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Drifting Inflation Targets and Stagflation

Edward S. Knotek II and Shujaat Khan

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Shujaat Khan
Edward S. Knotek II

Federal Reserve Bank of Kansas City

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Abstract

This paper revisits the phenomenon of stagflation. Using a standard New Keynesian dynamic, stochastic general equilibrium model, we show that stagflation from monetary policy alone is a very common occurrence when the economy is subject to both deviations from the policy rule and a drifting inflation target. Once the inflation target is fixed, the incidence of stagflation in the baseline model is essentially eliminated. In contrast with several other recent papers that have focused on the connection between monetary policy and stagflation, we show that while high uncertainty about monetary policy actions can be conducive to the occurrence of stagflation, imperfect information more generally is not a requisite channel to generate stagflation.

I   Introduction

The U.S. experience with stagflation in the 1970s was a watershed. The breakdown of a stable empirical Phillips curve relationship ushered in a new emphasis on expectations in macroeconomics. Since that time, sharp oil price increases have continually raised concerns about the risk of stagflation, due to the conventional view that the oil price spikes during the 1970s played a critical causal role in the decade's stagflation.

The interpretation of monetary policy has also been altered through the prism of the 1970s experience. Some economists view recent policy actions by the Federal Reserve as laying the groundwork for a return to the conditions of the 1970s (e.g., Meltzer 2011). Much recent research has suggested that the Federal Reserve's inflation target drifted higher during the 1970s, thereby explaining the high inflation of the decade (e.g., Ireland 2007, among others). But this research has been silent on the issue of whether monetary factors alone could have caused the economic stagnation—i.e., the "stag" in stagflation—of the decade as well. This paper examines the connection between monetary policy and stagflation in more detail. It shows that monetary stagflation is actually a fairly common occurrence under a drifting inflation target.

To fix terminology, we first turn to the U.S. historical record to provide a definition of stagflation. We identify three key conditions that characterize stagflation: inflation must be relatively high, at least one standard deviation above its long-run average; output must be stagnant, in that it is below trend and worsening relative to trend; and stagflation must be a sufficiently negative event that it lasts longer than a single quarter. Constructing and applying this algorithm to the U.S. data suggests that the United States faced two bouts of stagflation in the postwar era, 1974Q3-1975Q1 and 1980Q2-1980Q3.

The stagflation algorithm allows for a more exhaustive analysis of the factors that can generate stagflation than visual analysis alone. Thus, we take the algorithm to a New Keynesian dynamic, stochastic general equilibrium (DSGE) model featuring optimizing agents and monetary policy that endogenously responds to economic conditions.

In a world subject to shocks to the monetary authority's policy rule and a drifting inflation target, more than 90% of simulations undergo at least one stagflationary episode similar to the U.S. experience during the 1970s and early 1980s. Because the model only has monetary shocks, stagflation is generated by some variant of "go-stop" monetary policy. But the range of go-stop policies that can generate stagflation is diverse, and few go-stop policies ultimately result in stagflation. Drift in the inflation target, by contrast, is an essential feature in generating stagflation. Once this drift is eliminated, monetary policy is unable to generate stagflation through policy rule deviations alone in the baseline model.

Unlike other recent work on the monetary origins of stagflation, learning about the inflation target does not appear to play a key role in generating stagflation. However, when it is very difficult for private agents to disentangle shocks to the inflation target from those to the policy rule, the incidence of stagflation increases and the threat of a drifting inflation target is enough to generate the phenomenon. Thus, limiting monetary policy uncertainty through clearly communicated, credible, and fixed inflation targets would essentially eliminate the possibility of stagflation in the class of models considered here. These results are consistent with Goodfriend's (2012) belief that the Federal Open Market Committee's January 2012 formal adoption of a 2 percent longer-run goal for inflation will assist in preventing the types of go-stop policies conducive to stagflation.

II   What Is Stagflation?

Unlike Cagan's (1956) classic definition of hyperinflation, there is not a similar definition of stagflation. While most economists agree that the United States experienced stagflation in the 1970s and early 1980s, there is not agreement on precise start and end dates to the stagflation(s) that occurred during that time nor about the precise conditions that characterize stagflation. Blinder's (1979) first sentence reads, "*Stagflation* is a term coined by our abbreviation-happy society to connote the simultaneous occurrence of economic *stag*nation and comparatively high rates of in*flation*." Bruno and Sachs' (1985) introduction states, "The period of 'stagflation' (stagnation combined with inflation) broke out with a vengeance during 1973–75." Neither work returns to give a more rigorous definition.[1]

Using the U.S. historical record from the 1970s and early 1980s as a guide, this section proposes a formal quantitative algorithm for identifying stagflation. Applying the algorithm to the U.S. data identifies two stagflationary episodes: the third quarter of 1974 through the first quarter of 1975, and the second and third quarters of 1980. The remainder of the paper uses this algorithm to define stagflation.

Stagflation in the United States

Without a formal definition for guidance, stagflation appears to be a phenomenon that is known when it is seen. Figure 1 displays data for U.S. GDP growth and inflation from 1970

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[1] Iain Macleod, who is usually recognized as the creator of the term, defined stagflation as "not just inflation on the one side or stagnation on the other, but both of them together" (Nelson and Nikolov 2004).

through 1983, measured using fourth-quarter over fourth-quarter growth rates. Real GDP growth was negative for four years during this period—1970, 1974, 1980, and 1982—all of which coincided with NBER recessions. There were two inflationary peaks during this time: in 1974 at 10.9 percent, and in 1980 at 9.9 percent. Both inflation peaks coincided with negative real GDP growth. Thus, 1974 and 1980 were clearly stagflationary years: the economy was not only stagnant but was in fact contracting, and inflation was very high and had also accelerated from the previous year.[2]

Some years during this period are clearly non-stagflationary. While the economy contracted sharply in 1982, inflation had fallen by more than 3 percentage points from the previous year and was trending down. The years 1976, 1977, and 1978 saw strong and accelerating GDP growth above 4 percent coupled with high and rising inflation. The year 1973 was probably not part of a stagflation, notwithstanding its inclusion in the Bruno and Sachs (1985) quote above and that it is part of the 1973–75 recession as determined by the National Bureau of Economic Research's Business Cycle Dating Committee: while inflation picked up considerably from its pace in the previous year, increasing from 4.4 to 6.8 percent, real GDP growth was stronger than 4 percent.[3]

However, there are a few years that fall into a gray area in the stagflation spectrum. Output growth in 1979 had fallen off considerably from the previous year, suggesting a

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[2] The figure is slightly affected if GDP growth and inflation are computed using annual data instead of using fourth-quarter over fourth-quarter percentage changes. In the annual data, GDP growth was negative during four years: 1974, 1975, 1980, and 1982. GDP growth in 1970 was just barely positive in the annual data. The twin inflation peaks in the annual data both occurred one year later than in the fourth-quarter over fourth-quarter data: inflation was 9.0 percent in 1974 and 9.5 percent in 1975, and it was 9.1 percent in 1980 and 9.4 percent in 1981. The annual data would thus point to 1974–75 and 1980 as stagflationary years. However, the levels of annual data are constructed by taking averages of the year's quarterly numbers, implying that growth rates would be functions of eight quarters. This loss of precision tends to favor the fourth-quarter results in the text.

[3] The annual data reinforce the idea that 1973 was not stagflationary: the inflation acceleration from 1972 was milder, going from 4.3 to 5.5 percent; and real GDP growth was even stronger, at 5.8 percent. Separately, labor market indicators suggest little deterioration in the economy in 1973: unemployment held steady near 4.9 percent throughout the year and did not begin to turn up dramatically until mid-1974. Leamer (2008) also questions the inclusion of part of 1973 in the NBER recession dates.

stagnating economy coupled with high inflation. Economic conditions in 1975 and 1981 were also far from ideal. Inflation in both years had fallen but remained quite high at 7.6 percent in 1975 and 8.2 percent in 1981. Meanwhile, output growth in 1975 rebounded to 2.5 percent and was trending up, while in 1981 output growth was 1.2 percent before turning negative the following year. Finally, output contracted in 1970 at the same time that inflation was around 5 percent—a level of inflation that was only half the levels reached later in the decade, but which was nevertheless much higher than rates of approximately 1 percent early in the 1960s.

Figure 2 looks at the output gap and GDP inflation in quarterly data from 1970 through 1983.[4] The output gap was negative during five periods: 1969Q4 to 1972Q1; 1974Q3 to 1977Q1; 1978Q1; 1980Q2 to 1980Q3; and 1981Q4 to 1983Q4. Excluding the singular 1978Q1 observation, the other four periods at least partially coincide with NBER recessions.

Quarterly inflation was high throughout most of this period. Between 1947Q2 and 2012Q2, the mean annualized quarterly GDP inflation rate was 3.3 percent. Compared with this long-run average, inflation was above average continuously from 1972Q3 through 1983Q1. If we define "high inflation" as an inflation rate more than one standard deviation above its long-run average—in this case, inflation greater than 5.8 percent—then the U.S. experienced high inflation in 1971Q1; 1972Q1; 1973Q2 through 1975Q1; 1975Q3 and 1975Q4; 1976Q4 through 1977Q2; and 1977Q4 through 1981Q4.

If stagflation requires that the economy be stagnant—defined as an output gap that is negative—coupled with high inflation, then we have such an experience in the first quarter in each of 1971, 1972, and 1978; from mid-1974 into 1975; late 1976 into early 1977; and again in

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[4] The output gap is $100\ln(y_t/y_t^*)$, where y_t is real GDP in quarter t and y_t^* is computed using the Hodrick-Prescott filter with smoothing parameter 1600. The inflation rate is $400\ln(P_t/P_{t-1})$, where P_t is the GDP chain-type price index in quarter t.

1980.[5] Figure 1 downplays the potentially stagflationary episodes in 1971, 1972, 1976, 1977, and 1978. Real GDP growth was strong in each of these years, above 4 percent. Moreover, the acceleration in inflation over 1976–78 was coupled with accelerating growth in the economy— more in line with the traditional Phillips curve relationship rather than stagflation. Thus, a visual inspection of both the yearly and quarterly data suggests two viable stagflation candidates: 1974–75 and 1980.

A Stagflation Algorithm

The above analysis guides the creation of an algorithm for identifying stagflation in quarterly data that relies on a two-step procedure.

The first step identifies potential stagflation candidates as quarters that satisfy the following three criteria. (1) Inflation is high: it is at least one standard deviation above its long-run average. (2) Output is stagnant: the output gap is negative, hence output is below trend. (3) Output is worsening relative to trend: the output gap decreased since the previous quarter.

The second step uses two criteria to identify *stagflationary quarters* based on the list of potential candidates from the first step. (1) Potential candidates in consecutive quarters are classified as stagflationary quarters. (2) Non-consecutive potential candidates that are two quarters apart (e.g, time *t* and *t*+2) are classified as stagflationary quarters, as is the separating quarter (e.g., time *t*+1); singleton candidates lacking another candidate within two quarters are eliminated. These criteria prevent stagflations from being trivially short events and are in the spirit of the negative connotation of the term.

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[5] Omitting the period around the recent financial crisis and deep recession does not change the results.

Figure 3 plots the U.S. data from 1947Q2 through 2012Q2. Applying the stagflation

algorithm produces five stagflationary quarters: 1974Q3, 1974Q4, 1975Q1, 1980Q2, and

1980Q3.[6]

Alternative definitions of the output gap matter in defining stagflation. Figure 4 plots the

U.S. data using the Congressional Budget Office's estimate of potential real GDP to derive the

output gap. Using the CBO output gap along with inflation in the GDP chain-type price index in

the stagflation algorithm produces eight stagflationary quarters: the same five as above (1974Q3-

1975Q1 and 1980Q2-1980Q3), plus 1981Q2 through 1981Q4.

III   A New Keynesian Model

To investigate the monetary origins of stagflation, this paper relies on a relatively standard New

Keynesian DSGE model. Monetary policy follows a Taylor-type rule subject to transitory policy

shocks, and the monetary authority's inflation target is subject to exogenous time variation. We

allow for two cases: one in which economic agents need to learn about the drifting inflation

target—which is similar in spirit to recent work on monetary causes of stagflation in Barsky and

Kilian (2002), Orphanides and Williams (2005a, 2005b), and Knotek (2006)—and an alternative

in which agents can perfectly observe movements in the inflation target.

The representative household maximizes expected utility

$$E_t \sum_{s=0}^{\infty} \beta^s \left[\frac{\left(C_{t+s} - \gamma C_{t-1+s}\right)^{1-\sigma}}{1-\sigma} - \chi \frac{N_{t+s}^{1+\eta}}{1+\eta} + \delta \frac{\left(M_{t+s} / P_{t+s}\right)^{1-\omega}}{1-\omega} \right] \tag{1}$$

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[6] While one may wish to consider a broader definition of stagflation so that more of the 1970s and early 1980s are classified as stagflationary, the criteria seek to capture the heart of what constitutes stagflation.

by choosing the composite consumption good C_t (comprising differentiated goods c_{jt}), labor N_t, and end-of-period money balances M_t and one-period nominal bond holdings B_t, subject to the flow budget constraint

$$C_t + \frac{M_t}{P_t} + \frac{B_t}{P_t} + \tau_t \leq \frac{W_t}{P_t}N_t + \frac{M_{t-1}}{P_t} + \frac{(1+i_{t-1})B_{t-1}}{P_t} + \frac{D_t}{P_t}. \tag{2}$$

The household discounts the future at rate $0<\beta<1$ and potentially faces habit formation in consumption via $0\leq\gamma<1$ following Fuhrer (2000). The parameters σ and η are the coefficient of relative risk aversion and the inverse labor supply elasticity with respect to wages, respectively; ω governs the interest elasticity of real money holdings; and χ and δ are the relative weights placed on the disutility of labor and utility from money holdings, respectively. The household enters the period with money holdings M_{t-1} and bond holdings B_{t-1}, with the latter earning the risk free net interest rate i_{t-1} since the previous period. The household pays the price P_t for the composite consumption good, receives nominal wages W_t from supplying labor and nominal profits D_t from the firms in the economy, and pays net taxes of τ_t.

The first order conditions from the household's maximization problem produce a labor supply condition,

$$N_t = \left[\frac{W_t}{P_t} \frac{\lambda_t}{\chi} \right]^{1/\eta}, \tag{3}$$

a money demand condition,

$$\frac{M_t}{P_t} = \left[\frac{\lambda_t}{\delta}\left(1-\frac{1}{1+i_t}\right) \right]^{-1/\omega}, \tag{4}$$

and the Euler equation,

$$\lambda_t = \beta E_t\left[(1+i_t)\frac{P_t}{P_{t+1}}\lambda_{t+1} \right], \tag{5}$$

with

$$\lambda_t = (C_t - \gamma C_{t-1})^{-\sigma} - \gamma \beta E_t \left(C_{t+1} - \gamma C_t \right)^{-\sigma}. \tag{6}$$

Necessary and sufficient conditions for household optimization require that (3) through (6) hold in every period, the household's budget constraint binds with equality, the present value of the household's expected expenditures is bounded, and the transversality condition

$\lim_{T \to \infty} E_t[(1 + i_{T-1})(P_T / P_t)^{-1}(B_T + M_T)P_T^{-1}] = 0$ holds.

A continuum of monopolistically competitive firms indexed by j produce intermediate goods y_{jt} according to the constant returns to scale production function $y_{jt} = ZN_{jt}$, where Z is an aggregate measure of technology that is common across all firms and constant and N_{jt} is labor used by firm j. A final good firm purchases the intermediate goods at nominal prices p_{jt} and combines them using a constant returns to scale technology to produce the final composite good, $Y_t = [\int_0^1 y_{jt}^{(\theta-1)/\theta} dj]^{\theta/(\theta-1)}$, with $\theta > 1$ the elasticity of substitution between goods. Profit maximization by the final good producing firm yields a demand for each intermediate good given by $y_{jt} = (p_{jt} / P_t)^{-\theta} Y_t$, with the aggregate price level $P_t = [\int_0^1 p_{jt}^{1-\theta} dj]^{1/(1-\theta)}$.

The intermediate good firms set price p_{jt} to maximize the expected present value of their real profits, weighted by the household's marginal utility: $E_t \sum_{s=0}^{\infty} \beta^s \lambda_{t+s} D_{jt+s} / P_{t+s}$. Firms face quadratic adjustment costs in changing prices as in Rotemberg (1982), implying that real profits of firm j at time t are

$$\frac{D_{jt}}{P_t} = \frac{p_{jt}}{P_t} y_{jt} - \Psi_{jt} y_{jt} - \frac{\phi}{2} \left(\frac{p_{jt}}{\left(1 + \pi_{t-1}\right)^{\xi} E_t \left(1 + \pi_t^*\right)^{1-\xi} p_{jt-1}} - 1 \right)^2 Y_t, \tag{7}$$

10

where $\phi \geq 0$ measures the adjustment cost in price setting, measured in terms of final aggregate output, and Ψ_{jt} is real marginal cost. As in Ireland (2007), the parameter $0 \leq \xi \leq 1$ governs the extent to which price setting is backward- or forward-looking. At the extreme value of $\xi=1$, the firm can costlessly adjust its price in line with last period's inflation, π_{t-1}. If $\xi=0$, the firm can costlessly adjust its price in line with expectations of today's steady state inflation target, π_t^*. The expectation term E_t in (7) allows for the possibility that agents do not perfectly know the inflation target at a point in time.[7] The first order condition for the firm's maximization problem implies

$$
\begin{aligned}
0 = (1-\theta)\left(\frac{p_{jt}}{P_t}\right)^{-\theta}\left(\frac{Y_t}{P_t}\right) + \theta\Psi_{jt}\left(\frac{p_{jt}}{P_t}\right)^{-\theta-1}\left(\frac{Y_t}{P_t}\right) \\
- \phi\left(\frac{p_{jt}}{\Xi_t p_{jt-1}} - 1\right)\left(\frac{Y_t}{\Xi_t p_{jt-1}}\right) + \beta\phi E_t\left[\frac{\lambda_{t+1}}{\lambda_t}\left(\frac{p_{jt+1}}{\Xi_{t+1} p_{jt}} - 1\right)\left(\frac{p_{jt+1} Y_{t+1}}{\Xi_{t+1} p_{jt}^2}\right)\right]
\end{aligned}
\tag{8}
$$

with $\Xi_{t+s} = (1+\pi_{t-1+s})^\xi E_{t+s}(1+\pi_{t+s}^*)^{1-\xi}$.

In a symmetric equilibrium, every intermediate good producing firm faces the same marginal cost $\Psi_{jt} = \Psi_t$ and aggregate demand Y_t, thus $p_{jt} = P_t$ for all j. In the steady state, marginal costs are $\Psi = (\theta-1)/\theta = \mu^{-1}$, with μ the steady state markup of price over marginal cost. Costly price adjustment implies the aggregate resource constraint

$$
C_t + G_t + \frac{\phi}{2}\left(\frac{1+\pi_t}{(1+\pi_{t-1})^\xi E_t(1+\pi_t^*)^{1-\xi}} - 1\right)^2 Y_t = Y_t.
\tag{9}
$$

Government purchases G_t are held constant and the government budget constraint clears via lump sum taxation.

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[7] By contrast, Ireland (2007) assumes agents always know the inflation target.

Monetary policy

The central bank sets monetary policy via the nominal interest rate according to

$$\left(1+i_t\right)=\left(1+i_{t-1}\right)^{\psi_i}\left[\left(1+\overline{r}\right)\left(1+\pi_t\right)\left(\frac{1+\pi_t}{1+\pi_t^*}\right)^{\psi_\pi}\left(\frac{Y_t}{\overline{Y}}\right)^{\psi_y}\exp\left(\varepsilon_t\right)\right]^{(1-\psi_i)},\qquad(10)$$

with nonnegative weights ψ_i, ψ_π, and ψ_y placed on interest-rate smoothing, the inflation gap, and the output gap, respectively, with steady state real output $\overline{Y}$ and steady state real rate of interest $\overline{r}$. Transitory shocks to the policy rule, ε_t, are i.i.d. $N(0,\sigma_\varepsilon^2)$.

The central bank's inflation target π_t^* follows the process

$$\left(1+\pi_t^*\right)=\left(1+\overline{\pi}\right)^{(1-\rho)}\left(1+\pi_{t-1}^*\right)^{\rho}\exp\left(e_t\right)\qquad(11)$$

with $0\leq\rho\leq1$ and $\overline{\pi}$ steady state inflation provided that $\rho<1$. Shocks to the central bank's inflation target, e_t, are i.i.d. $N(0,\sigma_e^2)$. Kozicki and Tinsley (2001a, 2001b) and Ireland (2007) present evidence of time-variation in monetary policymakers' inflation objectives in the U.S., with Ireland's (2007) estimation results showing that it is impossible to reject the type of exogenous time-variation modeled in (11).[8]

When the central bank's inflation target is perfectly observable by private economic agents (i.e., there is no learning), then agents observe both ε_t and e_t shocks individually, $E_t\pi_t^*=\pi_t^*$, and neither the firm's contemporaneous real profit function in (7) nor the aggregate resource constraint in (9) contain expectations.

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[8] See also Cogley and Sbordone (2008), Cogley et al. (2010), and Coibion and Gorodnichenko (2011) for evidence of time-varying trend inflation, which in the present context is observationally indistinguishable from a time-varying inflation objective.

When the central bank's inflation target is not perfectly observable by private economic agents, they learn about it by means of a signal extraction problem. In the log-linearized model, let $\hat{\Pi}_t^* = \ln[(1+\pi_t^*)/(1+\bar{\pi})]$. Following Schorfheide (2005), define u_t as the composite monetary policy shock

$$u_t = -\psi_\pi \hat{\Pi}_t^* + \varepsilon_t \tag{12}$$

that is observable to private agents.[9] The log-linearized monetary policy rule (10) can be rewritten in terms of u_t, and agents employ the Kalman filter to update their inference regarding the inflation target.[10] Denoting today's expectation of the perceived inflation target today as $E_t\hat{\Pi}_t^*$, then

$$E_t\hat{\Pi}_t^* = E_{t-1}\hat{\Pi}_t^* + \frac{\kappa}{\rho}\left[u_t + \psi_\pi E_{t-1}\hat{\Pi}_t^*\right], \tag{13}$$

the one-step-ahead forecast of the household's perceived inflation target is given by

$$E_t\hat{\Pi}_{t+1}^* = \rho E_t\hat{\Pi}_t^*, \tag{14}$$

and the Kalman gain κ is

$$\kappa = \frac{-\rho}{\psi_\pi}\left[\frac{-x+\sqrt{x^2+4\psi_\pi^2\sigma_v^2}}{2-x+\sqrt{x^2+4\psi_\pi^2\sigma_v^2}}\right] \tag{15}$$

with $x = 1 - \rho^2 - \psi_\pi^2\sigma_v^2$ and the signal-to-noise ratio $\sigma_v^2 = \sigma_e^2/\sigma_\varepsilon^2$.

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[9] Agents always know all the parameters of the model, including ψ_π in (12) and the parameters in (11).
[10] The problem is similar to Erceg and Levin (2003), except that in their framework households observe the inflation target but must infer whether its movements are due to transitory or persistent components of π_t^*.

IV   Monetary Stagflation

To highlight how stagflation arises in the New Keynesian DSGE model presented above, we calibrate the model using relatively standard parameters. Simulations of the baseline model reveal that stagflation is a very common occurrence when the economy is subject to deviations from the monetary policy rule and a drifting inflation target: more than 90% of simulations undergo at least one stagflationary episode similar to the experience in the U.S. during the 1970s and early 1980s. Preventing the inflation target from drifting essentially eliminates the ability of monetary policy to generate stagflation through policy rule deviations alone.

In the baseline model, imperfect information about the monetary authority's inflation target generally does not play an important role in generating stagflation. However, when there is a great amount of policy uncertainty—i.e., when it is very difficult for private agents to disentangle shocks to the inflation target from those to the policy rule—the incidence of stagflation increases and in this case actual drift in the inflation target is not necessary to generate stagflation.

Model Calibration

The model frequency is quarterly. The annual real interest rate in the steady state is 2%, implying $\beta = 0.995$. Among the parameters governing the household's preferences, σ and η are both set to 1 and $\omega = 2.6$. We place a small weight on the utility of real money holdings, setting $\delta = 1 \times 10^{-4}$, and χ is calibrated so the household devotes one third of its time to employment in the steady state. The habit parameter is set to the estimate in Ireland (2007), $\gamma = 0.25$.

The intermediate goods firms face constant returns to labor and the technology parameter Z normalizes steady state output to 1. The steady-state markup is 15%, implying $\theta = 23/3$. The parameter governing the cost of price adjustment, ϕ, is 50, and the weight placed on lagged inflation, ξ, is 0.25, roughly translating to an average frequency of price change in a Calvo price-setting model of once every two and a half quarters. The steady state ratio of government spending to output is 0.08.

In the monetary policy rule, the reaction coefficient to the inflation gap is $\psi_\pi = 0.5$ as in the original Taylor rule, and the other coefficients on interest-rate smoothing and the output gap are $\psi_i = 0.21$ and $\psi_y = 0.25$, as in Erceg and Levin (2003). We assume the inflation target is stationary, with $\rho = 0.99$ and steady state inflation $\bar{\pi} = 2\%$ at an annual rate. We back out the signal-to-noise ratio from the point estimate of the Kalman gain reported by Erceg and Levin (2003), $\sigma_v^2 = 0.02$, and to match the volatility of inflation and monetary policy in our model economy to the U.S. data we set the variances of the transitory shocks to the interest rate target and the inflation target to $\sigma_\varepsilon^2 = 1 \times 10^{-4}$ and $\sigma_e^2 = 2 \times 10^{-6}$, respectively.

Simulation Results

Our study focuses on Monte Carlo simulations to illustrate the incidence of stagflation and the conditions most conducive to its occurrence. Thus, we simulate 1,000 model economies for 246 quarters each, matching the period from 1947Q2 through 2008Q3. Because we only focus on monetary shocks in our model economies, we ignore the period of the zero lower bound on U.S. monetary policy rates from the actual data.

Table 1 presents the results from the simulation exercise with the baseline parameters set out above. Line 1 shows the incidence of stagflation in the complete model under the assumption that agents other than the central bank need to learn about the inflation target. Line 2 shows the complete model under the assumption that the central bank's inflation target is observable to the representative household and firms.

In the model economies, the occurrence of stagflation is the rule rather than the exception: more than 90% of the simulated economies contain at least one stagflationary episode as defined in Section II. On average, between 7 and 9 quarters are classified as stagflationary, generally similar to the range of 5 to 8 stagflationary quarters from the U.S. historical record depending on how the output gap is defined. Monetary policy alone can thus easily generate the key characteristics of stagflation as observed in the United States. This stagflation is achieved in a setting with historically representative volatility in the inflation rate and the policy rate, and with less volatility in the output gap.[11]

Furthermore, the incidence of stagflation is actually slightly greater for simulated economies in which the inflation target is perfectly observable than when agents need to use a signal-extraction problem. This result runs counter to the previous work that has relied on some type of information imperfections to generate stagflation from monetary policy alone (Barsky and Kilian 2002; Orphanides and Williams 2005a and 2005b; Knotek 2006). We return to this point in more detail below.

The occurrence of stagflation is intimately tied to time-variation in the inflation target. Lines 3-4 show what happens in the model when all parameters of the model are unchanged but

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[11] Recall that the model was calibrated to match the U.S. data in terms of the volatility of the policy rate and inflation. To the extent that a more volatile environment could serve to create conditions for a temporarily high inflation rate and/or decouple movements in inflation and the output gap, this could artificially increase the likelihood of observing stagflation. Adding real shocks to the model to increase the volatility of the output gap would help the model economies better fit the U.S. data.

the model economies are only subjected to e shocks to the inflation target.[12] Once again, stagflation occurs in the vast majority of model simulations at least once, and the stagflation statistics are only modestly affected. By contrast, lines 5-6 present results when the economies are only subject to shocks to the interest rate target from ε. Without changing any of the intrinsic parameters inside the model, stagflation ceases to occur once the inflation target stops drifting.[13]

With only monetary shocks in the model, variants of "go-stop policy"—policy easing followed by policy tightening—are behind the emergence of stagflation. We illustrate this phenomenon graphically in Figure 5 for the baseline case with two policy shocks and learning about the inflation target.[14] For each identified stagflationary episode, we look at the window of monetary shocks surrounding it, with time 0 on the horizontal axis denoting the first stagflationary quarter of an episode. Panel (a) shows the distribution of composite monetary policy shocks u from equation (12), while panel (b) shows the distribution of inflation target shocks e and panel (c) shows policy rule shocks ε.

The figure shows a distinctive pattern of go-stop innovations: relatively more accommodative shocks precede the stagflation, then a rapid switch to tighter policy shocks starts the onset of the stagflationary episode.[15] Outside of these episodes, the shocks are essentially mean zero. Panel (b) shows that stagflation is typically preceded by a gradual upward drift in the inflation target coming through a series of above-average e shocks; mechanically, upward drift in the inflation target is necessary to push the inflation rate high enough to satisfy the stagflation

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[12] In particular, we leave the signal-to-noise ratio in the learning case unchanged—so agents always assign a non-zero probability to the possibility of a shock to the interest rate target coming from ε, when in reality these shocks do not occur.

[13] We subject the model economies to the same sequences of shocks, hence different shock processes do not drive the result.

[14] The figure is similar for the case in which there are two shocks and the inflation target is observable by the private agents.

[15] That said, the figure only shows the plus/minus one standard deviation bands; the two standard deviation bands are quite wide, suggesting that there is a wide range of shock combinations that can ultimately deliver stagflation.

criteria set out in Section II. Panel (c) shows that typically the actual stagflation event is coupled with a go-stop set of policy rule deviations.

However, few actual go-stop policy episodes in the simulations produce stagflation. We define a go-stop policy episode using the plus-minus one standard deviation area outlined in Figure 5 in the six quarter window from period −3 to +2. For each of the different cases, we search for sequences of composite monetary shocks u over six consecutive quarters that fall entirely within this pattern. Once a sequence is identified as a go-stop episode, we determine whether a stagflation occurred around this pattern or not.[16] As Table 2 shows, go-stop policy episodes yield stagflation only slightly more than 10% of the time in the cases with two shocks. Because stagflation does not occur in the cases with only shocks to the interest rate target ε, we define the go-stop policy episodes for these cases from the corresponding cases with both shocks. In spite of being hit with the same sets of ε shocks, these go-stop policy episodes fail to produce any stagflations. Thus, go-stop policy which only takes the form of deviations from a Taylor-type rule rather than incorporating a drifting inflation target fails to generate stagflation.

Alternative Parameterizations

We explore the robustness of the above results to a wide range of model parameterizations. In short, the basic findings—that learning is not necessary to generate stagflation, but a time-varying inflation target is necessary—continue to hold.

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[16] In particular, while the go-stop episode is defined using a six quarter window, we look over a nine quarter window for stagflations—we look at the three quarters immediately beyond the go-stop window as well. To avoid double counting whether a given go-stop episode generates stagflation or not, if a given sequence of quarters fits the go-stop definition we skip to the end of that sequence before resuming the search for the next go-stop episode.

Table 3 considers two polar parameterizations of the model. Lines 1-6 focus on a pure forward-looking New Keynesian model with an inflation-targeting central bank. The forward-looking model maintains the baseline parameterization except that it sets ξ, γ, ψ_i, and ψ_y to zero. The incidence of stagflation is roughly similar to the baseline when there are two shocks, and again stagflation never occurs when the inflation target is fixed. Lines 3-4 show a slight divergence from the baseline, with fewer stagflationary episodes under learning and more frequent stagflations under the perfect information model.

Lines 7-12 consider a New Keynesian model with greater inertia than in the baseline, as the backward-looking component in price adjustment ξ and habit formation parameter γ are both increased to 0.75. While the simulations now produce a trivial number of stagflations when only shocks to the interest rate rule occur alongside learning (line 11), the results are generally otherwise little changed.

Variations to parameters governing the monetary policy rules are presented in Table 4. Moving to the Taylor (1993) parameters ($\psi_i = 0$ and $\psi_y = 0.5$, lines 1-2) from the baseline has little effect on the incidence of stagflation when there are both shocks to the interest rate rule and the inflation target. Increasing the amount of interest rate smoothing (from $\psi_i = 0.21$ to $\psi_i = 0.7$, lines 3-4) tends to dampen both the interest rate responses in the model and the incidence of stagflation, though monetary stagflation still occurs in the vast majority of simulated economies.

By contrast, reducing the persistence of inflation target fluctuations dramatically lowers the incidence of stagflation. Lines 5-6 show the results of going from $\rho = 0.99$ to $\rho = 0.7$, which dramatically reduces the half-life of a target shock from 17 years to 2 quarters. This change essentially eliminates stagflation when there is learning about the inflation target, and the incidence sharply declines when the target is observable as well. A reduction in ρ operates along

two margins. Whether there is learning or not, reducing ρ makes shocks to the inflation target more similar to shocks to the interest rate rule as the low frequency movements in inflation disappear, and interest rate shocks by themselves yield extremely few stagflations. But in addition, reducing ρ in the case with learning reduces both the size of the Kalman gain κ and the ratio κ/ρ in absolute terms, which makes expectations of the target stickier via equation (13) and further dampens the model.

Varying the Signal-to-Noise Ratio and the Role of Learning

The final exercise varies the signal-to-noise ratio σ_v^2. For the sake of exposition, Table 5 presents two extreme cases: the first decreases the signal-to-noise ratio by a factor of 50, while the second increases the signal-to-noise ratio by a factor of 50. The changes in the signal-to-noise ratio are achieved by changing the variance of shocks to the inflation target σ_e^2.

Changing the signal-to-noise ratio generates counterfactual volatility in both inflation and the policy rate compared with the U.S. record. Nevertheless, the results shed additional light on how monetary stagflation can arise. Decreasing the signal-to-noise ratio by reducing the variance of inflation target shocks essentially eliminates stagflation (lines 1-2), whether there is learning or not. In essence, this case moves toward the world in which the only shocks are those to the policy rule, and such a world under the baseline model does not generate any stagflation (see Table 1). That is, the world becomes less volatile through the decrease in σ_e^2 and more certain in the sense that shocks are "known" to be transitory and to the policy rule.

By contrast, increasing the variance of inflation target shocks and thus the signal-to-noise ratio tends to raise the probability of stagflation across the board to virtually 100% of simulations

when both shocks are present (lines 3-4). But perhaps more interestingly, stagflation is also now endemic in the model with only ε shocks to the policy rule when private agents need to learn about the inflation target: every simulation suffers from at least one stagflation (line 5), whereas no simulations suffer stagflation when the inflation target is observable (line 6).[17]

These results suggest that extremely uncertain environments can cause the incidence of stagflation to rise and can help explain why previous work has relied on some type of information imperfection to generate stagflation. Impulse responses assist in highlighting the intuition. Intuitively, imperfect information generates additional persistence in the New Keynesian model, as well as a certain degree of overshooting as private agents need to learn about the true nature of the shocks they face. Figure 6 shows impulse responses in the baseline model (with its relatively low signal-to-noise ratio, i.e., a small variance of inflation target shocks to policy rule shocks) to a positive ε shock to the interest rate, and Figure 7 shows impulse responses to a negative e shock to the inflation target.[18] The modest overshooting occurs in the case of an ε shock under learning, as inflation remains lower than normal, the monetary authority subsequently eases policy, and output turns slightly positive for a time.[19]

A highly uncertain environment can amplify this overshooting. Figure 8 shows that a high signal-to-noise ratio (e.g., from a large variance of inflation target shocks to policy rule shocks) and the same initial positive ε shock to the interest rate as before cause inflation to decline sharply while the output gap actually turns positive under learning. Therefore, reversing signs means that a negative ε shock becomes stagflationary in an impulse response exercise—

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[17] Knotek (2006) finds more frequent stagflation in economies with more information frictions, but this result partly stems from a relatively high signal-to-noise ratio and the lack of endogenous responses from the monetary authority.
[18] To maintain the same composite shock u between impulse responses, we set the shocks to 1% for the e shock and 0.5% for the ε shock.
[19] By contrast, following an e shock under learning it takes a considerable time for inflation to catch up to where it would be under perfect knowledge, and the result is a longer-lived deviation of the output gap from steady state.

and, as evidenced by the table, it does so frequently in simulations as well. Walking through the stagflation intuition, when private agents see a decline in the policy rate, they place considerable odds on an increase in the inflation target given the large signal-to-noise ratio. This amplifies the movements in actual inflation. Subsequently, the monetary authority seeks to act against the high inflation by reversing course and raising the policy rate—which in turn causes the real rate to oscillate and depresses output. As the monetary authority works to contain inflation through tighter policy, output temporarily worsens relative to trend for a time. Thus, stagflation occurs under elevated uncertainty.

The lack of a stagflation algorithm as proposed in Section II has limited previous studies to identifying stagflation through some type of an impulse response exercise (i.e., visual inspection) such as the one just outlined, rather than using stochastic simulations to identify whether a model generates stagflation as a normal matter of course. Barksy and Kilian (2002) and Orphanides and Williams (2005a) both consider environments with some type of information imperfection on the part of private agents. Barsky and Kilian (2002) propose that if agents are slow to "wake up to" a regime change that takes the form of go-stop monetary policy, this can generate stagflation similar to the U.S. experience. The present paper shows that a regime change is not necessary to generate stagflation from monetary factors; relatively "normal" series of shocks will suffice.[20] Orphanides and Williams (2005a) assume that agents use finite memory least squares learning to form inflation expectations and that, in response to a particular sequence of inflationary shocks meant to resemble events during the 1970s, stagflation

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[20] To the extent that a regime change might produce great uncertainty about the monetary authority's goals—similar to the case in which the signal-to-noise ratio is increased—then such conditions would tend to increase the probability of stagflation.

can arise if the monetary authority is too dovish on inflation.[21] Yet the present paper shows that, even with the monetary authority following stabilizing Taylor-type rules with standard coefficients from the literature, stagflation from monetary factors can still arise.

Taken together, the baseline results and robustness exercises in this paper suggest that stagflation in the spirit of the 1970s is likely a common feature of many New Keynesian DSGE models that allow for both time-varying inflation targets and shocks to a policy rule.

V   Conclusion

This paper examines the phenomenon of stagflation. Using the U.S. historical record, it proposes an algorithm to identify stagflation, and it applies the algorithm to model simulations from a relatively standard New Keynesian DSGE model. The simulations reveal that stagflation may not be as rare as is commonly perceived. In a world subject to shocks to the monetary authority's policy rule and a drifting inflation target, more than 90% of simulations undergo at least one stagflationary episode similar to the U.S. experience during the 1970s and early 1980s. Preventing the inflation target from drifting essentially eliminates the ability of monetary policy to generate stagflation through policy rule deviations alone.

Whether or not private agents need to learn about the inflation target does not appear to play a key role in the incidence of stagflation. However, when there is a great amount of policy uncertainty—i.e., when it is very difficult for private agents to disentangle shocks to the inflation target from those to the policy rule—the incidence of stagflation increases and in this case actual drift in the inflation target is not necessary to generate stagflation; the threat of a drifting

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[21] However, the structural shifts that would give rise to the need for finite memory least squares are omitted from the Orphanides and Williams (2005a) analysis.

inflation target is enough to generate the phenomenon. Thus, limiting monetary policy uncertainty through credible and fixed inflation targets would reduce or eliminate the possibility of stagflation in the class of models considered here.

The model we consider in this paper is relatively standard and omits key features of the current landscape. Most notably, as we only allow for shocks to the policy rule and the inflation target—both of which, in the real world, may be under the control of the monetary authority—we omit the zero lower bound on interest rates as a binding constraint. Thus, the key results are likely best interpreted as applying during normal times. Indeed, as one example, Eggertsson (2012) finds that an economy at the zero lower bound may actually benefit from policies that would be counterproductive under regular circumstances, and one proposed solution for exiting and avoiding the zero lower bound calls for either a permanently higher or temporarily higher inflation target (e.g., Blanchard et al. 2010). We leave the potential stagflationary consequences of such measures, if any, for future research.

VI   Works Cited

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Figure 1: U.S. GDP Growth and Inflation, 1970–83
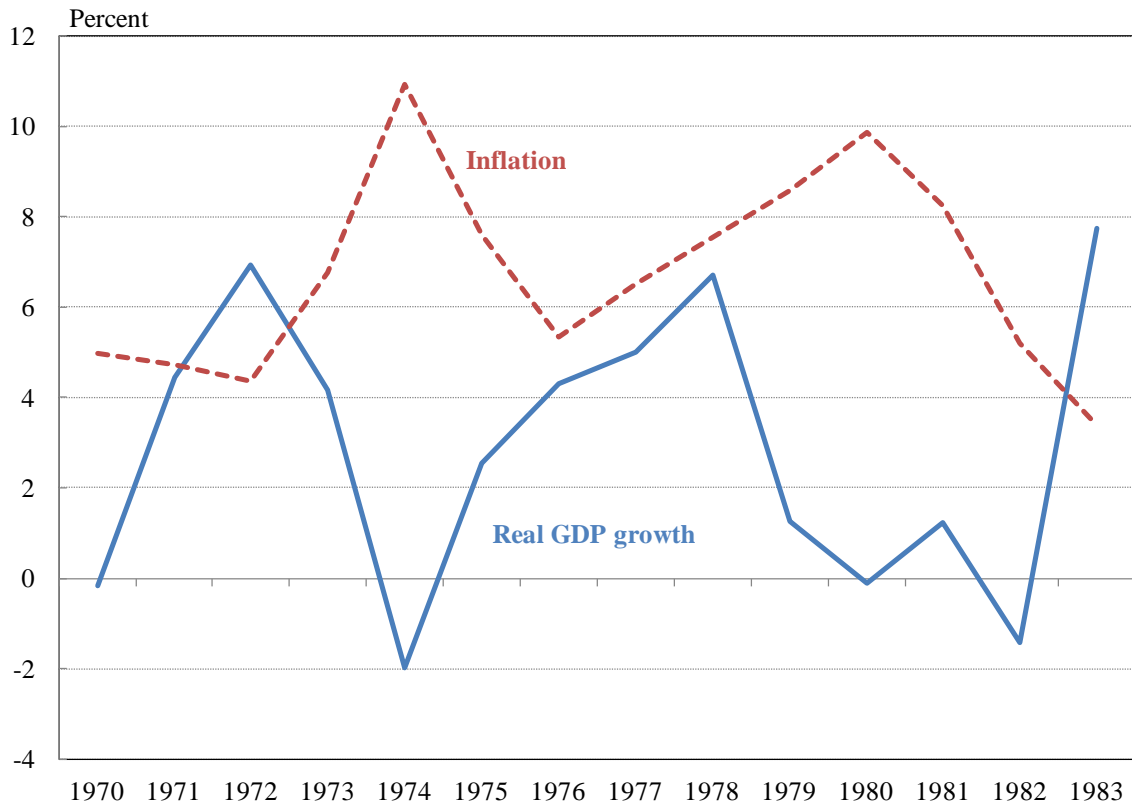
Notes: Real GDP growth is the Q4/Q4 percentage change. Inflation is the Q4/Q4 percentage
change in the GDP chain-type price index.
Source: BEA and authors' calculations.

Figure 2: Quarterly Data on the U.S. Output Gap and Inflation, 1970–83
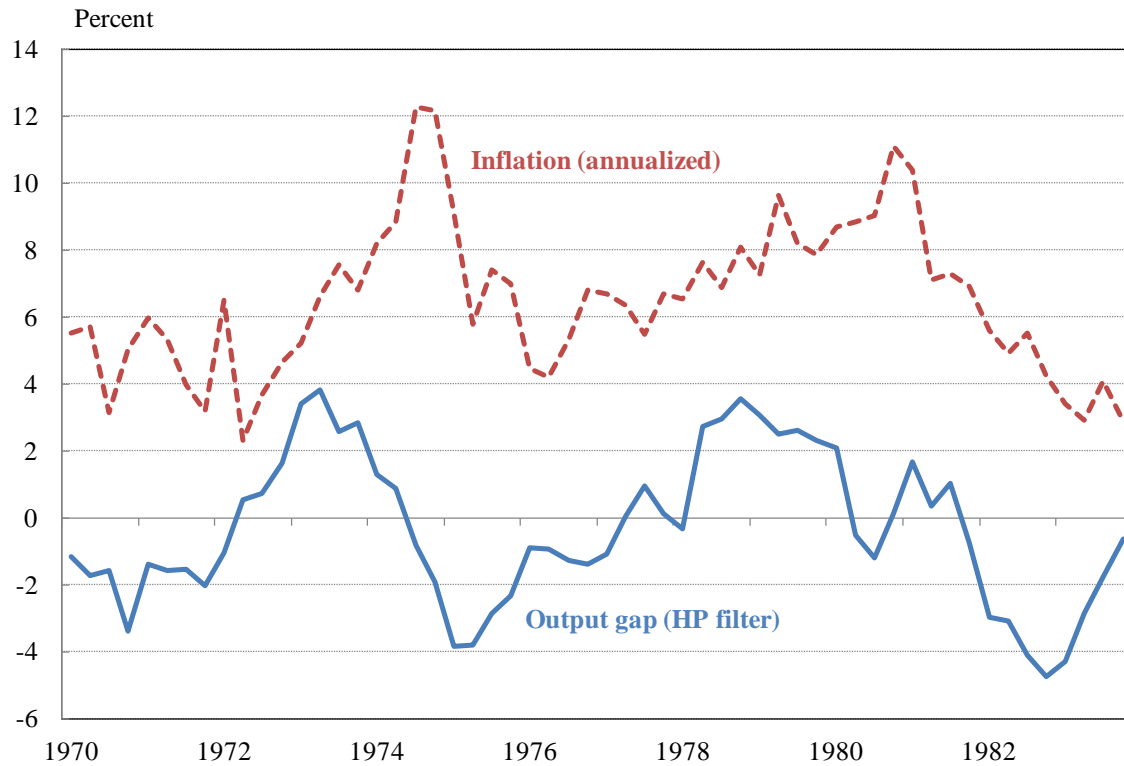
Notes: The output gap is constructed using the Hodrick-Prescott filter with smoothing parameter 1,600. Inflation is the annualized growth rate in the quarterly GDP chain-type price index.
Source: BEA and authors' calculations.

Figure 3: Stagflation in the United States
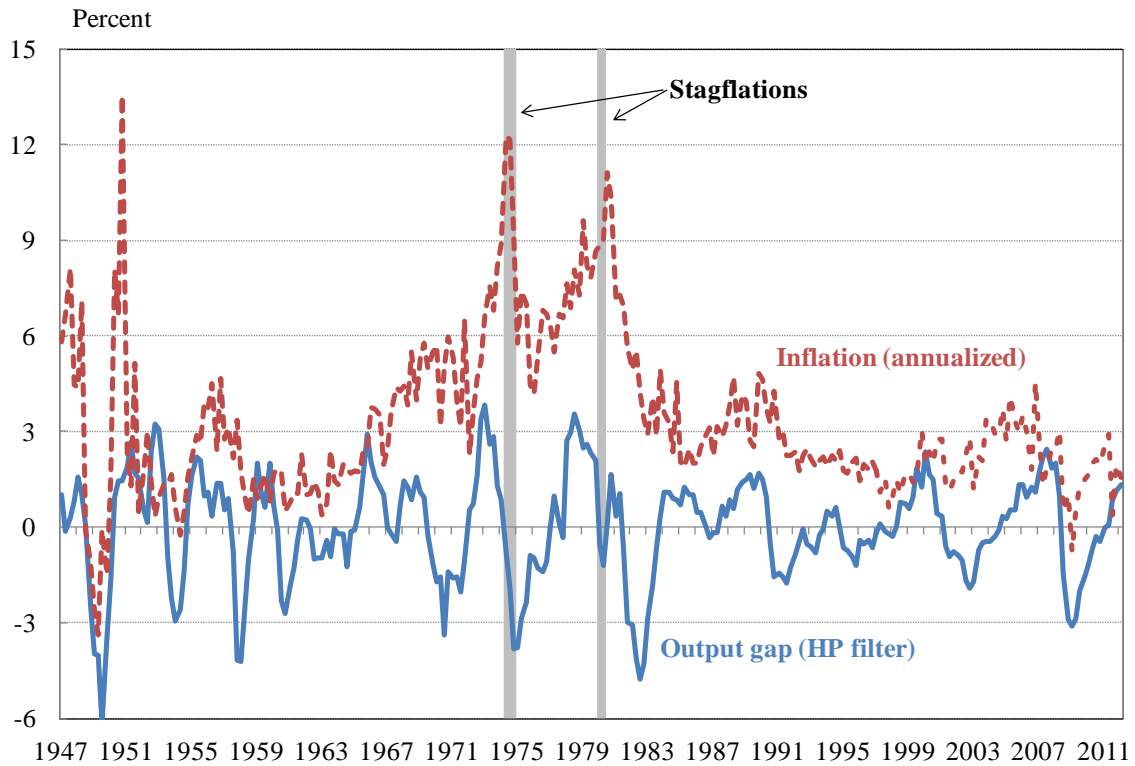
Notes: The output gap is constructed using the Hodrick-Prescott filter with smoothing parameter 1,600. Inflation is the annualized growth rate in the quarterly GDP chain-type price index. Stagflation is defined using the algorithm in Section II.
Source: BEA and authors' calculations.

Figure 4: Stagflation in the United States, CBO Output Gap
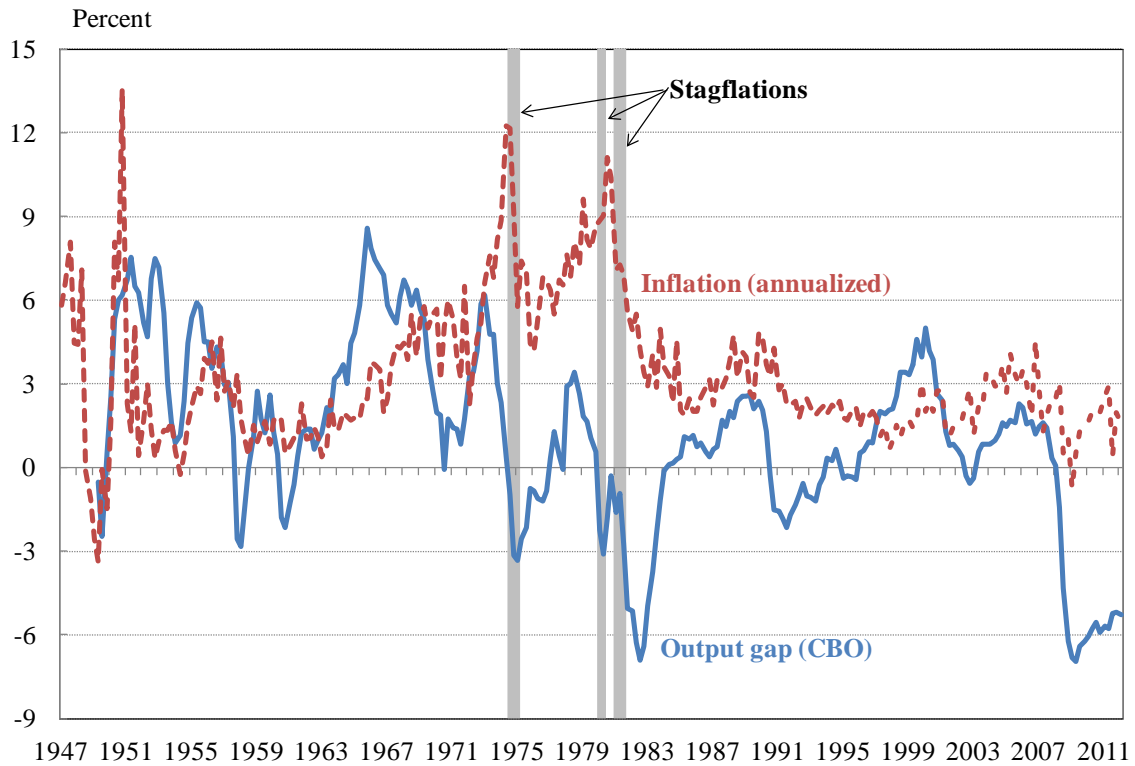
Notes: The output gap is computed using potential GDP from the CBO. CBO estimates of potential GDP are unavailable for 1947Q1 through 1949Q2. Inflation is the annualized growth rate in the quarterly GDP chain-type price index. Stagflation is defined using the algorithm in Section II.
Source: BEA and authors' calculations.

Figure 5: Go-Stop Monetary Policy around Stagflations

(a) Composite monetary shocks u

(b) Inflation target shocks e

(c) Policy rule shocks ε

Quarters after the start of stagflation
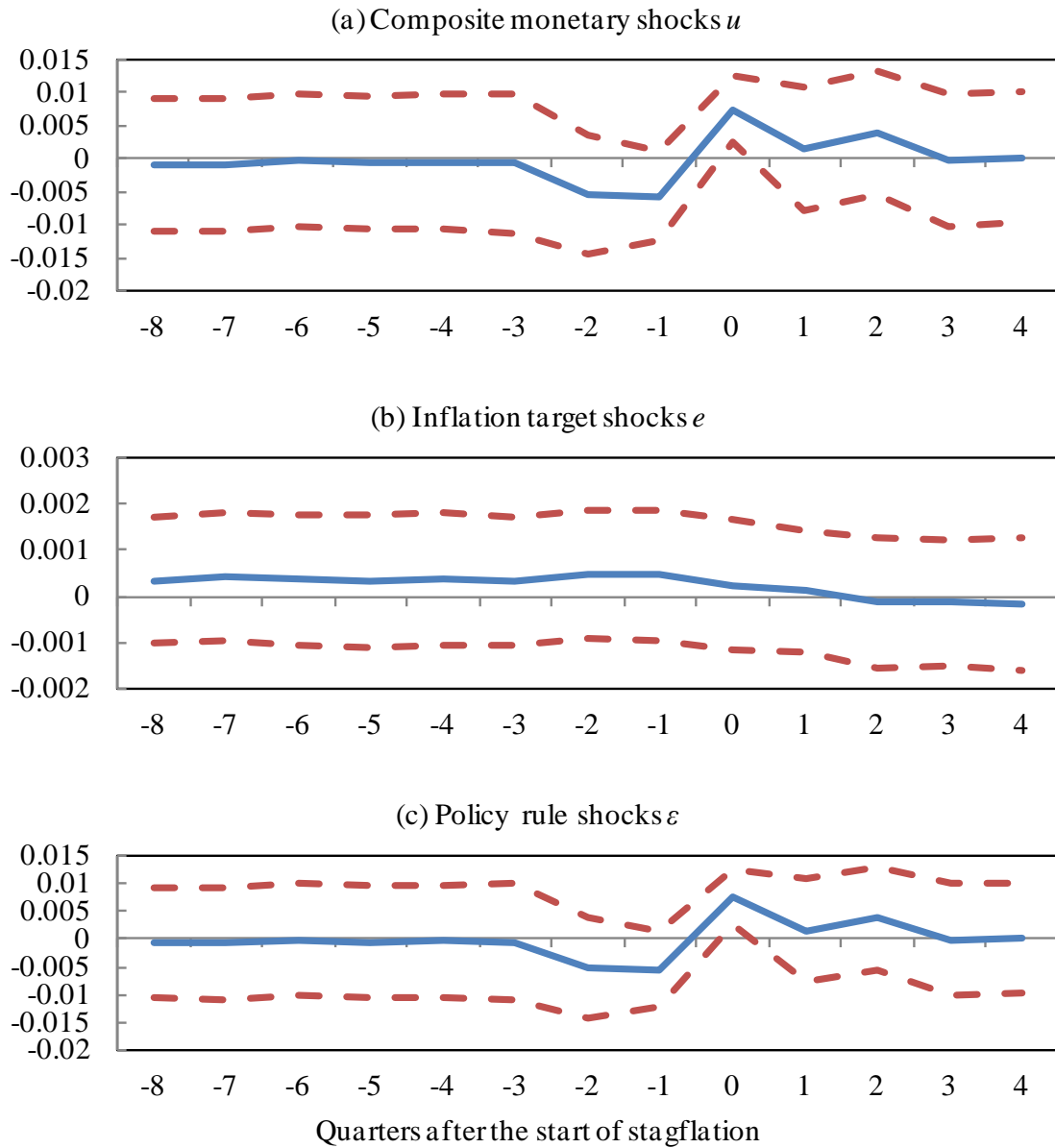
Notes: The figure plots the mean (solid line) and one standard deviation bands (dashed lines) for the distribution of shocks around the start of each stagflationary episode. Shocks are plotted for the baseline parameterization of the model when private agents need to learn about the inflation target.

Figure 6: Impulse Responses to a Policy Rule Shock, Baseline Model

(a) Policy rate

% deviation from ss

(b) Real rate

(c) Expected inflation target

(d) Inflation

(e) Output gap
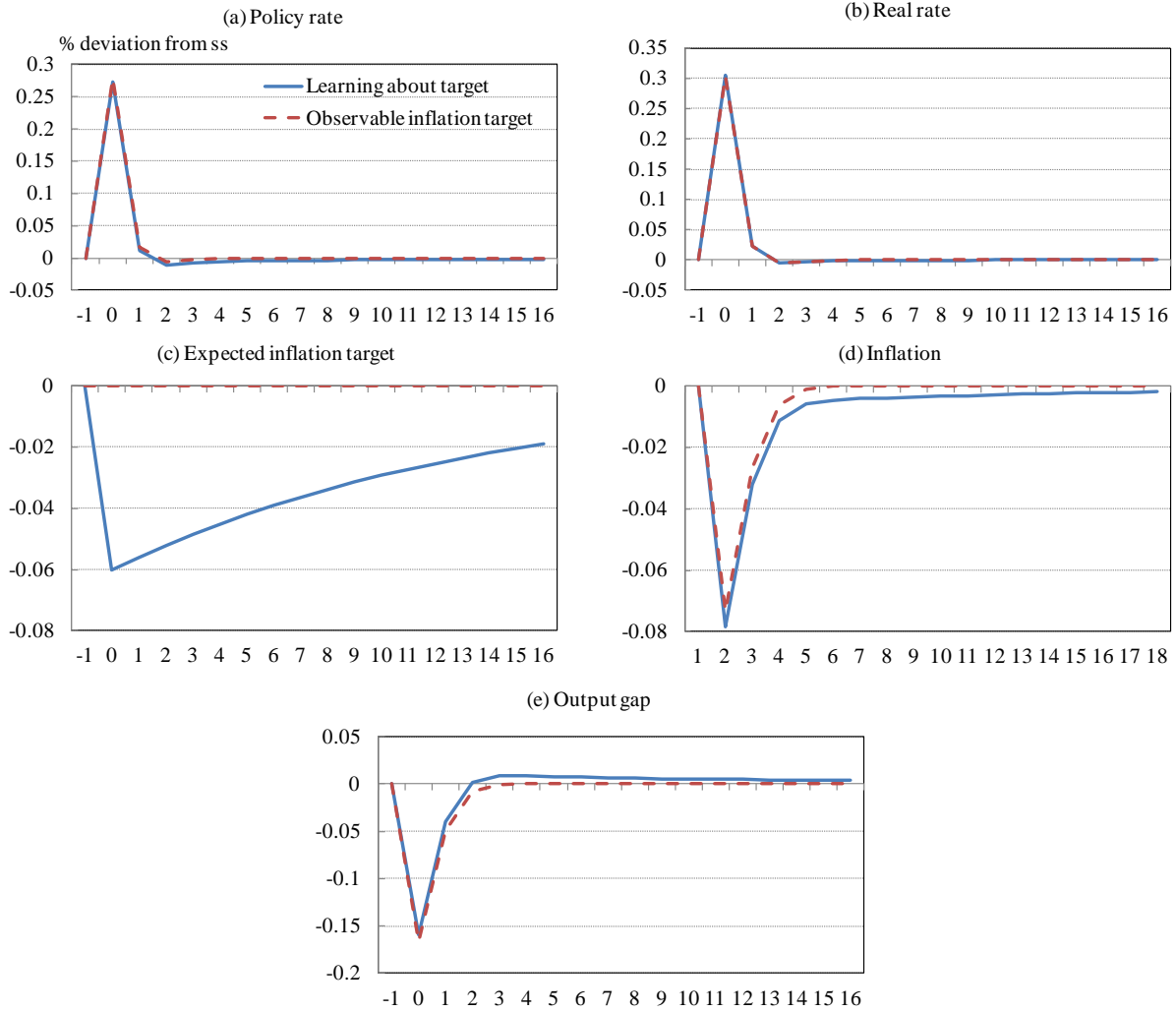
Note: Impulse responses to a 0.5% positive shock ε to the policy rule.

Figure 7: Impulse Responses to an Inflation Target Shock, Baseline Model

(a) Policy rate

(b) Real rate

(c) Expected Inflation Target

(d) Inflation

(e) Output gap
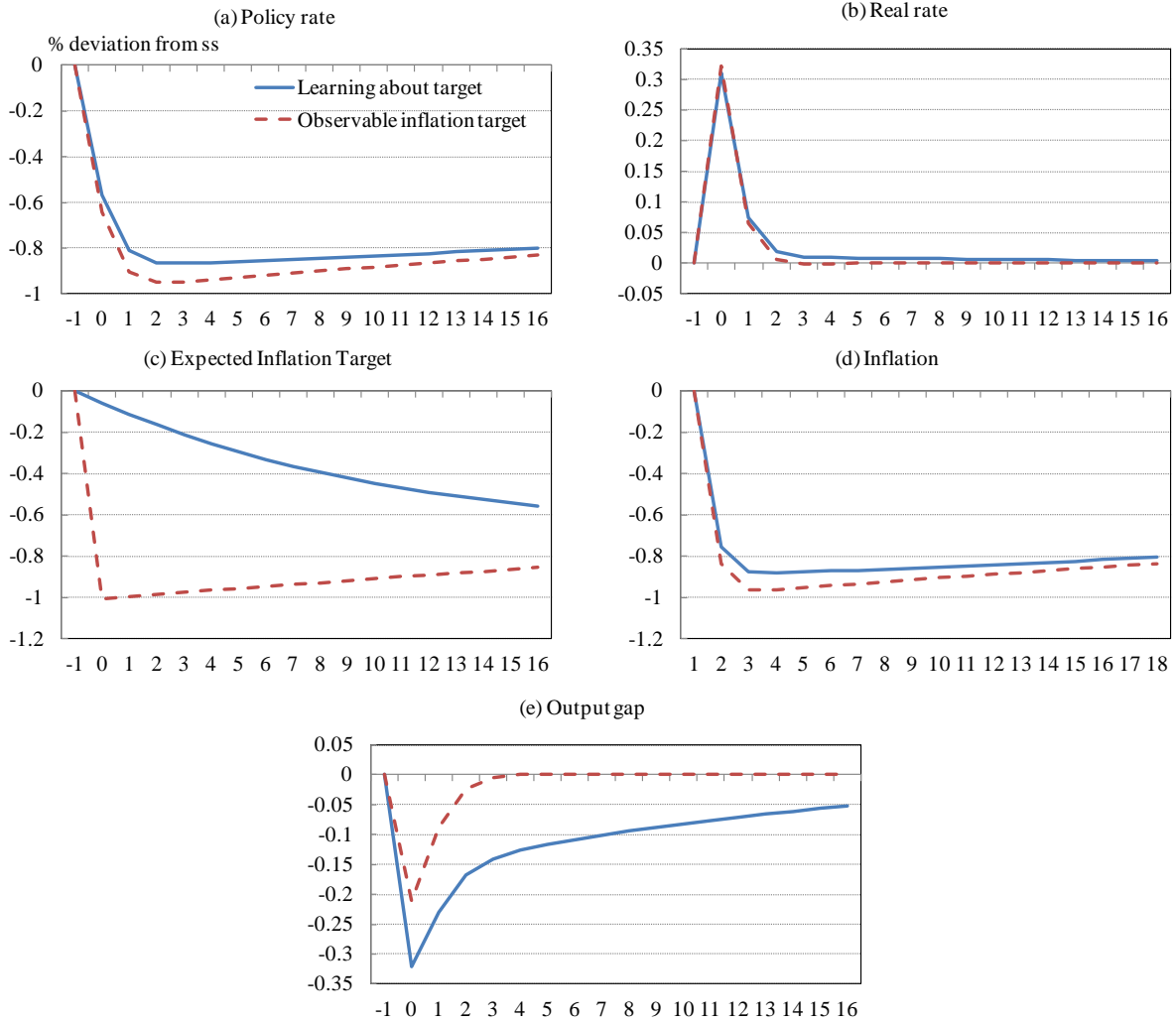
Note: Impulse responses to a 1% negative shock *e* to the inflation target.

Figure 8: Impulse Responses to a Policy Rule Shock, Increased Signal-to-Noise Ratio

(a) Policy rate

% deviation from ss

— Learning about target
- - Observable inflation target

(b) Real rate

(c) Expected inflation target

(d) Inflation

(e) Output gap
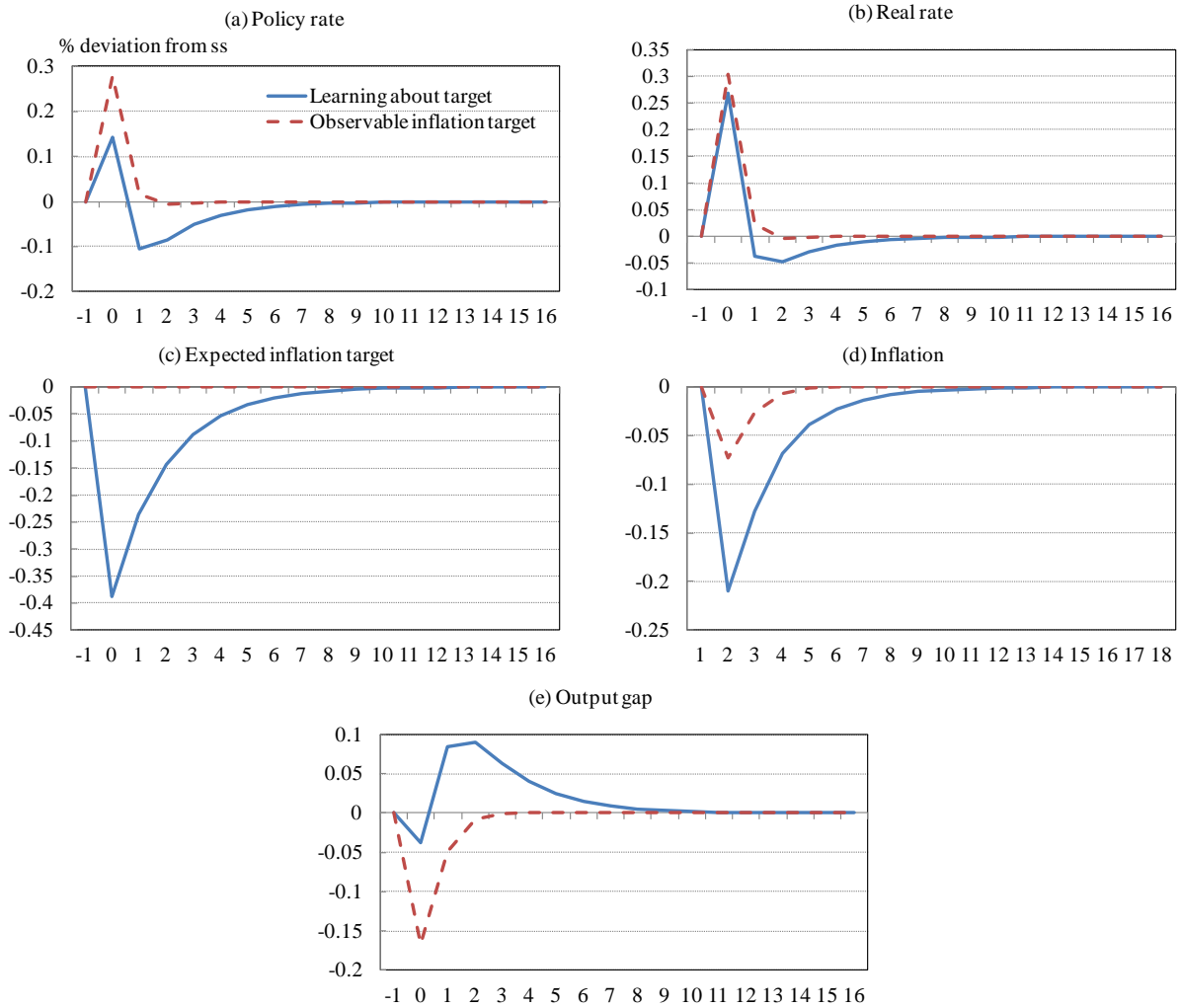
Note: Impulse responses to a 0.5% positive shock ε to the policy rule.

Table 1: Stagflation in a Baseline Monetary Model

Case	Percentage of simulations with at least 1 stagflation	Average number of stagflationary quarters	Standard deviation of (%):		
			Output gap	Inflation	Policy rate
1. Shocks to e and ε, learning about π_t^*	90.4	7.5	0.3	2.5	3.2
2. Shocks to e and ε, π_t^* observable	94.4	8.7	0.3	2.5	3.3
3. Shocks to e only, learning about π_t^*	87.3	6.5	0.1	2.4	2.3
4. Shocks to e only, π_t^* observable	99.4	12.0	0.0	2.5	2.4
5. Shocks to ε only, learning about π_t^*	0	0	0.3	0.7	2.2
6. Shocks to ε only, π_t^* observable	0	0	0.3	0.6	2.2
7. U.S. data, HP filtered output gap	…	5	1.7	2.5	3.3
8. U.S. data, CBO output gap	…	8	2.8		

Notes: The baseline model is calibrated as in Section IV. Shocks to e affect the inflation target π_t^*. Shocks to ε affect the interest rate target. The results are based on 1,000 simulated economies over 246 quarters. Stagflationary quarters satisfy the algorithm constructed in Section II. The standard deviations for U.S. data are for 1947Q2 through 2008Q3 for the HP filtered output gap and inflation, 1949Q3 through 2008Q3 for the CBO output gap, and 1954Q3 through 2008Q3 for the fed funds rate.

Table 2: Go-Stop Policy Episodes and Stagflation

Case	Number of go-stop monetary policy episodes	Number of go-stop episodes with at least 1 stagflationary quarter	Percentage of go-stop episodes with at least 1 stagflationary quarter
1. Shocks to e and ε, learning about π_t^*	4085	419	10.3
2. Shocks to e and ε, π_t^* observable	4135	453	11.0
3. Shocks to e only, learning about π_t^*	4537	405	8.9
4. Shocks to e only, π_t^* observable	3246	510	15.7
5. Shocks to ε only, learning about π_t^*	4107	0	0
6. Shocks to ε only, π_t^* observable	4231	0	0

Notes: A go-stop monetary policy episode is defined as a sequence of composite monetary policy shocks over six quarters that falls entirely within the pattern traced out by the plus/minus one standard deviation range of policy shocks that actually generated stagflation; for example, see Figure 5(a) from quarter −3 to +2. Case (5) uses the same definition of go-stop monetary policy episodes as case (1), and case (6) uses the same definition of go-stop episodes as case (2). See Section IV for more details.

Table 3: Alternative Calibrations of the Model

Case	Percentage of simulations with at least 1 stagflation	Average number of stagflationary quarters	Standard deviation of (%): Output gap	Inflation	Policy rate
Forward-looking model:					
1. Shocks to e and ε, learning about π_t^*	88.5	7.6	0.6	2.6	3.8
2. Shocks to e and ε, π_t^* observable	91.8	8.5	0.7	2.6	3.9
3. Shocks to e only, learning about π_t^*	68.4	4.3	0.1	2.4	2.4
4. Shocks to e only, π_t^* observable	100.0	24.1	0.0	2.5	2.5
5. Shocks to ε only, learning about π_t^*	0	0	0.6	0.8	2.9
6. Shocks to ε only, π_t^* observable	0	0	0.7	0.7	2.9
Inertial model:					
7. Shocks to e and ε, learning about π_t^*	90.4	6.6	0.1	2.4	3.6
8. Shocks to e and ε, π_t^* observable	94.0	8.1	0.1	2.5	3.6
9. Shocks to e only, learning about π_t^*	94.4	7.3	0.0	2.4	2.3
10. Shocks to e only, π_t^* observable	99.0	9.6	0.0	2.4	2.4
11. Shocks to ε only, learning about π_t^*	0.5	0.0	0.0	0.5	2.7
12. Shocks to ε only, π_t^* observable	0	0	0.1	0.5	2.7
13. U.S. data, HP filtered output gap	…	5	1.7	2.5	3.3
14. U.S. data, CBO output gap	…	8	2.8		

Notes: The forward-looking model uses the baseline parameters with $\xi=\gamma=\psi_i=\psi_y=0$. The inertial model uses the baseline parameters with $\xi=\gamma=0.75$. Shocks to e affect the inflation target π_t^*. Shocks to ε affect the interest rate target. The results are based on 1,000 simulated economies over 246 quarters. Stagflationary quarters satisfy the algorithm constructed in Section II. The standard deviations for U.S. data are for 1947Q2 through 2008Q3 for the HP filtered output gap and inflation, 1949Q3 through 2008Q3 for the CBO output gap, and 1954Q3 through 2008Q3 for the fed funds rate.

Table 4: Alternative Monetary Policy Parameterizations

Case	Percentage of simulations with at least 1 stagflation	Average number of stagflationary quarters	Standard deviation of (%):		
			Output gap	Inflation	Policy rate
Taylor (1993) rule:					
1. Shocks to e and ε, learning about π_t^*	94.5	9.1	0.3	2.4	3.5
2. Shocks to e and ε, π_t^* observable	97.0	10.6	0.3	2.5	3.7
Inertial policy rule:					
3. Shocks to e and ε, learning about π_t^*	73.4	4.3	0.3	2.6	2.4
4. Shocks to e and ε, π_t^* observable	81.2	5.3	0.4	2.6	2.5
Low inflation target persistence:					
5. Shocks to e and ε, learning about π_t^*	0.1	0.0	0.3	0.7	2.2
6. Shocks to e and ε, π_t^* observable	16.5	0.5	0.3	0.8	2.3
7. U.S. data, HP filtered output gap	…	5	1.7	2.5	3.3
8. U.S. data, CBO output gap	…	8	2.8		

Notes: The Taylor (1993) rule uses the baseline parameters with $\psi_i=0$ and $\psi_y=0.5$. The inertial policy rule uses the baseline parameters with $\psi_i=0.7$. The low inflation target persistence uses the baseline parameters with $\rho=0.7$. Shocks to e affect the inflation target π_t^*. Shocks to ε affect the interest rate target. The results are based on 1,000 simulated economies over 246 quarters. Stagflationary quarters satisfy the algorithm constructed in Section II. The standard deviations for U.S. data are for 1947Q2 through 2008Q3 for the HP filtered output gap and inflation, 1949Q3 through 2008Q3 for the CBO output gap, and 1954Q3 through 2008Q3 for the fed funds rate.

Table 5: Alternative Signal-to-Noise Ratios

Case	Percentage of simulations with at least 1 stagflation	Average number of stagflationary quarters	Standard deviation of (%): Output gap	Inflation	Policy rate
Decreased signal-to-noise ratio:					
1. Shocks to e and ε, learning about π_t^*	2.4	0.1	0.3	0.7	2.3
2. Shocks to e and ε, π_t^* observable	2.7	0.1	0.3	0.7	2.3
Increased signal-to-noise ratio:					
3. Shocks to e and ε, learning about π_t^*	99.6	11.9	0.6	17.2	16.9
4. Shocks to e and ε, π_t^* observable	99.4	12.6	0.4	17.4	17.3
5. Shocks to ε only, learning about π_t^*	100	11.9	0.3	2.1	1.6
6. Shocks to ε only, π_t^* observable	0	0	0.3	0.6	2.2
7. U.S. data, HP filtered output gap	…	5	1.7	2.5	3.3
8. U.S. data, CBO output gap	…	8	2.8		

Notes: The decreased signal-to-noise ratio case uses the baseline parameters with $\sigma_v^2 = 4 \times 10^{-4}$ and $\sigma_e^2 = 4 \times 10^{-8}$. The increased signal-to-noise ratio case uses the baseline parameters with $\sigma_v^2 = 1$ and $\sigma_e^2 = 1 \times 10^{-4}$. Shocks to e affect the inflation target π_t^*. Shocks to ε affect the interest rate target. The results are based on 1,000 simulated economies over 246 quarters. Stagflationary quarters satisfy the algorithm constructed in Section II. The standard deviations for U.S. data are for 1947Q2 through 2008Q3 for the HP filtered output gap and inflation, 1949Q3 through 2008Q3 for the CBO output gap, and 1954Q3 through 2008Q3 for the fed funds rate.