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David Kiefer

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REVEALED PREFERENCES FOR MACROECONOMIC STABILIZATION

David Kiefer*
University of Utah

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In the new Keynesian model of endogenous stabilization governments have objectives with respect to macroeconomic performance, but are constrained by an augmented Phillips curve. Because they react more quickly to inflation shocks than private agents, governments can lean against the macroeconomic wind. We develop an econometric test of this characterization of the political-economic equilibrium. Applying this methodology to a variety of quadratic social welfare functions provides inferences about the functional form of stabilization preferences and about the formation of expectations.

JEL classification codes: E61, E63
Key words: endogenous stabilization, policy objectives, adaptive expectations

I. Introduction

A number of plausible assumptions are consistent with an endogenous stabilization model.[1] One of these relates to the functional form of the government's objective function; using US and OECD series on inflation and growth we compare eight quadratic forms. Although identification issues arise and some statistical ambiguity remains, our preferred form (circular indifference curves with an inflation policy target) has a significantly better statistical fit than the agnostic vector autoregression benchmark.

Because expected inflation enters the analysis as a shift parameter for the augmented Phillips curve, another modeling assumption concerns the formation of inflation forecasts by economic agents. We develop theoretical solutions and econometric specifications for two possibilities: strongly rational and simple

* Economics Department, 1645 Campus Center Dr., Room 308, Salt Lake City, UT 84112, phone: (801) 581-7481, fax: (801) 585-5946, email: kiefer@economics.utah.edu. I am grateful to Jorge Streb and two anonymous referees for insightful comments.

[1] Another name is political business cycle theory. The original insight for this literature dates to Kalecki (1943); also see Nordhaus (1975) or Hibbs (1977).

adaptive expectations. Rationality is the overwhelming assumption of the economics literature because it coheres with the notion on well-informed maximizing agents. We find, however, that its implications do not conform well to observed outcomes when applied to endogenous stabilization; an adaptive model fits the data better. The adaptive rule, often labeled naïve, could be the rational strategy in an uncertain world.

II. Economic structure and objectives

The literature on political macroeconomics invariably invokes an augmented Phillips curve as a structural constraint on policymakers.[2] Conventionally this is an inverse relation between the unexpected inflation and the gap between actual and natural unemployment. Since the labor and product markets are linked, the natural output Y_t^* is conceptually equivalent to the natural rate of unemployment. We substitute the output gap, defined as $y_t = \ln(Y_t) - \ln(Y_t^*)$ for the unemployment gap as the measure of macroeconomic disequilibrium in our Phillips curve,[3]

$$\pi_t = \pi_t^e + \psi y_t + \varepsilon_t, \tag{1}$$

where π_t is the inflation rate and ε_t defines a random inflation shock. Expected inflation is π_t^e, is the inflation rate and ε_t defines a random inflation shock. Expected inflation is π_t^e, the forecast of a typical agent based on information available in the previous period. Assuming expectations are fulfilled in the long run, this relation rules out any long-run deviation from $y = 0$. However, as long as economic agents do not fully anticipate the effects of fiscal, monetary and other policies, governments are able to temporarily increase output at the cost of more rapid inflation.

Another essential element is an assumption about political objectives. One possibility is to suppose that the government's goals are given by a quadratic function of growth and inflation,

$$U_t = -\frac{1}{2}\left(\left(g_t - g_t^*\right)^2 + \left(\pi_t - \hat{\pi}\right)^2\right) \tag{2}$$

where the growth rate of real output is $g_t = \ln(Y_t) - \ln(Y_{t-1})$, and $g_t^* = \ln(Y_t^*) - \ln(Y_{t-1}^*)$ is the natural rate of growth.

[2] See, for example, Nordhaus (1975), Barro and Gordon (1983) or Alesina (1987).

[3] The name of this equation derives from Phillips' (1958) study of the inverse relation between the unemployment rate and the wage inflation rate. Later Friedman (1968) reformulated the relation in terms of price inflation and added expected inflation.

The modeling of collective objectives is controversial. Textbooks often define social welfare as an aggregation of individual preferences. Governmental targets may reflect a weighted average of citizen preferences, with heavier weights assigned to the ruling party's core constituents. Differing targets for inflation could account for ideological differences. It is also possible that the governments in all countries share the same target. In the regression models below we incorporate this heroic assumption as a first approximation. Functions such as (2) have been called "abbreviated social welfare functions" because they are written in terms of economic indicators such as inflation rather than citizen preferences; see Lambert (1993). Quadratic forms are tractable because they always result in linear solutions. Within the quadratic family, a variety of alternatives are plausible. Equation (2) has circular indifference curves, but these can be made elliptical by adding a parameter to reflect the relative weight of inflation versus growth goals. Some models allow parabolic indifference curves. Sometimes the growth target differs from the natural rate. Another alternative asserts that goals are specified in terms of output levels, rather than growth rates. Objectives might also include the discounted value of expected future outcomes. The government might plan for its current term of office only, or it might plan to be in office for several terms, discounting the future according to the probability of holding office. Alternatively, it might weigh preelection years more heavily. Here we assume that only current conditions matter.[4] Beginning with (2), this paper examines the statistical performance of some of these possibilities.

III. Endogenous stabilization under circular objectives with an inflation target

The government has limited options in a new Keynesian model of activist stabilization. It is assumed that the government can exploit information and implementation advantages to lean against the macroeconomic wind, although its goals ($g_t = g_t^*$ and $\pi_t = \hat{\pi}$) may be unattainable.[5] The government uses up-todate information to guide policy, observing shocks and setting inflation accordingly. It has an information advantage over agents, who forecast inflation in the previous period. Rational agents come to understand that a policy of $\hat{\pi} > 0$ implies inflation;

[4] See Kiefer (2000) for empirical evidence that only current conditions matter in political business cycle econometrics.

[5] Fischer (1977) is an early example in this literature.

this expectation is a self-fulfilling prophecy. The stylized fact of inflation is consistent with the hypothesis that governments target inflation.[6]

The long-run equilibrium is disturbed by exogenous shocks. To derive the government's policy, we rewrite the Phillips curve using the definition of the growth rate:

$$g_t \equiv y_t - y_{t-1} + g_t^*,\ \pi_t = \pi_t^e + \psi\left(g_t + y_{t-1} - g_t^*\right) + \varepsilon_t.$$

And use this to substitute for g_t in (2),

$$U_t = -\frac{1}{2}\left(\left(\frac{\pi_t - \pi_t^e - \varepsilon_t}{\psi} - y_{t-1}\right)^2 + \left(\pi_t - \hat{\pi}\right)^2\right).$$

Maximizing with respect to π_t, the government's preferred policy is

$$\pi_t = \frac{\pi_t^e + \varepsilon_t + \psi y_{t-1} + \psi^2 \hat{\pi}}{1+\psi^2},\ g_t = g_t^* - y_{t-1} + \frac{y_{t-1} - \psi\left(\pi_t^e + \varepsilon_t - \hat{\pi}\right)}{1+\psi^2}. \qquad (3)$$

Among other things, this implies that inflation and growth depend on conditions inherited from the past, expectations and policy targets. We assume that the government can implement its preferred policy through various policy instruments, and that the various government agencies (central banks and treasuries) pursue this common policy.

In the absence of shocks or uncertainty, the time-consistent equilibrium inflation rate should occur where inflation is just high enough so that the government is not tempted to spring a policy surprise. This equilibrium is the natural output, natural growth and an ideologically determined rate of inflation,

$$y = 0,\ g = g^*,\ \pi = \hat{\pi}.$$

Ideally a rational agent uses available information to forecast inflation. The typical agent knows what the inflation target is; she also knows the slope of the Phillips curve, the long-run growth trend and the pre-existing economic condition.

[6] Barro and Gordon (1983) originally identified this inflationary bias. Their paper invokes a slightly different objective function based on unemployment and inflation, with an unemployment target below the natural rate. An inflation bias can result from either the unemployment or the inflation target.

However, we suppose that she cannot predict the next inflation shock ε_t. Her information set is $I = \{\hat{\pi}, g_t^*, \psi, y_{t-1}\}$ This assumption about forecaster sophistication is strong. To obtain the rational expectation of π given I, we take the conditional expectation of the inflation equation (3) and solve:

$$\pi_t^e = E(\pi_t) = \hat{\pi} + \frac{y_{t-1}}{\psi}, \tag{4}$$

so that expectations are given by the government's inflation target with a correction for pre-existing economic conditions. Substituting (4) into (3) gives the rational solution

$$\pi_t = \hat{\pi} + \frac{\varepsilon_t}{1+\psi^2} + \frac{y_{t-1}}{\psi},\ g_t = g_t^* - y_{t-1} - \frac{\psi\varepsilon_t}{1+\psi^2}\ . \tag{5}$$

A weak alternative is that inflation expectations are simply observed inflation in the previous year , $\pi_t^e = \pi_{t-1}$, which we substitute into (3) as a regression specification. Commonly referred to as the adaptive expectations model, it assumes that agents are quick learners, but forgetful. Although many economists view the adaptive model with suspicion because such forecasts can be irrational, adaptive behavior may often be found. This simple forecasting rule has the desirable property that it too can converge to the time-consistent equilibrium. For this reason we characterize the adaptive model as weakly rational.[7]

IV. Other functional forms

A. Elliptical objectives

In light of the formal adoption of inflation targeting at a number of central banks, including the new European Central Bank, we consider a modification to our

[7] Before elections the situation can be less certain. Then, a sophisticated agent takes into account her opinion about the outcome of the upcoming election. Invoking rational expectations under these conditions, expected inflation equals a weighted average of partisan targets, with the appropriate weights being the agent's prediction of which party will hold power during the next period, see Alesina (1987). Furthermore, in many countries early elections can be called at any time. Under these constitutions every year is potentially an election year, and there is always a positive probability of government change. Here we ignore these complications in order to concentrate on the functional form of the government's objective.

restrictive assumption that equal deviations from natural growth and the target inflation imply equal loss. We can generalize (2) to give elliptical, rather than circular, indifference curves with

$$U_t = -\frac{1}{2}\left(\left(g_t - g_t^*\right)^2 + \lambda\left(\pi_t - \hat{\pi}\right)^2 \right), \tag{6}$$

where the strength of inflation targeting is parameterized by the magnitude of λ.[8] Another reason for considering the elliptical form is the literature on the advantage of a conservative central banker, originating with Rogoff (1985). Often this type of conservatism is modeled in terms of the λ weight.[9]

Certainly the assumption that λ=1 is restrictive; perhaps we can settle this issue empirically. Deriving the government's preferred policy as before, the elliptical solution is

$$\pi_t = \frac{\pi_t^e + \varepsilon_t + \psi y_{t-1} + \lambda\psi^2\hat{\pi}}{1+\lambda\psi^2}, \; g_t = g_t^* - y_{t-1} + \frac{y_{t-1} - \lambda\psi\left(\pi_t^e + \varepsilon_t - \hat{\pi}\right)}{1+\lambda\psi^2}. \tag{7}$$

Comparing the circular solution with this one, and relabeling the circular model parameter with a tilde, we see that (7) is equivalent to (3) if

$$\frac{1}{1+\tilde{\psi}^2} = \frac{1}{1+\lambda\psi^2}, \quad \frac{\tilde{\psi}}{1+\tilde{\psi}^2} = \frac{\lambda\psi}{1+\lambda\psi^2}, \quad \frac{\tilde{\psi}^2}{1+\tilde{\psi}^2} = \frac{\lambda\psi^2}{1+\lambda\psi^2}.$$

Since this is only true in the trivial case that $\lambda = 1$, (7) is identified with respect to (3).

In this model the rational inflation expectation is $\pi_t^e = \hat{\pi} + \frac{y_{t-1}}{\lambda\psi}$. Substituting this expression into (7) gives the rational expectations solution:

$$\pi_t = \hat{\pi} + \frac{\varepsilon_t}{1+\lambda\psi^2} + \frac{y_{t-1}}{\lambda\psi}, \; g_t = g_t^* - y_{t-1} - \frac{\lambda\psi\varepsilon_t}{1+\lambda\psi^2} \tag{8}$$

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[8] Alesina's (1988) objective function generalizes (6) by allowing growth targets other than the natural rate and by including future inflation and growth.

[9] A similar advantage also results from a policymaker who is conservative in the sense that her target is closer to zero than that of the public; see Kiefer (2004).

B. Growth targets

There are other plausible objective functions; below we survey a variety of quadratic alternatives. Instead of an inflation target, the government might have a growth rate target:

$$U_t = -\frac{1}{2}\left((g_t - \hat{g})^2 + \pi_t^{\,2}\right), \tag{9}$$

where $\hat{g}$ is the government's preferred rate of growth. While (2) could be motivated by seigniorage, this form may be interpreted as compensation for labor market or tax imperfections, or it may be that governments prefer high growth for ideological reasons. It is possible that governments and voters target growth rates in excess of the natural growth rate, even when this is logically unsustainable.

Governmental options are still limited by the Phillips curve (1), and the economic-political equilibrium is still disturbed by exogenous shocks. As before we derive the government's policy by using the Phillips curve to substitute for g_t in the objective function. In this case the government's preferred policy is:

$$\pi_t = \frac{\pi_t^e + \varepsilon_t + \psi y_{t-1} + \psi\left(\hat{g} - g_t^*\right)}{1+\psi^2}, \tag{10}$$

$$g_t = g_t^* - y_{t-1} + \frac{y_{t-1} - \psi\left(\pi_t^e + \varepsilon_t\right) + \left(\hat{g} - g_t^*\right)}{1+\psi^2}.$$

In the absence of shocks and uncertain government changes, the time-consistent equilibrium is the natural output, natural growth and an ideologically determined rate of inflation,

$$y = 0,\ g = g^*,\ \pi = \frac{\hat{g} - g^*}{\psi}.$$

An identification problem arises again in the comparison of inflation and growth targets forms. Whenever $\left(\hat{g} - g_t^*\right) = \psi\hat{\pi}$, the solution (3) is indistinguishable from (10). However, notice that the growth target version implies a variable equilibrium (to the extent that g_t^* evolves over time), while the inflation target version assumes a fixed equilibrium. Thus, the two models do differ slightly, but, as empirical results below confirm, this slight difference may be insufficient to distinguish between them using only observations on inflation and growth.

In the case of a growth rate target, the rational expectation of π is: $\pi_t^e = \dfrac{y_{t-1} + \hat{g} - g_t^*}{\psi}$. Substituting this expression into (10) gives the rational solution

$$\pi_t = \frac{\varepsilon_t}{1+\psi^2} + \frac{y_{t-1} + \hat{g} - g_t^*}{\psi},\ g_t = g_t^* - y_{t-1} - \frac{\psi\varepsilon_t}{1+\psi^2}. \tag{11}$$

Likewise, we can generalize the growth target form to elliptical indifference curves,

$$U_t = -\frac{1}{2}\left((g_t - \hat{g})^2 + \lambda\pi_t^{\,2}\right). \tag{12}$$

Now we find that the government's preferred policy is

$$\pi_t = \frac{\pi_t^e + \varepsilon_t + \psi y_{t-1} + \psi\left(\hat{g} - g_t^*\right)}{1+\lambda\psi^2}, \tag{13}$$

$$g_t = g_t^* - y_{t-1} + \frac{y_{t-1} - \lambda\psi\left(\pi_t^e + \varepsilon_t\right) + \left(\hat{g} - g_t^*\right)}{1+\lambda\psi^2},$$

and the rational solution is

$$\pi_t = \frac{\varepsilon_t}{1+\lambda\psi^2} + \frac{y_{t-1} + \hat{g} - g_t^*}{\lambda\psi},\ g_t = g_t^* - y_{t-1} - \frac{\psi\varepsilon_t}{1+\psi^2}. \tag{14}$$

C. GDP gap targets

Next we consider a related form parameterized on income levels rather than growth rates,

$$U_t = -\frac{1}{2}\left(y_t^{\,2} + (\pi_t - \hat{\pi})^2\right) \tag{15}$$

If voters are concerned about the income level rather than its growth rate, this is arguably the better form. Deriving the government's policy as before we find that the government's preferred policy is

$$\pi_t = \frac{\pi_t^e + \varepsilon_t + \psi^2\hat{\pi}}{1+\psi^2},\ g_t = g_t^* - y_{t-1} - \frac{\psi\left(\pi_t^e + \varepsilon_t - \hat{\pi}\right)}{1+\psi^2}. \tag{16}$$

In the absence of shocks, the time consistent equilibrium is unchanged, $y = 0,\ g = g^*,\ \pi = \hat{\pi}.$

Now the rational inflation expectation is $\pi_t^e = \hat{\pi}.$ Substituting this expression into (16) gives the rational solution

$$\pi_t^e = \hat{\pi} + \frac{\varepsilon_t}{1+\psi^2},\ g_t = g_t^* - y_{t-1} - \frac{\psi\varepsilon_t}{1+\psi^2}. \tag{17}$$

Likewise, we can generalize the GDP gap form to elliptical indifference curves,[10]

$$U_t = -\frac{1}{2}\left(y_t^2 + \lambda(\pi_t - \hat{\pi})^2\right). \tag{18}$$

Now we find that the government's preferred policy is

$$\pi_t = \frac{\pi_t^e + \varepsilon_t + \lambda\psi^2\hat{\pi}}{1+\lambda\psi^2},\ g_t = g_t^* - y_{t-1} - \frac{\lambda\psi\left(\pi_t^e + \varepsilon_t - \hat{\pi}\right)}{1+\lambda\psi^2}. \tag{19}$$

The time-consistent equilibrium is unchanged, as is the rational expectation. The rational solution is

$$\pi_t = \hat{\pi} + \frac{\varepsilon_t}{1+\lambda\psi^2},\ g_t = g_t^* - y_{t-1} - \frac{\lambda\psi\varepsilon_t}{1+\lambda\psi^2}. \tag{20}$$

D. Parabolic objectives

Another alternative quadratic form is a parabolic function,

$$U_t = g_i - (\pi_t - \hat{\pi})^2. \tag{21}$$

A conceptual shortcoming of the quadratic form is its satiation with respect to growth. The parabolic form seems more plausible because it holds that governments are never sated.[11] We derive the policy as before,

$$\pi_t = \frac{1}{2\psi} + \hat{\pi},\ g_t = g_t^* - y_{t-1} + \frac{1}{2\psi^2} - \frac{\pi_t^e + \varepsilon_t - \hat{\pi}}{\psi}. \tag{22}$$

[10] For example, see Clarida et al. (1999).

[11] For example, see Alesina (1987). Nordhaus (1975) considers a parabolic function with inflation as the linear term.

This solution implies that inflation depends only on the inflation target and the slope of the Phillips curve, while growth depends on expectations, lagged output and policy targets.

Now the rational expectation is $\pi_t^e = \frac{1}{2\psi} + \hat{\pi}$. Substituting into (22) gives the rational expectations solution:

$$\pi_t = \frac{1}{2\psi} + \hat{\pi},\ g_t = g_t^* - y_{t-1} - \frac{\varepsilon_t}{\psi}. \tag{23}$$

The parabolic function can also be generalized with a policy weight on inflation analogous to the elliptical forms.[12]

$$U_t = g_i - \lambda(\pi_t - \hat{\pi})^2. \tag{24}$$

Now the solution is:

$$\pi_t = \frac{1}{2\lambda\psi} + \hat{\pi},\ g_t = g_t^* - y_{t-1} + \frac{1}{2\lambda\psi^2} - \frac{\pi_t^e + \varepsilon_t - \hat{\pi}}{\psi}. \tag{25}$$

And substituting the rational expectation, $\pi_t^e = \frac{1}{2\lambda\psi} + \hat{\pi}$, into (25) gives the rational expectations solution:

$$\pi_t = \frac{1}{2\lambda\psi} + \hat{\pi},\ g_t = g_t^* - y_{t-1} - \frac{\varepsilon_t}{\psi}. \tag{26}$$

Unfortunately the difference between the simple model and its policy-weighted generalization cannot be identified for either the adaptive and rational cases. Labeling the unweighted parameters with a tilde, it can be seen that the two parabolic models are indistinguishable whenever

$$\psi = \tilde{\psi} = \frac{1-\lambda}{2\lambda\left(\tilde{\hat{\pi}} - \hat{\pi}\right)}. \tag{27}$$

[12] See, for example, Alesina et al. (1997).

V. Econometric specification and data

Although we may be unable to establish empirically a single most valid model, we nevertheless attempt to narrow the field by fitting the inflation and growth regressions implied by these eight objective functions and both expectations models. Each model can be written as a two-equation reduced form for inflation and growth with four predetermined variables (natural growth, expected inflation, lagged output gap, and inflation shock) of the form:

$$\pi_t = \Pi\left(\pi_t^e, \varepsilon_t, y_{t-1}, g_t^*\right) + e_{\pi t}, \; g_t = G\left(\pi_t^e, \varepsilon_t, y_{t-1}, g_t^*\right) + e_{gt}, \tag{28}$$

where the functions Π and *G* are given by the various theoretical solutions: (3), (7), (10), (13), (16), (19), (22) and (25). These models are linear in variables but nonlinear in their coefficients. Each model in Tables 2, 3 and 5 is identified by its assumed social welfare equation number.

Our basic data are derived from the Penn World Table (PWT6.1), which includes internationally comparable time series on the national accounts for almost all the countries in the world for 1950-2000. Percentage growth is measured as the log difference in real GDP per capita; for details on variable construction see Table 1. Although it is customary to study stabilization outcomes with aggregate statistics, such analysis is equally appropriate with per capita data. The difference is that aggregate growth rates include population growth. Since population growth changes slowly, it has little effect on short-run stabilization.

The inflation rate is defined using the purchasing power parity and GDP estimates from the PWT. In Table 1 the numerator of the implicit deflator is GDP per capita measured in current local currency, and the denominator is the same quantity measured in real terms (1996 local currency units). As an example Figure 1 compares this measure of inflation to official US statistics. It is clear that they are quite close and that the PWT measure can be interpreted as an implicit deflator rate, and is an appropriate indicator of macrostabilization.

Our models call for measures of macroeconomic disequilibrium and the underlying output trend. The published series include only real output per capita, and not its natural level. We estimate a smoothly evolving trend in potential output by fitting a cubic trend to the observed growth rates according to:

$$\ln\left(\frac{Y_t}{Y_{t-1}}\right) = \beta_0 + \beta_1 t + \beta_2 t^2 + \beta_3 t^3, \tag{29}$$

Table 1. Variable definitions

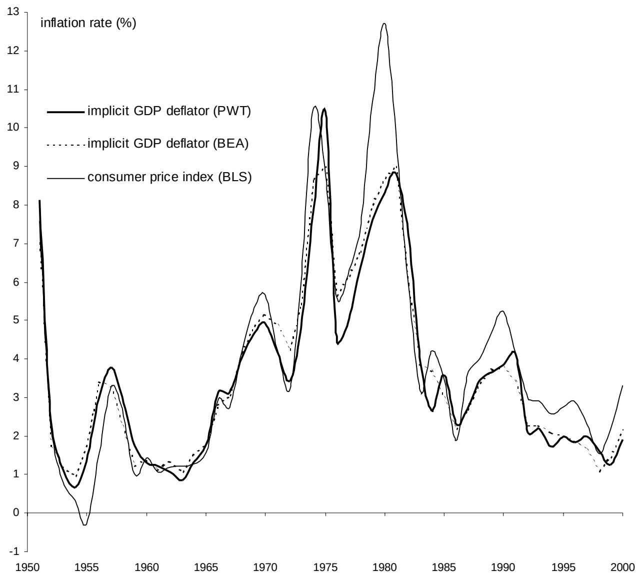
	Symbol	Definitions using PWT 6.1 variable names
Real GDP per capita	Y_{it}	RGDPCHit
Natural real GDP per capita	Y_{it}^{*}	estimated by cubic smoothing
Growth rate	g_{it}	$\ln(RGDPCH_{it}) - \ln(RGDPCH_{it-1})$
Implicit deflator	p_{it}	$\frac{PPP_{it}(CGDP_{it})}{PPP_{i96}(RGDPCH_{it})}$
Inflation rate	π_{it}	$\ln(p_{it}) - \ln(p_{it-1})$

one cubic regression for each country. The predicted values from these regressions are used to estimate Y^{*} according to:

$$\ln(Y_t^{*}) = \ln(Y_0^{*})\left(\prod_{s=0}^{t} \hat{\beta}_0 + \hat{\beta}_1 s + \hat{\beta}_2 s^2 + \hat{\beta}_3 s^3\right) \tag{30}$$

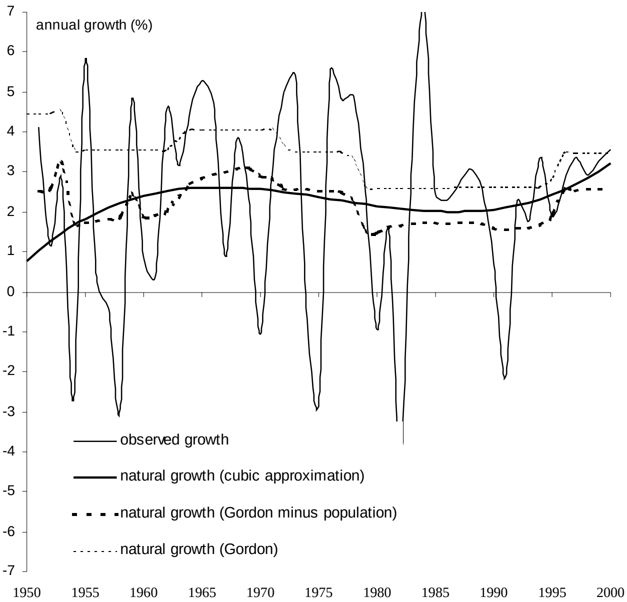
We use the results to construct the required series, the output gap y and the trend growth rate g^{*}. This method makes the convenient assumption that macroequilibrium was achieved in the first year of observation; it also implies macroequilibrium for the last observation. Since neither assumption can be justified, we delete the first two and last two observations for each country from the dataset.

Figure 1. Comparing inflation rates: United States



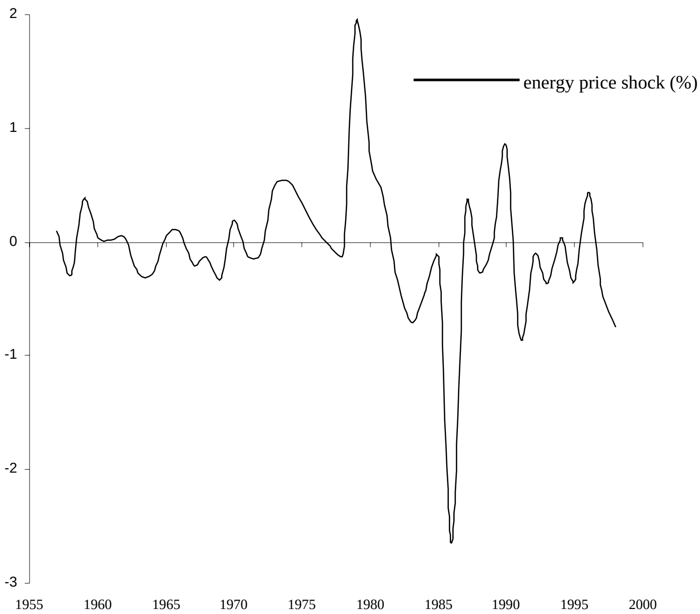
There are other smoothing methods. Gordon (1999) estimates the output gap by picking a list of benchmark dates when he judges that the US economy approximated macroequilibrium, and estimates the natural growth rate between these dates as constant. His benchmark dates are: 1949Q1, 1954Q1, 1957Q3, 1963Q3, 1970Q2, 1974Q2, 1979Q3 1987Q3, 1990Q4, and 1995Q1. Figure 2 compares our estimated natural growth with Gordon's. To make the series comparable, we convert Gordon's aggregate statistics to a per capita basis by subtracting US population growth (according to PWT). By definition the natural level changes over time as technology advances and as capital is accumulated. Assuming that these influences evolve slowly, natural output should also. Thus, it seems inconsistent that Gordon's natural growth is discontinuous at benchmark dates. However, we do not find much difference between these two estimates for the US. Either method illustrates the fact that the underlying growth rate of the US economy has changed over time. Clearly, our methodology yields smoother changes in the natural growth, showing a slight slowing of growth for the US from the 1960s through the 1980s, with acceleration in the 1990s.13 Both methods give quite similar estimates of natural trend and the output gap for the US.

Figure 2. Real GDP growth observations and estimated natural rates: United States



[13] The bumpy appearance of Gordon's estimate is in part explained by subtraction of population growth. Although population growth should be quite smooth itself, the PWT reports anomalous population jumps in 1953 and 1958.

Figure 3. Energy price shock, United States



Measuring the conceptual shock variable accurately is problematic. There are many potentially important types of shocks to consider, and different countries may experience different impacts. Here we use only an energy cost shock, the difference between the US inflation rates of the CPI and of the CPI less energy, hoping that the US experience reflects that of other countries. Clearly, this indicator under-measures the energy shock in 1974-5 due to US price controls; see Figure 3. We model the inflation shock as proportional to this indicator.

VI. An empirical comparison of modeling assumptions

The goodness-of-fit statistics in Tables 2 and 3 are the basis for our inferences about social welfare functions. Comparing system likelihood statistics is appropriate when then number of observations is the same, as they are for both the US and OECD samples. This is less ambiguous than a comparison of the two $R2$ statistics, one for the inflation regression and one for growth.[14]

Table 2 reports ordinary least squares results for the United States, covering 1958-1998. Table 3 repeats the same regressions on an expanded database of 18

[14] There is R 2 ambiguity between models (a) and (c) in Table 4.

Table 2. System log likelihood statistics: United States 1958-1998

Expectation assumption	Adaptive		Rational	
Error structure	Spherical	AR(1)	Spherical	AR(1)
VAR(1) benchmark	-161.0	-160.2	-161.0	-160.2
Circular inflation target (2)	-152.1	-148.7	-184.8	-152.4
Elliptical inflation target (6)	-150.7	-148.6	-184.8	-152.4
Circular growth target (9)	-153.4	-148.6	-184.4	-152.3
Elliptical growth target (12)	-151.5	-148.3	-184.4	-152.3
Circular output target (15)	-171.9	-160.4	-189.8	-161.1
Elliptical output target (18)	divergent	-159.2	-189.8	-161.1
Parabolic (21)	-191.6	-159.2	-193.3	-165.8
Weighted parabolic (24)	-191.6	-159.2	-193.3	-161.6

Note: 41 observations.

Table 3. System log likelihood statistics: OECD 1958-1998

Expectation assumption	Adaptive		Rational	
Error structure	Spherical	AR(1)	Spherical	AR(1)
VAR(1) benchmark	-3291.1	-3286.1	-3291.1	-3286.1
Circular inflation target (2)	-3267.5	-3166.8	-3872.4	-3155.2
Elliptical inflation target (6)	-3266.8	3141.3	-3872.4	-3155.2
Circular growth target (9)	-3363.6	-3167.8	-3878.5	-3156.1
Elliptical growth target (12)	-3363.6	-3142.7	-3878.5	-3156.1
Circular output target (15)	-3606.1	-3234.7	-3886.9	-3240.6
Elliptical output target (18)	-3565.9	-3234.2	-3886.9	-3240.6
Parabolic (21)	-3897.1	-3234.2	-3904.9	-3313.4
Weighted parabolic (24)	-3897.1	-3234.2	-3904.9	-3240.6

Note: 704 observations.

OECD countries, the same countries included in the Alesina and Roubini (1992) study of political business cycles.[15] As a comparison of alternative models of expectation formation, we first assume adaptive, or weakly rational, expectations.

[15] They are Australia, Austria, Belgium, Canada, Denmark, Finland, France, Germany (only after reunification), Ireland, Italy, Japan, Netherlands, New Zealand, Norway, Sweden, Switzerland, United Kingdom and United States.

For example, replacing π_t^e by π_{t-1} in (3) gives the specification for the circular inflation target model under adaptive expectations. This adds lagged inflation as an exogenous variable. And second, we invoke the strongly rational expectations. For example, using (5) gives the circular inflation target model under rational expectations.

The first row of numbers reports a VAR(1) benchmark model. This is a two-equation linear system in inflation and growth, including only the endogenous variables lagged one year as regressors. Sims (1980) recommends this specification as superior to structural models such as those developed here in light of uncertainty about the true nature of political economy. Although his concern about structural uncertainty is also relevant to uncertainty about social welfare functions, our goal is to reduce theoretical uncertainty by considering a range of plausible functions. The VAR(1) is a naïve benchmark against which we measure the fit of more complicated hypotheses.

An examination of the residuals of these estimates suggests that the assumption in (28) of well-behaved errors is invalid. Although autocorrelation corrections are standard, we are reluctant to add additional structure to account for the autocorrelation because this is not part of our theoretical development. Nevertheless we add a minimum model of AR(1) errors as

$$e_{it} = \rho e_{it-1} + u_{it}, i = \pi, g. \quad (31)$$

The same autocorrelation parameter generates both inflation and growth errors, and the errors u_{it} are well behaved.[16] We estimate this complication by substituting this equation into (28) and rearranging as

$$\pi_t = \rho\pi_{t-1} + \Pi\left(\pi_t^e, \varepsilon_t, y_{t-1}, g_t^*\right) - \rho\Pi\left(\pi_{t-1}^e, \varepsilon_{t-1}, y_{t-2}, g_{t-1}^*\right) + u_{\pi t}, \quad (32)$$

$$g_t = \rho g_{t-1} + G\left(\pi_t^e, \varepsilon_t, y_{t-1}, g_t^*\right) - \rho G\left(\pi_{t-1}^e, \varepsilon_{t-1}, y_{t-2}, g_{t-1}^*\right) + u_{gt}. \quad (33)$$

Clearly, the AR(1) version adds considerable dynamic complexity that is not part of our choice-theoretic explanation. Both the spherical error and AR(1) error models are estimated on the same data to insure comparability.

Judging by the likelihood statistics, the adaptive expectations model fits the data better than the rational version; in the absence of the autocorrelation

[16] Experiments with different autocorrelation parameters for inflation and growth reveal that the difference between these parameters is usually insignificant.

correction, only adaptive versions exceed the VAR(1) benchmark. This result suggests that economic agents are not nearly as sophisticated as the strongly rational model assumes. However, with the autocorrelation correction, both adaptiv and rational versions exceed the benchmark. We might take the view that here is some support for the rational hypothesis; or we might take the view that such pragmatic error modeling can make even an inadequate model fit the data well.

Table 4 presents detailed results for eight of the more likely alternatives (shaded in Tables 2 and 3). The *R*2 statistics imply that all these models predict inflation more accurately than growth and that most of improvement due to the autocorrelation correction occurs in the growth equation. In all of these models the estimated slope of the Phillips curve is positive, as expected, and statistically significant, although its magnitude varies markedly depending on whether we correct for autocorrelation. These results imply considerable uncertainty about the slope of the Phillips curve; our estimate under the spherical error assumption is quite flat, but quite steep under AR(1) errors. Possibly the flat estimates of model (a) and (e) are biased because of the inclusion of lagged inflation (taken as exogenous in our adaptive expectation versions) that is correlated with the errors, and because models (b) and (f) correct for this bias.[17]

In all cases the estimated target variable implies equilibrium inflation rates of around 4% or 5%. However, the energy shock coefficients in Table 4 are contradictory, possibly due to the deficiency of our energy price indicator.

These results validate our conjecture that it will be difficult to distinguish empirically between the models with inflation as a target and those with growth as target. In Table 2 the highest likelihood is achieved by the elliptical growth target objective with adaptive expectations, although the improvement over the circular inflation target version is slight. In Figure 4 the generated elliptical growth target tangency solutions (solid dots) display a pattern quite similar to those of the circular inflation target solutions (open dots). The circular alternatives are restrictive

[17] The rational expectations specification does not suffer from this particular form of endogeneity bias, since it models expectations differently, as described above. However, the rational circular inflation target models show a similar uncertainty concerning the Phillips curve slope, model (d) estimates 2.72 with AR(1) errors, while the circular error version of the same model (not reported) estimates 1.71. Although the rational expectations specification could plausibly suffer from other forms of endogeneity bias, this would seem to be evidence against the endogeneity bias explanation of this Phillips curve instability. Such bias remains a worry in the rational model in the case that ε_t, g_{t-1} or g^*_t are correlated with serially correlated errors. In any case our autocorrelation specification should not suffer from endogeneity bias.

because they impose the value judgment that inflation and growth are equally important in determining policy, but there may be merit in this restriction. In the US case the weighting parameter in model (c) is not significantly different from unity, although for the OECD in model (g) it is. However, model (g) verges on instability with rather extreme parameter estimates. Such instability is symptomatic of a model that is barely identified; one of the elliptical models in Table 2 does not converge.

Divergence happens with the inflation weighting parameter λ approaching zero and the Phillips curve slope ψ approaching infinity. Model (g) illustrates this tendency; its Phillips curve slope is unexpectedly steep, its inflation weight is unexpectedly low. Thus, we find two types of specification uncertainty associated with Phillips curve slope estimation, one due to serial correlation, and another connected to target weighting.

Figure 4. Comparing circular (b) and elliptical (c) models, United States 1958-1998

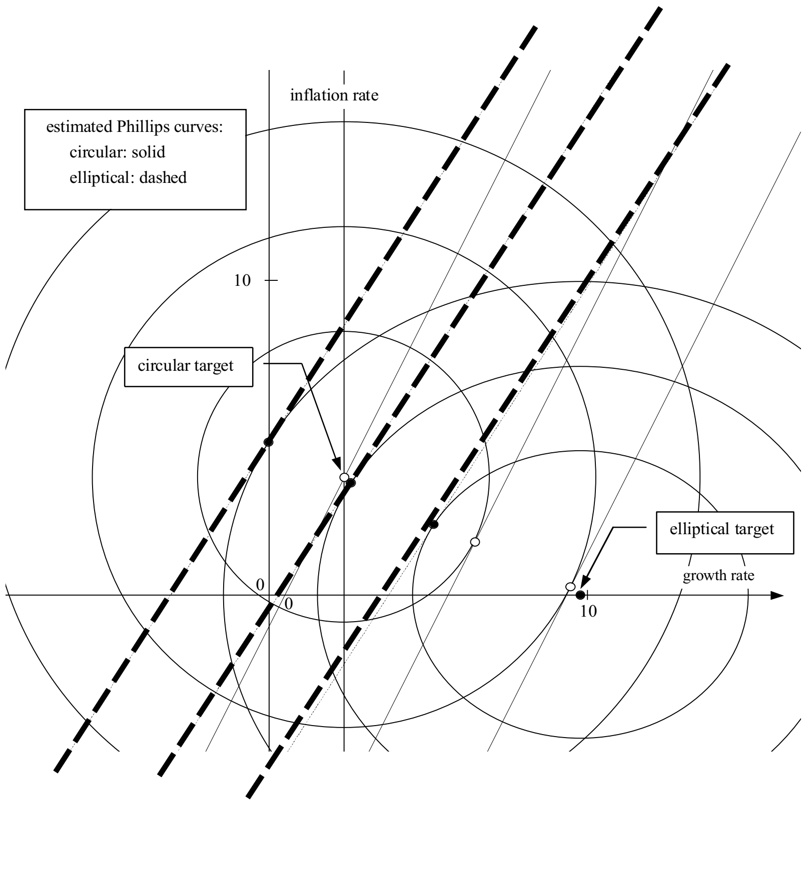


Table 4. Detailed regression result from selected models

Model	(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)
	Circular inflation target	Circular inflation target	Elliptical growth target	Circular inflation target	Circular inflation target	Circular inflation target	Elliptical growth target	Circular inflation target
Sample	US	US	US	US	OECD	OECD	OECD	OECD
Expectations model	Adaptive	Adaptive	Adaptive	Rational	Adaptive	Adaptive	Adaptive	Rational
Error structure	Spherical	AR(1)	AR(1)	AR(1)	Spherical	AR(1)	AR(1)	AR(1)
Phillips curve slope	0.51	1.92	1.54	2.72	0.23	2.89	6.02	2.01
	(4.72)	(3.34)	(2.33)	(4.81)	(10.50)	(11.86)	(5.02)	(14.25)
Target	4.02	3.80	9.71	3.73	5.23	5.04	5.06	5.03
	(7.21)	(6.18)	(4.33	(5.15)	(13.48)	(13.03)	(13.09)	(12.24)
Goal weighting			1.26				0.31	
			(0.62)*				(10.94)*	
Energy shock	0.51	-0.18	-0.09	-1.29	0.32	-1.48	-2.66	-1.02
	(1.56)	(-0.18)	(-0.10)	(-0.88)	(2.03)	(-3.95)	(-3.07)	(-3.57)
Autocorrelation		0.69	0.68	0.77		0.79	0.79	0.80
parameter		(6.05)	(5.63)	(10.09)		(45.01)	(45.45)	(51.65)
R^2 (inflation)	0.82	0.79	0.80	0.77	0.65	0.66	0.67	0.67
R^2 (growth)	0.18	0.31	0.30	0.25	0.25	0.33	0.35	0.33
System log likelihood	-152	-149	-148	-152	-3268	-3167	-3143	-3155

Notes: t-ratios in parentheses. * $H_0 : \lambda = 1$.

Textbook discussion often presents identification as an algebraic issue, logically prior to estimation.18 Our results demonstrate that algebraic identification does not guarantee stable parameter estimates.19 In light of the wide discussion of inflation targeting and central bank independence, the inflation weight estimate of 0.31 in model (g) is suspiciously low. It is questionable whether policymakers could have such a low weight.20 We prefer the circular inflation target version as more intuitive and consistent with the literature. Any conclusions derived from this specification needs to be qualified by the recognition of this restriction.

VII. Country heterogeneity

The OECD models above assume that all countries share the same target and the same Phillips curve slope. Table 5 reports results that relax this assumption by allowing different parameters for each of the 18 countries.21 The first and second columns report likelihood statistics for fixed target effects in the adaptive versions, with and without the autocorrelation correction. Again the autocorrelation correction markedly increases the statistical fit. The third and fourth columns impose an identical target, but allow 18 different Phillips curve slopes, with and without the autocorrelation correction. The fifth column

[18] The issue is algebraic for our parabolic specifications. Our parameter estimates (details unreported) exactly satisfy (27).

[19] Perhaps the generality of the elliptical model, using two parameters to define the objective function, asks too much of these data. We investigate this idea by estimating a restricted elliptical version with a zero inflation target. Although this restricted model uses only one parameter to define the objective function (the same as the circular versions), it does not fit the US data as well. The OECD estimate of the zero-target elliptical specification is divergent.

[20] In a study of the relative importance of macroeconomic indicators to individual (rather than government) utility, Welsch (2007) finds that inflation, unemployment and growth rates are all important determinants of “life satisfaction.” He estimates roughly equal weights for inflation and unemployment rates, less for the growth rate.

[21] The political business cycle literature emphasizes that macroeconomic outcomes are also determined by election cycles and central bank independence, which certainly differ among countries. Both effects can be conceptualized as adding additional specification to the modeling of our target. We neglect these effects here in order to focus on the functional form question. Kiefer (2006) develops the political economy of the target along these lines and reports that the central bank independence and political ideology (as measured by party platform statements and updated by election results) have a relatively small effect on goodness-of-fit.

Table 5. Cross country differences in adaptive expectations models: OECD 1958-1998

System log likelihood	Target effects		Slope effects		Energy shock effects	Goal weight effects	Target and slope effects
Error structure	Spherical	AR(1)	Spherical	AR(1)	AR(1)	AR(1)	AR(1)
VAR(1) benchmark	-3291	-3286	-3291	-3286	-3286	-3286	-3286
Circular inflation target (2)	-3260	-3159	-3257	-3149	-3160	-3167	-3141
Elliptical inflation target (6)	-3359	-3135	-3256	-3128	-3134	-3131	-3121
Circular growth target (9)	-3326	-3160	-3324	-3156	-3161	-3168	-3142
Elliptical growth target (12)	-3326	-3135	-3324	-3133	-3135	-3135	-3123
Circular output target (15)	-3600	-3229	-3547	-3229	-3231	-3235	-3224
Elliptical output target (18)	-3560	-3228	-3556	-3229	divergent	-3234	-3224
Parabolic (21)	-3860	-3228	divergent	-3230	-3231	-3234	-3224
Weighted parabolic (24)	-3260	-3228	divergent	-3229	-3231	divergent	-3141

Note: 704 observations.

imposes an identical target and slope, but allows different inflation shock coefficients. The sixth column imposes identical target, slope and shock effects, but allows different goal weights for the elliptical models. Overall, it appears that the greatest source of heterogeneity is due to different Phillips curve slopes. The seventh column combines different target and slope effects, but requires identical energy shock effects and $1 = \lambda$.

Table 6 reports selected estimates of the country-varying parameters; all models are circular except for model (l). Even though an elliptical form maximizes the

Table 6. Selected results with adaptive expectations and AR(1) errors: OECD 1958-1998

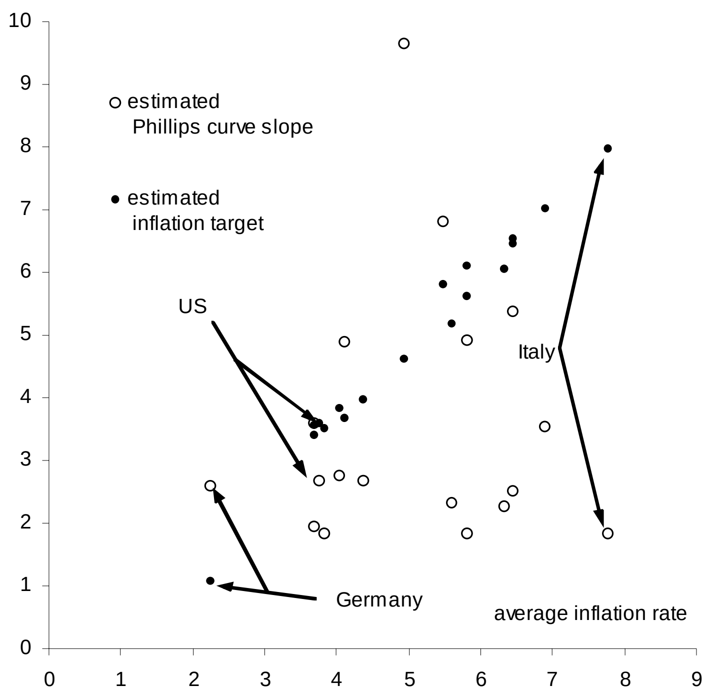
Model	(i)	(j)	(k)	(l)	(m)	
	Circular	Circular	Circular	Elliptical	Circular	
Country	Target effects	Slope effects	Energy shock effects	Goal weight effects	Target effects	+ slope effects
Australia	5.80*	4.63*	-1.12	0.65	5.78*	4.51*
Austria	3.40*	3.44*	-0.87	0.32*	3.41*	3.37*
Belgium	3.85*	2.31*	-0.96	0.26*	3.87*	2.28*
Canada	4.00*	1.84*	-2.43*	0.29*	4.10*	1.81*
Denmark	5.99*	4.61*	0.31	0.55	6.05*	4.48*
Finland	6.01*	2.11*	-3.28*	0.31*	6.11*	2.04*
France	5.17*	2.01*	-3.43*	0.17*	5.21*	1.95*
Germany	1.16	2.90	-0.67	0.52	1.18	2.78
Ireland	7.03*	3.41*	-3.43*	0.32*	7.02*	3.32*
Italy	7.91*	1.80*	-0.75	0.27*	7.95*	1.80*
Japan	3.52*	1.84*	-1.46	0.29*	3.52*	1.77*
Netherlands	3.73*	3.05*	-1.23	0.40*	3.73*	3.02*
New Zealand	6.43*	6.83*	0.21	0.42*	6.54*	6.76*
Norway	4.64*	8.87	1.65	0.80	4.63*	8.63
Sweden	5.57*	1.79*	-2.18*	0.25*	5.62*	1.74*
Switzerland	3.52*	1.84*	-2.16*	0.21*	3.57*	1.82*
UK	6.44*	2.57*	-1.01	0.19*	6.45*	2.50*
US	3.61*	2.41*	-1.97	0.42*	3.63*	2.40*
R^2 (inflation)	0.67	0.67	0.67	0.68	0.67	
R^2 (growth)	0.33	0.35	0.33	0.36	0.35	
System log likelihood	-3159	-3149	-3160	-3131	-3141	

Notes: 704 observations. The selected results are shaded in Table 5. * Statistically significant at the 5% level; for the goal weight cases $H_0: \lambda = 1$.

likelihood, we prefer the circular form for the reasons argued above, theoretical coherence and estimation stability. Several of the elliptical estimates diverge; and the weights estimated in model (l) are unexpectedly low. Model (m) reports estimates for a model with two types of heterogeneity; we hold the energy shock effects constant because in model (k) they either have the wrong sign or are insignificant. Allowing for heterogeneity in these ways does increase the goodness of fit as compared to Table 3.

Figure 5 plots our estimates of the inflation targets from model (m) against country-specific average inflation. The apparent positive tendency reflects the time-consistent relation between targets and inflation. The differences between the outlying results for Germany and Italy validate the conventional wisdom that Germany has a strong preference for price stability, while Italy does not; the correlation is 0.99. Country-specific estimates of the Phillips curve slopes do not reveal any relation to inflation outcomes.

Figure 5. Inflation targets correlate with average inflaion, model (m)



VIII. Conclusion

We develop a model of political and economic interaction, and test its relevance to the macroeconomic history of the US and OECD countries. Although our results exhibit considerable uncertainty, some conclusions emerge. One of these is that the endogenous stabilization hypothesis contributes to our understanding of aggregate outcomes. Our political business cycle models are statistically superior to a more agnostic alternative, as long as we invoke an adaptive theory of expectations, rather than the more conventional rational theory. Even with a careful modeling the strongly rational model of expectations does not improve on a naive benchmark, except when an autocorrelation correction is added. Mixed conclusions emerge from our statistical comparison of alternative preference forms. Although it is hard to distinguish between circular and elliptical indifference curves, or between growth and inflation targets, the quadratic form is more likely than the parabolic one, and inflation (or growth) goals are more likely than level goals.

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