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The Output-Inflation Tradeoff in the United States: New Evidence on the New Classical vs. New Keynesian Debate.*

by

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Abstract:

The empirical examination of the output-inflation tradeoff in the United States over a 30 year period reveals that both aggregate uncertainty and average inflation were instrumental in shaping the output-inflation tradeoff. The division of the whole sample period into two distinct sets of subintervals suggests that the New Keynesian view according to which the output-inflation tradeoff is sensitive to changes in average inflation held only unambiguously in the latter part of the respective sample period. The empirical results suggest further that the tradeoff appears to have been sensitive only to changes in aggregate uncertainty in the early part of the sample period, a fact consistent with the New Classical view.

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I. Introduction.

The New Keynesian interpretation of the output-inflation tradeoff poses a fundamental challenge to the New Classical paradigm. In a recent paper, Ball, Mankiw and Romer(BMR,(1988)) use the standard Lucas model to test the predictions of the New Keynesian hypothesis against those of the New Classical view. Both views predict that the slope of the Phillips Curve - the response of real output to a given aggregate demand shock - becomes steeper as aggregate demand becomes less stable. Sharp differences between the two competing views emerge, however, as one inquires further about the causes underlying the varying response of real output to fluctuations in nominal aggregate demand. According to the New Classical view, the output-inflation tradeoff worsens as the variability of aggregate nominal demand shocks increases. The presence of unexpected, erratic fluctuations in aggregate demand makes for greater uncertainty in the movement of relative prices. Ultimately, confusion about the proper interpretation of price signals abounds and, because of the tendency of agents to attribute locally observed changes in prices to be largely due to aggregate factors, the overall output response to a given aggregate demand shock decreases.

In contrast, while not discounting the effect of aggregate variability, the New Keynesians stress the effect of rising inflation on the response of real output to nominal aggregate demand shocks. As the inflation rate continually ratchets upward, increases in the prices of goods and services occur with greater frequency even in the face of nominal rigidities such as menu costs or near-rational behavior on the part of agents. With prices being raised more often in an inflationary environment, the effect on real output of unexpected changes in nominal aggregate demand ought to dwindle. The diminished response of real output to nominal aggregate demand shocks is a direct consequence of increasing nominal price flexibility. Changes in nominal aggregate demand are reflected to a greater extent in changes in nominal prices and less in real output.

This paper provides further evidence on the output-inflation tradeoff in the United States. Ball, Mankiw and Romer(1988) and DeFina(1991) have each carried out an empirical analysis of the New Keynesian and the New Classical hypotheses about the output-inflation tradeoff. Although complementary to the empirical analyses of BMR and DeFina, the examination of the output-inflation tradeoff undertaken in this paper differs from the existing literature on two counts.

First, the empirical analysis of the output-inflation tradeoff is carried out using quarterly time-series data.

The choice of quarterly data derives from the assumed short-run nature of the output-inflation tradeoff. Given the short-run nature of this tradeoff, quarterly data should yield more conclusive evidence than annual data on the relationship between the factors involved in the output-inflation tradeoff. Moreover, the use of quarterly data permits the division of the whole sample period into two distinct sets of subperiods. The division allows an examination of the effect of varying levels of average inflation and aggregate variability on the output-inflation tradeoff.

Second, in contrast to previous studies this paper employs a different measure of aggregate volatility. The results reported in this paper are based on Kalman filtering. Underlying the choice of a different proxy for aggregate volatility is the intent to show that the distinction between aggregate variability and aggregate uncertainty is crucial in assessing the output-inflation tradeoff along New Classical and New Keynesian lines. Contrary to previous findings the statistical evidence in this paper finds aggregate uncertainty to be an important factor in the determination of the output-inflation tradeoff.

II. Background.

Following the original idea developed by Lucas(1973), Ball, Mankiw, and Romer first estimate the output response coefficient to nominal aggregate demand shocks for 43 countries over the 1948-1985 period.[1] Then they run a cross-section regression of the estimated values of the output response coefficient on the mean rate of inflation, the square of the mean rate of inflation, the standard deviation of nominal GNP growth, and the variance of nominal GNP growth.[2] BMR's empirical findings reveal that the average rate of inflation is a statistically significant determinant of the output-inflation tradeoff whereas aggregate variability, modelled by the standard deviation and variance of nominal GNP shocks, is not. Moreover, the estimated effect of the standard deviation of nominal GNP growth on the output-inflation tradeoff is found to be positive and not negative as predicted by the Lucas hypothesis. In summary, the evidence which BMR present casts doubt on the validity of the New Classical hypothesis about the output-inflation tradeoff.

In a follow-up study using the same annual data as BMR, DeFina(1991) introduces a few desirable changes. Most important, he dispenses with the assumption that the coefficient which measures the response of real output to nominal aggregate demand shocks remained constant over the whole sample period. Instead the size of this coefficient is assumed to vary inversely with the level of average inflation. Furthermore, besides adding a supply shock to the standard Lucas model, DeFina also models aggregate variability by means of a moving standard deviation of the rate of inflation and not by the growth rate of nominal GNP.[3] The results reported by DeFina lend further support to the New Keynesian notion that the output-inflation tradeoff is sensitive to the average rate of inflation rather than aggregate variability.

III. Estimation Strategy.

In line with previous approaches, I adopt a version of the Lucas model as the basic framework for the empirical analysis of the output-inflation tradeoff. The choice of the Lucas framework derives from a testable implication of the New Classical view. According to this view, average inflation does not impact on the output-inflation tradeoff. The decisive factor shaping the uncertainty which agents face is the variability of the rate of inflation, and not the mean rate of inflation.[4] A test of the New Classical hypothesis thus consists of examining the influence of the mean rate of inflation on the response coefficient of real output to nominal aggregate demand shocks. The presence of the predicted negative effect will invalidate the New Classical view. An examination of the New Keynesian view involves determining the impact of average inflation on the response coefficient of real output to nominal aggregate demand shocks after accounting for the impact of aggregate variability. Controlling for aggregate variability is necessary on account of the positive correlation between the mean rate of inflation and aggregate variability.

The New Keynesian hypothesis about the output-inflation tradeoff can be easily incorporated into the extended Lucas model. Let

$$y_t = b_0 + b_1 y_{t-1} + b_2 time + b_3 dx_t + b_4 \mu_t \qquad (1)$$
$$dx_t \sim N(0, \sigma_x^2) \qquad \mu_t \sim N(0, \sigma_\mu^2)$$

where y_t = the level of real output

time = linear time trend

dx_t = shock to nominal aggregate demand

μ_t = real aggregate supply shock

represent the Lucas model.[5] The coefficient of dx_t, $b_3 (> 0)$, measures the response of real output to a nominal aggregate demand shock while the coefficient of μ_t, $b_4 (< 0)$, measures the response of real output to a real aggregate supply shock.[6]

The New Keynesians argue that there exists an inverse link between the coefficient of dx_t and average inflation. Specifically, the size of b_3 decreases, ceteris paribus, as the mean rate of inflation increases. In contrast, the new Classical view hypothesizes that there exists an inverse link between b_3 and aggregate variability, proxied by the variability of the rate of inflation. In algebraic form:

$$(2) \qquad b_3 = f(ai_t, vi_t) \qquad \frac{\partial f}{\partial ai_t} < 0 \qquad \frac{\partial f}{\partial vi_t} < 0$$

where ai_t = average rate of inflation

vi_t = variability of the rate of inflation.

The New Keynesian view stresses the notion that the frequency of price adjustment accelerates when inflation is high. The interval at which prices are adjusted shrinks as the rate of inflation continues to climb. In essence, the slope of the Phillips Curve is expected to be steeper when the average rate of inflation is high than when it is low.[7]

For simplicity, the functional relationship between the output response coefficients and the mean rate and the variability of inflation is modelled as a linear one:

$$(3) \qquad b_3 = f_0 + f_1 ai_t + f_2 vi_t \qquad f_0 > 0 \quad f_1 < 0 \quad f_2 < 0$$

The empirical specification of the New Keynesian and the New Classical hypotheses is obtained by substituting equation (3) into equation (1):

(4) $$y_t = b_0 + b_1 y_{t-1} + b_2 time + f_0 dx_t + f_1 dxai_t + f_2 dxvi_t + b_4 \mu_t$$

where $dxai_t = dx_t * ai_t$

$dxvi_t = dx_t * vi_t$

IV.A. Aggregate Variability vs. Uncertainty About Inflation.

In previous work(DeFina(1991)) the standard deviation of the rate of inflation served as a proxy for aggregate variability. While this construct has been employed frequently in the literature, its use as a measure of volatility has been criticized on several grounds.[8] Perhaps the most serious drawback associated with a moving variance or standard deviation of the inflation rate as a proxy for volatility is its failure to distinguish between expected and unexpected changes in the rate of inflation. Certainly, there may be a great deal of variability in the rate of inflation without there being much uncertainty. Such would be the case if agents anticipated wide swings in the rate of inflation. Thus volatility in the observed rate of inflation may be extreme in the face of contemporaneous low uncertainty about inflation. Conversely, there may be a great deal of uncertainty about inflation although the observed volatility of the inflation rate may be extremely low. The simple moving standard deviation has the further drawback that it shares a close positive correlation with the mean rate of inflation over the sample period. The empirical assessment of the impact on the output-inflation tradeoff of aggregate variability - represented by a moving standard deviation - relative to the mean rate of inflation would thus be tainted by imprecise coefficient estimates.[9]

In view of the desirability to distinguish between measures of volatility based on expected and unexpected inflation, an alternative measure of the volatility inherent in the rate of inflation is suggested. This measure is derived from a simple equation modelling the inflation process and is based on the unanticipated part of inflation. The measure of uncertainty is determined by application of the Kalman Filter routine.[10] The absolute value of the one-step Kalman Filter forecast error is taken to capture the short-term unpredictability of the inflation process which in turn is viewed as the extent of uncertainty faced by agents. It is this type of short-term uncertainty which should play a central role in the temporal decision making process in the Lucas model.

IV.B. Empirical Results.

Table 1 contains some basic information for the United States about the quarterly growth rates of real and nominal output as well as the rate of inflation over the whole sample period and sample subperiods. The choice of different subperiods is motivated by two factors. First, as pointed out by BMR, the economy of the United States underwent major structural changes in the wake of the 1973 oil crisis. On the basis of this argument, the whole sample period is divided into two subperiods with 1972:4 serving as the cut-off date of the first subperiod. Second, the United States experienced dramatic increases in the rate of inflation during the late 1960s and 1970s. The rise in inflationary pressure followed a period of relatively stable prices during the 1950s and early- through mid-1960s. Inflationary pressure abated again around 1982 and has remained low since then. Taken altogether, the whole sample period can be broken down into three distinct subperiods, each capturing a sustained period of either low or high inflation. The first subperiod ranges from 1960:1 to 1968:4 and is characterized by low inflation. The second subperiod, the high-inflation period, begins in 1969:1 and ends in 1981:4. Finally, the third subperiod, marked by relatively low inflation, covers the 1982:1-1992:4 period.

Table 2 contains the estimates of the coefficients and other summary information for the whole sample period.[11,12] The findings suggest that the mean rate of inflation had a significantly negative effect on the magnitude of the coefficient of dx_t, the nominal aggregate demand shock. The impact of average inflation on the the response of output to nominal aggregate demand shocks is significant at the one percent level.[13] Equally important is the observation that aggregate uncertainty appears to have exerted downward pressure on the size of dx_t. The hypothesis that aggregate uncertainty does not reduce the size of the coefficient of dx_t is rejected at the five percent level. The latter finding stands in marked contrast to the time series evidence reported by DeFina and the cross-country evidence reported by BMR. In these studies the mean rate of inflation had the predicted negative effect on the magnitude of the output response coefficient of nominal aggregate demand shocks while the effect of the volatility measure was insignificant.[14]

IV.C. Empirical Results Based on an Analysis of Subperiods.

This section reports the coefficient estimates of the equation embodying the New Classical and New Keynesian view for the different sample subperiods. As pointed out above, two distinct sets of sample subperiods need to be distinguished. The first set follows BMR's example and separates the whole sample period into two subperiods. The cut-off date is 1972:4. The second set consists of three distinct subperiods. The cut-off dates for the subperiods are chosen so as to yield three distinct periods of either high or low inflation.

Table 3 contains the empirical findings for the "through 1972:4" period and the "after 1972:4" period, respectively.[15] The results paint a mixed picture. It is evident that the New Classical view but not the New Keynesian view receives firm support from the data for the period up to the first oil crisis. In marked contrast during the "after 1972:4" period there is strong support for the New Keynesian view but not the New Classical view. Hence the regression results of Table 3 fail to back unequivocally either view. Taken altogether, the evidence points to the relevance of the New Classical view during the pre-oil crisis period and to the relevance of the New Keynesian view in the succeeding period.

A division of the whole sample period into intervals of low, high, and again low inflation sheds further light on the changing nature of the output-inflation tradeoff. Table 4 contains the empirical findings for each subperiod.[16,17] There is ample evidence in support of the New Classical view but not the New Keynesian view in both the low-inflation period(1960:1-1968:4) and the high-inflation period(1969:1-1981:4). The interaction term $dxkvari_t$ is significant in both equations at the one percent and five percent level, respectively. In contrast there is no evidence that average inflation had a materially negative effect on the coefficient of dx_t. During the high-inflation period the prominence of supply shocks is underscored by the significance of the coefficient of μ_t at the five percent level.

Examination of the coefficient estimates reported in Column 3 reveals that the output-inflation tradeoff underwent a dramatic change in the low-inflation period of the 1980s and early 1990s. The findings for this period attest to the significant role of both average inflation and aggregate uncertainty in shaping the output-inflation tradeoff. The coefficient of the interaction term $dxai4_t$ is statistically significant at the one percent level and the coefficient of $dxkvari_t$ is significant at the five percent level.[18] On the whole, the empirical results for the third subperiod provide a firm backing of the New Keynesian view.[19]

A conceivable alternative explanation for the link between the average rate of inflation and the output response coefficients ties the change in the output response coefficients to the degree of persistence in nominal aggregate demand shocks.[20] The greater the degree of persistence in aggregate demand disturbances, the smaller the output response coefficient associated with dx_t. Since agents can form rough estimates of future disturbances based on their past history, the response of real output to nominal aggregate demand disturbances should decline and nominal price flexibility should increase. In essence this alternative explanation proposes that with inflation rising the size of price mark-ups increases while the frequency of price adjustment may not change at all. Consider Table 5 which contains information relevant to this alternative explanation. Persistence in the nominal aggregate demand disturbances dx_t is measured by d_1, the coefficient of dx_{t-1} in an AR(1) process and given for each subperiod.

Indeed, in both the "After 72:4 period" and Subperiod III the degree of persistence in nominal aggregate demand shocks is markedly higher than in the other periods. Interestingly enough, the statistical evidence in favor of the New Keynesian hypothesis is strongest in just these two sample subperiods.[21] Taken altogether, the degree of persistence in the nominal demand shocks on the one hand and the mean rate of inflation on the other may both cause the size of the coefficient of nominal aggregate demand shocks to decline. If this assessment is true, then the strength of the New Keynesian argument is somewhat weakened.

In the light of persistent aggregate demand shocks a closer examination of the New Keynesian and New Classical views requires estimation of the anticipated and unanticipated component of the aggregate demand shock.[22] The New Keynesian view implies that first and foremost the size of the coefficient of the anticipated nominal aggregate demand shock varies inversely with the mean rate of inflation but does not rule out a negative effect on the unanticipated component brought about by an increases in aggregate uncertainty. The New Classical view in contrast suggests that the size of the coefficient of only the unanticipated nominal aggregate demand shock declines in the face of increases in the level of aggregate uncertainty.

Tables 6 and 7 show that there is substantial evidence in favor of the New Keynesian proposition. Increases in the mean rate of inflation cause the coefficient on the anticipated component of the nominal aggregate demand shock to decline. This effect is significant at the one percent level in both periods. Notice further that changes in mean inflation have no effect on the size of the unanticipated component of the nominal aggregate demand shock. The importance of aggregate uncertainty on the output-inflation tradeoff is corroborated by the statistical results. In both periods, the coefficient on the unanticipated component of the nominal aggregate demand shock declined in size as the level of aggregate uncertainty rose. The term $fdxkvari_t$ is significant at the one percent level in both tables.

V. Conclusion.

On balance, the examination of the statistical findings for the United States over the whole sample period tends to favor the New Keynesian view over the New Classical view. Indeed there appears to be a consistent pattern which leads one to believe that the output-inflation tradeoff was sensitive to changes in the mean rate of inflation throughout the 1960:1-1992:4 period.

However, the subdivision of the whole sample period into two separate sets of subperiods uncovers plausible evidence in favor of the argument that the output-inflation tradeoff did not become sensitive to inflation until the latter part of the sample period. The findings reveal that the average rate of inflation had a negligible effect on the output response coefficient of nominal aggregate demand shocks before the 1973 oil crisis and likewise during the low inflation period as well as the subsequent high-inflation period. These findings are consistent with the New Classical view. By contrast, the findings for the post-1972:4 period and likewise for the low inflation period of the 1980s and early 1990s are in agreement with the New Keynesian claim. Paradoxically, although average inflation was markedly lower during the third subperiod relative to the second subperiod, its impact on the output response coefficients was in general much more pronounced in the low-inflation period than in the high-inflation period.

In contrast to the previous findings by DeFina and BMR the statistical findings reported in this paper point to the relevance of aggregate uncertainty as an instrumental factor in the determination of the output-inflation tradeoff. The evidence shows that this measure of volatility had a negative impact on the output response coefficient of nominal aggregate demand shocks in the period leading up to the first oil crisis and in each low- or high-inflation period.

Appendix:

This appendix contains a brief description of the assumptions underlying the measure of aggregate uncertainty employed in the paper. In addition it lays out the steps taken to generate this measure of volatility.

1. Expectations about the inflation process are based on the principle of weak rationality. Agents therefore base their forecasts of the rate of inflation solely on past information about the rate of inflation.

2. In practice, this assumption implies that the current rate of inflation is regressed on its lagged levels. The number of regressors is chosen so as to remove serial correlation in the regression residuals.

3. The number of observations necessary to generate starting values of the regression coefficients is determined prior to executing the Kalman Filter routine.

4. Execution of Kalman Filter routine. This procedure updates coefficient estimates in light of new information on the current rate of inflation.

5. The recursive residuals are obtained by taking the difference between the current rate of inflation and the inflation forecast. Lastly, take the absolute value of the residual of each period to obtain the desired measure of uncertainty.

Footnotes

[1] The sample period varies from country to country. The coefficient estimates are based on annual data.

[2] BMR posit a non-linear relationship between the output response coefficent and the variables in question.

[3] This choice seems appropriate since the extent of aggregate variability is influenced by both demand- and supply-side factors.

[4] See BMR, p.32

[5] This paper shirks the issue of modelling trends largely because its objective is to compare its findings to those obtained earlier by DeFina and BMR.

[6] In accordance with the Lucas model, the aggregate demand shock is proxied by the change in nominal GNP; the aggregate supply shock is modelled as a change in the real price of oil(log of wholesale petroleum price minus log of GNP deflator).

[7] A complete examination of the output-inflation tradeoff would also consider the effects of average inflation and aggregate volatility on the response of real output to supply shocks. Applied to the analysis of supply-side shocks, i.e. shifts in the Phillips Curve caused by real factors, the New Keynesian(New Classical) hypothesis would predict that the effects of supply shocks ought to be more pronounced in times of high average inflation(aggregate variability). In such an environment a supply shock ought to result in a greater change in real output, ceteris paribus, the steeper the slope of the Phillips Curve, thus implying an increase in the absolute size of the coefficient of the supply shock. Unfortunately, due to the high degree of collinearity between average inflation and changes in the relative price of oil it is next to impossible to measure accurately the effect of average inflation on the size of the coefficient of the supply shock.

[8] See Pagan et. al.(1983), Engle(1983), Jansen(1989), and Evans(1991), for example.

[9] The correlation between the moving rate of inflation and the moving standard deviation of the rate of inflation is .338 for the whole sample period.

[10] See the Appendix for further details on how this measure of aggregate uncertainty is constructed.

[11] Since the measure of aggregate uncertainty is a generated regressor, the results reported are subject to the criticism voiced by Pagan(1984) that the standard errors of the coefficient estimates are inconsistent. All standard errors reported in the paper are estimated in accordance with the technique presented in Murphy and Topel(1985).

[12] Note the presence of serial correlation in the residuals of the estimated equation. As a rule, if Durbin's h statistic is close to or exceeds 2.00, consistent estimates of the regression coefficients are obtained through the application of the Hatanaka estimation procedure.

[13] The mean rate of inflation is calculated as follows:

$$ai4_t = (lp_{t-1}+lp_{t-2}+lp_{t-3}+lp_{t-4})/4$$

where lp_{t-j} is the log of the rate of inflation at time t-j; j=1,2,3,4.

[14] The effect of an eight-period moving standard deviation on the output-inflation tradeoff proves to be statistically insignificant. A similar finding is reported by DeFina.

[15] Supply shocks do not enter the "through 1972:4" period.

[16] Supply shocks do not enter the 1960:1-1968:4 low inflation period.

[17] As each of the three subperiods represents a distinct period of either high or low inflation a separate Kalman Filter equation is estimated for each subperiod to generate the measure of aggregate uncertainty. For the high-inflation period(69:1-81:4) the last three quarterly rates of inflation of the low-inflation period(60:1-68:4) are used to generate the starting values of the coefficients of the equation on which the inflation forecasts are built. Similarly, for the forecasting equation of of the third subperiod(82:1-92:4) the last three quarterly rates of inflation of the high-inflation period are used.

[18] Notice that the effect of aggregate uncertainty on the size of the output response coefficient is significant in the high-inflation and both low-inflation periods while it is insignificant in the "after 1972:4" period. This is due to the fact that in the latter case the measure of aggregate uncertainty is based on the whole sample period, i.e. the Kalman Filter equation is estimated for the whole sample period but only the post-72:4 values of the residual are used to construct the measure of aggregate uncertainty.

[19] The results do not change much if the equations are reestimated but based on the rate of inflation rate consisting of the previous eight rates of inflation instead

of the previous four.

[20] This point is also raised and discussed by Ball, Mankiw and Romer in the context of cross-country data. They surmise that in high-inflation countries the size of the output response coefficient and average inflation are inversely related since in those countries changes in aggregate demand are more persistent. In the end they argue, however, that the effect of persistent demand changes is far too small to account for the negative correlation between average inflation and the size of the output response coefficient. See their footnote 53.

[21] Notice that changes in aggregate demand are not more persistent in Subperiod II, the high-inflation period. Instead the degree of persistence in those disturbances is greatest in Subperiod III, a period of relatively low inflation. With inflation being low, agents are less prone to adjust prices; yet since they are aware of the persistence in aggregate demand shocks, they tend to adjust prices more frequently. Hence the response of real output to nominal aggregate demand shock declines.

[22] Anticipated and unanticipated nominal aggregate demand shocks are formed via a rolling regresssion technique whereby the previous eight observations are used to produce an AR(1) forecast of the nominal aggregate demand shock. The unanticipated component of the nominal aggregate demand shock is then obtained by subtracting the anticipated from the actual nominal aggregate demand shock.

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TABLE 1: AGGREGATE DATA FOR THE UNITED STATES.

	Real Growth		Nominal Growth		Inflation	
	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.
Whole Period (1960:1-1992:4)	.00715	.00930	.01892	.01023	.01177	.00656
Through 1972:4	.00944	.00811	.01770	.00934	.00826	.00497
After 1972:4	.00566	.00975	.01972	.01075	.01406	.00649
Subperiod I (1960:1-1968:4)	.01040	.00748	.01672	.00904	.00632	.00429
Subperiod II (1969:1-1981:4)	.00572	.01129	.02347	.01142	.01775	.00544
Subperiod III (1982:1-1992:4)	.00618	.00736	.01534	.00743	.00917	.00246

Note: All data are quarterly. They were taken from the IFS tape and various issues of International Financial Statistics. Output is defined as real GDP. The GDP deflator is computed as the ratio of nominal GDP to real GDP multiplied by 100.
Real growth is defined as the difference in the log of output.
Nominal growth is defined as the difference in the log of nominal GDP.
Inflation is defined as the first difference in the log of the GDP deflator.

Table 2:
Dependent variable: y_t

	Whole Period (60:1-92:4) Hatanaka Estim. Procedure
constant	.630** (.096)
y_{t-1}	.914** (.013)
time	.0006** (.00009)
dx_t	1.043** (.073)
$dxai4_t$	-.110** (.039)
$dxkvari_t$	-.094* (.047)
μ_t	-.006** (.0015)
Summary Statistics	
ρ	.233
Durbin's h	2.69
std.error of regression	.0035

Note: dx_t = shock to nominal aggregate demand.
$ai4_t$ = average rate of inflation consisting of the previous 4 quarterly rates of inflation.
$kvari_t$ = aggregate variability measured as the absolute value of the one-step Kalman Filter forecast error.
$dxai4_t = dx_t*ai4_t$.
$dxkvari_t = dx_t*kvari_t$.
μ_t = aggregate supply shock.
y_t = level of real output.

** denotes significance at the 1 percent level.
* denotes significance at the 5 percent level.
# denotes significance at the 10 percent level.

Standard errors of the coefficient estimates appear in parentheses.

Table 3:

Dependent variable: y_t

	Through 72:4 (60:1-72:4)	After 72:4 (73:1-92:4) Hatanaka Estim. Procedure
constant	.223[#] (.128)	.584[**] (.171)
y_{t-1}	.970[**] (.017)	.920[**] (.022)
time	.0001 (.0002)	.0006[**] (.0001)
dx_t	.992[**] (.089)	1.141[**] (.115)
$dxai4_t$	-.044 (.090)	-.149[**] (.055)
$dxkvari_t$	-.260[**] (.098)	-.039 (.052)
μ_t	----	-.0029[#] (.0017)
Summary Statistics		
ρ	-.02	.20
Durbin's h	-.12	1.84
std.error of regression	.0030	.0034

Table 4:

Dependent variable: y_t

	Low Inflation (60:1-68:4)	High Inflation (69:1-81:4)	Low Inflation (82:1-92:4)
constant	.318 (.303)	.590** (.232)	.322** (.109)
y_{t-1}	.957** (.041)	.919** (.031)	.957** (.014)
time	.0003 (.0004)	.0006* (.0003)	.0002** (.00009)
dx_t	1.008** (.107)	1.066** (.151)	1.258** (.111)
$dxai4_t$	-.216 (.145)	-.069 (.078)	-.279** (.103)
$dxkvari_t$	-.284** (.112)	-.127* (.065)	-.226* (.107)
μ_t	------	-.009* (.004)	-.0022 (.0016)
Summary Statistics			
ρ	-.02	.05	.14
Durbin's h	-.12	.36	.97
std.error of regression	.0026	.0039	.0020

Note: A separate Kalman Filter equation is estimated for each subperiod to generate the measure of aggregate uncertainty. For the high-inflation period(69:1-81:4) the last three quarterly rates of inflation of the low-inflation period(60:1-68:4) are used to generate the starting values of the coefficients of the equation on which the inflation forecasts are built. Similarly, for the forecasting equation of the third subperiod(82:1-92:4) the last three quarterly rates of inflation of the high-inflation period are used.

Table 5:

Equation estimated: $dx_t = d_0 + d_1 dx_{t-1} + u_t$

Sample Period: 1960:1-1992:4.

	Through 72:4	After 72:4	Subperiod I	Subperiod II	Subperiod III
d_0	.015** (.003)	.012** (.002)	.012** (.003)	.022** (.004)	.007** (.002)
d_1	.146 (.142)	.383** (.104)	.278# (.163)	.044 (.144)	.542** (.126)
α	.02	-.03	.01	.03	-.09

Note: α measures the degree of first degree autocorrelation in the residuals.

Table 6:
Dependent variable: y_t

	After 72:4 (73:1-92:4)
constant	.578** (.161)
y_{t-1}	.921** (.022)
time	.0006** (.00015)
$fodx_t$	1.493** (.166)
$fodxai4_t$	-.305** (.073)
fdx_t	.953** (.143)
$fdxai4_t$	.019 (.071)
$fdxkvari_t$	-.278** (.113)
μ_t	-.002 (.0015)
Summary Statistics	
ρ	.06
Durbin's h	.52
std.error of regression	.0029

Note: $fodx_t$ = anticipated component of nominal aggregate demand shock.
$fodxai4_t$ = anticipated component of nominal aggregate demand shock times average rate of inflation.
fdx_t = unanticipated component of nominal aggregate demand shock.
$fdxai4_t$ = unanticipated component of nominal aggregate demand shock times average rate of inflation.
$fdxkvari_t$ = unanticipated component of nominal aggregate demand shock times level of aggregate uncertainty.

Table 7:
Dependent variable: y_t

	Subperiod III (82:1-92:4)
constant	.454** (.121)
y_{t-1}	.938** (.016)
time	.0004** (.00011)
$fodx_t$	1.464** (.142)
$fodxai4_t$	-.399** (.108)
fdx_t	.866** (.124)
$fdxai4_t$	.064 (.123)
$fdxkvari_t$	-.516** (.175)
μ_t	-.0015 (.0015)
Summary Statistics	
ρ	-.11
Durbin's h	-.76
std.error of regression	.0017

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