselves.

TABLE 6: PAIRWISE GRANGER CAUSALITY TESTS ON THREE MEASURES OF MONEY AND INFLATION: 1967:1 - 1996:4, Lags: 8

Variables Subject to Granger Test

Changes in freely-determined inflation (ΔFree Inf)
Changes in regulated inflation (ΔRegulated Inf)
Changes in adjusted monetary base (ΔMoney Base)
Changes in M1 (ΔM1)
Changes in M2 (ΔM2)

Null Hypothesis:	**Obs**	**F-Statistic**
Prob		
ΔMoney Base does not Granger Cause ΔFree Inf	110	2.61365
0.01261		
ΔFree Inf does not Granger Cause ΔMoney Base		1.13005
0.35069		
ΔMoney Base does not Granger Cause ΔRegulated Inf	110	0.86131
0.55198		
ΔRegulated Inf does not Granger Cause ΔMoney Base		0.66628
0.71981		
ΔM1 does not Granger Cause ΔFree Inf	110	1.59501
0.13685		
ΔFree Inf does not Granger Cause ΔM1		0.87217
0.54292		
ΔM1 does not Granger Cause ΔRegulated Inf	110	0.56107
0.80710		
ΔRegulated Inf does not Granger Cause ΔM1		1.69108
0.11082		
ΔM2 does not Granger Cause ΔFree Inf	110	1.25613
0.27608		
ΔFree Inf does not Granger Cause ΔM2		2.12664
0.04074		
ΔM2 does not Granger Cause ΔRegulated Inf	110	0.25414
0.97861		
ΔRegulated Inf does not Granger Cause ΔM2		1.29135
0.25762		

4.1. Granger Causation: Changes in Money Supply and Changes in Inflation

Table 6 shows the results from considering Granger Causation between changes in regulated- and freely-determined inflation and three monetary aggregates, the adjusted money base, M1, and M2, using eight lagged periods.[11]

The top paired hypothesis tests in Table 6 make it clear that while we can reject the null hypothesis that changes in the money base do not Granger cause changes in freely-determined inflation, the reverse causation cannot be rejected. That is, changes in the adjusted money Granger cause changes in freely-determined inflation – with a significance level of approximately one percent. However, changes in the adjusted money base are not Granger caused by changes in freely-determined inflation. The second pair of hypothesis test results show that whereas there is evidence that changes in freely-determined inflation are preceded by changes in the adjusted money base, changes in regulated inflation and changes in the adjusted money base have neither direction of Granger causation. These results convincingly show that freely-determined inflation moves very differently in response to money than does regulated inflation.

In the case of the monetary aggregate, M1, we are unable to reject any of the null hypotheses, that there is no Granger causal link between changes in inflation and changes in M1. In the case of the broader monetary aggregate M2, at the five percent level, we can reject the null hypothesis that changes in freely-determined inflation do not Granger cause changes in the money supply. However, we cannot reject the null hypothesis that changes in M2 do not Granger cause changes in freely-determined inflation. With changes in regulated inflation, there is no Granger causation between inflation and M1 or M2, just as with the adjusted money base.

[11] While we show results for only eight periods, the results are not sensitive to the length of the lags.

TABLE 7: PAIRWISE GRANGER CAUSALITY TESTS ON MEASURES OF MONEY SHOCK AND INFLATION: 1967:1 - 1996:4, Lags: 8

Variables Subject to Granger Test

Changes in freely-determined inflation (ΔFree Inf)
Changes in regulated inflation (ΔRegulated Inf)
Shocks in change in money supply:
- Money base (Mon Base Shock)
- M1 (M1 Shock)
- M2 (M2 Shock)

Anticipated change in the adjusted money base (Anticipated ΔMon Base)

Null Hypothesis:	**Obs**	**F-Statistic**	**Prob**
Mon Base Shock does not Granger Cause ΔFree Inf	103	1.92445	0.06642
ΔFree Inf does not Granger Cause Mon Base Shock		0.31595	0.95804
Mon Base Shock does not Granger Cause ΔRegulated Inf	103	0.65384	0.73029
ΔRegulated Inf does not Granger Cause Mon Base Shock		0.48597	0.86308
M1 Shock does not Granger Cause ΔFree Inf	103	1.53766	0.15617
ΔFree Inf does not Granger Cause M1 Shock		0.27444	0.97265
M1 Shock does not Granger Cause ΔRegulated Inf	103	0.48775	0.86183
ΔRegulated Inf does not Granger Cause M1 Shock		0.57940	0.79220
M2 Shock does not Granger Cause ΔFree Inf	103	1.12190	0.35687
ΔFree Inf does not Granger Cause M2 Shock		0.51141	0.84479
M2 Shock does not Granger Cause ΔRegulated Inf	103	0.63094	0.74968
ΔRegulated Inf does not Granger Cause M2 Shock		0.49819	0.85440
Anticipated ΔMon Base does not Granger Cause ΔFree Inf	103	0.43676	0.89583
ΔFree Inf does not Granger Cause Anticipated ΔMon Base		3.65548	0.00104
Anticipated ΔMon Base does not Granger Cause ΔRegulated Inf	103	0.27151	0.97355
ΔRegulated Inf does not Granger Cause Anticipated ΔMon Base		1.48604	0.17414
Anticipated ΔMon Base does not Granger Cause Mon Base Shock	103	0.25309	0.97878

Mon Base Shock does not Granger Cause Anticipated ΔMon Base	4.98442	4.3E-05

4.2. Granger Causation: Money Shocks and Changes in Inflation

Table 7 considers the inflation-money precedence relationship using money supply shocks. Money shocks are calculated following the procedures used by Sims (1980). Specifically, we triangularized the system with the variables ordered as changes in money, GDP, unemployment, wages (in the form of compensation of non-farm business workers), inflation (in the form of the GDP deflator), and import prices. The money shocks are the unexplained changes in the monetary aggregates.

The top two paired Granger Causation results in Table 7, using money shocks, confirm the results of Table 6, which uses total changes in the money supply, although at lower levels of significance. We find that at the 10% level shocks in changes in the money base Granger cause changes in freely-determined inflation. However, while shocks in money do seem to Granger cause changes in freely-determined inflation, changes in regulated inflation do not follow shocks in changes in the adjusted money base.

The differences in significance levels between the tops of Tables 6 and 7 suggest that changes in the total money base, not just the part which is a surprise, are associated with changes in freely-determined inflation: the p-values are respectively 1% versus 6%. The results for M1 shocks and M2 shocks in Table 7 are very similar to those in Table 6, except for changes in M2 versus changes in freely-determined inflation. Whereas changes in freely-determined inflation may Granger cause subsequent *total* changes in M2, they do not affect M2 *shocks*.

The endogeneity of monetary policy, as measured by changes in the money base, is apparent from the Granger tests of the link between changes in freely-determined inflation and changes in the *anticipated* money base. In Table 7 we see that changes in freely-determined inflation Granger cause changes in the anticipated money base. As we shall

show later, it would appear that higher freely-determined inflation may cause a reduction in future money base growth, and that this can be anticipated. The very bottom of Table 7 shows that for the total period studied, the Federal Reserve may be correcting money base shocks, with these future corrections being predictable.

4.3. Impulse Responses Between Inflation and the Money Supply

Figures 8-12 consider the response relationships between money and inflation that parallel the responses considered earlier between the inflation series themselves. The top two panels of Figure 8, which are based on one- and two-period lags, confirm the results shown at the top of Table 7.[12] We see that changes in freely-determined inflation follow changes in the adjusted money base, labeled AMBCHG.[13] A significant response occurs after two quarters.The bottom two panels show that changes in regulated inflation have no changes in the adjusted money base, labeled AMBCHG. The length of the lag is two significant response to changes in the money base. While not shown in the figure, inclusion of changes in the adjusted money base in the generation of the impulse functions between changes in freely-determined and regulated inflation has little or no effect: changes in regulated inflation follow changes in freely-determined inflation, but not vice versa. This conclusion is robust to the selection of different monetary aggregates and to the use of shocks in the different monetary aggregates: Whatever money measures we use in the VARs, regulated inflation follows freely-determined inflation by two quarters.

Figure 9 shows the impulse response relationships for M1. The top two panels show a statistically significant response of changes in freely-determined inflation to changes in M1 with a two quarter lag. The effect is significant with one- and two-period lags in the

[12] Results for longer lags are very similar, differing only by the speed of convergence.
[13] As before, the order of inclusion in the VARs for Figures 8 – 12 is the order of impulse shown. For example, in the top-left panel of Figure 8, we show the response of freely-determined inflation to changes in the adjusted money base.

VAR. The bottom panels show that with a one-period lag, regulated inflation has a statistically significant response at three quarters. That is, it takes an extra quarter before M1 has affected regulated inflation than it does for freely-determined inflation. However, with a two-period lag the impulse for regulated inflation is insignificant. Overall, the results show a far noisier response of regulated inflation than of freely-determined inflation: the standard-error bands are substantially wider for regulated inflation.

Figure 10 repeats the results for the inflation impulses for M2. With the one-period VAR lag, changes in freely-determined inflation follow changes in M2 by two quarters and changes in regulated inflation follow by three quarters. Again, we find a longer lag of regulated inflation, consistent with a lag from freely-determined to regulated inflation. The responses of regulated inflation also appear to be noisier. With a two-period VAR lag, neither inflation shows any significant response. Figure 11 shows that the only money shock-inflation responses that are significant are those for freely determined inflation and the money base and M1: the two standard-error band is just above zero.[14] As in all impulse responses, regulated inflation shows a noisier response than freely-determined inflation.

A possible reason for the differences between impulses for the different money measures is apparent from Figure 12, which shows the reverse direction responses, specifically from the inflation series to the money supplies.[15] We see that the adjusted money base declines in response to freely determined inflation, although the effect is barely significant. The base does not respond to regulated inflation. The change in M1 significantly declines after increases in freely-determined inflation, but as with the base, does not respond to regulated inflation. In the case of the broader monetary aggregate M2, higher rates of freely-determined and regulated inflation are followed by significantly

[14] Results are shown only for a one period VAR lag. As before, the effect of longer lags is to affect the rate of convergence.
[15] Figure 12 uses two-period VAR lags.

lower money supply growth, although it is more significant for freely-determined inflation. It would appear that there is stabilization in this monetary aggregate to variations in inflation: the freely-determined inflation index is approximately 70% of the total CPI. Overall, the different impulse response functions correspond to the Granger causation results shown earlier.

5. Conclusions

The series of freely-determined and regulated inflation that we have constructed show that when we judge stickiness against the benchmark of unfettered prices, there is stickiness brought about by price regulation. This is clearly apparent in the Granger Causation tests and the impulse functions relating the two inflation series. There is a lag of two quarters between the two series, a lag that is in addition to any stickiness that exists in the freely-determined sector. If we use the approximate three to six month delay in price adjustment found in the survey by Blinder (1994:121) for the "private, non-farm, for profit, unregulated sector", then regulated inflation would show an approximate nine to twelve month delay. Many regulated prices such as university tuition, bus fares and property taxes are set annually, consistent with this conclusion.

Consideration of the connection between the money supply and inflation supports the conclusion concerning the relationship between the two inflation series. We find that changes in the adjusted money base Granger causes changes in freely-determined inflation, but not vice versa. In the case of regulated inflation, there is no Granger causation. The Granger links between M1 and M2 and the two inflation series similarly show a lack of any causal link between changes in the money supply and changes in inflation. Calculation of the money shocks shows results similar to those for the changes in total money supplies, although the causal link between changes in the adjusted money base and

freely-determined inflation is less significant for the money shock than for the total change.

The Granger results are complemented and enhanced by the impulse response relationships between the inflation series and the different monetary aggregates. Changes in freely-determined inflation do appear to follow changes in all monetary aggregates, as well as the to the shocks in the money base and M1. The lag is two quarters. There are significant responses of regulated inflation to total changes in M1 and M2, both with three quarter lags, i.e., one quarter longer than freely-determined inflation. Responses of regulated inflation are everywhere noisier. In conclusion, the responses of freely-determined inflation to money are earlier and less noisy than regulated inflation.

We believe that the results shown in this paper demonstrate the importance of studying regulation as a cause of price stickiness, whether interest in this matter involves the causes of stickiness, or the consequences. As for the *causes* of stickiness, regulation highlights some, but not all, of the explanations that have been advanced in the implicit or explicit context of market-oriented firms. For example, of the twelve theories summarized by Blinder (1994:122), regulatory price delays are compatible with the need to be seen to be "fair" to customers, waiting for costs to rise[16], bureaucratic delays in decision making, and adjusting other elements such as service rather than prices.[17]As for the *consequences* of price stickiness, this paper has considered the possible relevance of price regulations for the connection between changes in the money supply and changes in inflation. The results demonstrate that regulated inflation has a noisier response to the money supply, and where there is a significant response, regulated inflation comes later: regulated inflation lags are longer and noisier than freely-determined inflation. Therefore, it is

[16] Regulatory bodies do not approve rate increases until costs have been shown to have increased, rather than in anticipation of cost increases. The analogy of lags at traffic lights comes to mind in this context: everybody waits for the one ahead to move, rather than all move simultaneously.

possible that the inclusion of regulated items in the overall CPI has influenced empirical studies of money and inflation. The regulated sector is a non-trivial part of the economy, and its influence on price stickiness in the overall economy should be recognized just as should the microeconomic consequences of price regulation.

[17] Municipal transport authorities may respond to cost increases by reducing service in the short run, rather than increasing prices. Similarly, civic governments may scale back service delivery rather than raise property taxes, at least in the short run.

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Appendix: Classifications and Index Weights

Category	*Regulated or Freely-Determined (R or FD)*	*1986 Weights*
FOOD & BEVERAGES		
Dairy	R	1.261
Other Food	FD	14.929
Alcoholic Beverages	R	1.568
HOUSING		
Rent, Residential	R	6.058
Lodging while out of town	FD	1.863
Tenant's Insurance	R	.036
Owner's Equivalent Rent	FD	19.100
Household Insurance	R	.412
Maintenance & Repairs	FD	.222
Fuel & Other Utilities	R	7.908
Household Furnishings & Operations	FD	7.193
APPAREL & UPKEEP		
Apparel & Upkeep	FD	6.309
TRANSPORTATION		
New Vehicles	FD	5.591
Used Cars	FD	1.259
Motor Fuel	R	2.897
Auto Maintenance & Repair	FD	1.543
Other Transportation Commodities	FD	.769
Other Transportation Services	R	3.627
Public Transportation	R	1.488
MEDICAL CARE		
Medical Care	R	5.749
ENTERTAINMENT		
Entertainment	FD	4.385
MISCELLANEOUS		
Personal Care	FD	1.231
Tobacco Products	FD	1.246
School Books & Supplies	FD	.217
Personal & Educational Services	R	3.142

Totals: FD = 65.857% and R = 34.146%