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Theories of Policy Accommodation: The Persistence of Inflation and Gradual Stabilizations 1/

Prepared by José De Gregorio 2/

Authorized for distribution by Peter Wickham

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Abstract

Persistent inflation and slow stabilization are usually the result of policy accommodation resorted to in an attempt to avoid the recessionary costs of a sharp reduction of inflation. This paper reviews three explanations for why policymakers, despite their dislike of inflation, may nevertheless choose to adopt accommodative policies. It emphasizes the role of indexation, uncertainty about policymakers' preferences, and the existence of fixed costs associated with the implementation of a stabilization program. The paper also presents some evidence on the extent of persistence of inflation across countries.

JEL Classification Numbers:
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Contents

I. Introduction

Inflation exhibits a high degree of persistence. This means that if inflation rises today it is likely that it will remain high for some time thereafter. To study the phenomenon of inflation, there are mainly two (complementary) approaches. The first approach analyzes inflation in the context of public finance, where inflation is related to the financing of the budget. The second approach considers inflation as an instrument that is used to exploit a short-run trade-off between inflation and unemployment in order to reduce macroeconomic fluctuations. This paper analyzes the persistence of inflation under this second approach. In this context, a particular manifestation of the persistence of inflation is the relatively slow speed at which many stabilization programs are implemented. Instead of aiming at sharp reductions in inflation, many policymakers prefer to stabilize gradually.

From the early literature on rational expectations (e.g., Taylor, 1980) it is known that persistent inflation will arise whenever governments follow an accommodative monetary policy. Such policymakers prefer to follow a policy that is contingent upon the current state of the economy, rather than to follow a fixed rule, in order to balance the costs of inflation and the costs of unemployment. In general, unemployment arises because of some stickiness of wages and prices. Most of these models, however, take the structure of the economy as given and assign no role to private agents' behavior. Indeed, in a world where almost everybody dislikes inflation, its stubbornness is puzzling.

As recently shown by Cukierman and Liviatan (1990), however, informational frictions (lack of credibility) may result in "inflation inertia" without requiring additional stickiness or preferences biased toward tolerating inflation. This paper follows this line of argument in a framework where the government and the public dislike inflation as well as deviations of output from full employment, but the inability to coordinate their actions generates the incentive for accommodation. Three different cases where monetary policy ends up being accommodative are discussed below.

The basic model for the paper is a monetary policy game in the spirit of Barro and Gordon (1983). Similar models have been used to consider uncertainty and the role of credibility, central bank behavior, the role of political institutions, and so forth. 1/ This paper extends the analysis to models that predict persistent inflation rates and gradual stabilization. The underlying reason for accommodation is a bias in people's expectations about inflation. Although the government has no inflationary bias, the three models show that people have inflationary expectations above zero (optimal in this case). This expectational bias induces the government to accommodate in order to avoid the severe recessions associated with inflation that is lower than expected. The models presented below provide different explanations for the upward bias in inflationary expectations in a

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1/ See, for example, Cukierman (1990), Chapter 11 in Blanchard and Fischer (1989), Rogoff (1989), and Persson and Tabellini (1991).

common theoretical framework. Each one of the models highlights certain elements of the economic and informational structure that may induce governments to adopt accommodative policies.

The paper is divided in six sections. Section II presents some cross-country evidence on the persistence of inflation. Section III introduces a model in which indexation causes the government to accommodate inflationary expectations rather than to reduce inflation over a short period of time. Section IV presents a simplified version of the model developed by Cukierman and Liviatan (1990), which focuses on the role of uncertainty about the preferences of policymakers as a cause of accommodative policies. The last model, discussed in Section V, considers a policymaker who faces a fixed cost each time he/she decides to reduce inflation. The uncertainty of the public about whether the current economic conditions are such that the policymaker will bear the fixed cost results in inflation persistence. Finally, Section VI concludes.

II. Cross-Country Evidence on the Persistence of Inflation

This section presents different measures of the persistence of inflation and documents evidence for quarterly inflation rates in a sample of 29 countries during the period of QI-1970 to QII-1990 (Table). The sample includes countries with annual inflation rates ranging from 4 percent to 180 percent. A brief discussion of the evidence and what the theories of inflation explain about these facts follows. The results shown in the table, however, cannot validate or reject any theory of inflation and its persistence.

1. Measures of persistence

An important issue in measuring persistence of a time series is the order of integration of the variable. The concept of persistence is different for a variable that has a unit root than for a variable that does not. Figure 1 below presents four examples of the impulse response functions for time series of inflation. 1/ The specific univariate representation of each series is presented at the bottom of the figure. Cases I and II are stationary in levels (I(0)); that is, a shock at time 0 has no long-run effects. Cases III and IV are series that have a unit root, in which a shock at t=0 will have permanent effects, and as a consequence the impulse response function does not converge to zero. These last two examples represent variables that are stationary in first differences (I(1)).

1/ The impulse response function for a univariate process corresponds to the graph of the effects over time of a unitary shock to the variable at t=0. For a formal presentation of several measures of persistence for I(1) time series, see Campbell and Mankiw (1987) and Cochrane (1988).

Table. Persistence of Inflation Across Countries, QI-1970 to QII-1990

	Average Inflation (Annual)	Persistence I(0)			Persistence I(1)		
		ADF	AR(1)	AR(4)	ADF	AR(1)	AR(4)
Argentina 1/	179.0	-2.775	3.489	3.145	-4.016	0.820	0.697
Australia	9.2	-2.814	1.724	2.887	-5.062	0.689	0.494
Austria	4.9	-1.509	2.194	5.481	-4.761	0.739	0.372
Belgium	5.9	-1.922	5.269	7.210	-5.080	0.853	0.658
Bolivia	165.4	-2.800	2.340	2.846	-5.018	0.653	0.640
Brazil 1/	83.6	-0.148	4.962	15.403	-3.957	0.973	0.299
Canada	7.0	-1.875	4.761	7.189	-3.692	0.767	0.620
Chile	73.5	-1.562	4.246	6.971	-4.573	0.760	0.503
Colombia	22.2	-3.920	1.542	1.495	-5.288	0.798	0.455
Denmark	7.9	-2.209	1.739	3.139	-5.829	0.682	0.430
Egypt	13.1	-2.388	0.994	1.518	-5.662	0.622	0.277
Finland	8.9	-1.520	3.143	6.857	-4.135	0.659	0.494
France	7.9	-1.456	7.879	9.262	-4.925	0.824	0.658
Germany	3.8	-1.472	4.340	7.470	-4.320	0.801	0.495
Greece	16.5	-3.332	2.387	2.311	-4.790	0.817	0.528
India	8.4	-5.007	4.163	2.655	-3.625	0.981	0.970
Israel	69.7	-2.734	6.132	6.874	-3.860	0.801	1.019
Italy	11.8	-2.136	5.137	5.518	-5.046	0.786	0.651
Japan	5.5	-2.257	3.293	5.444	-4.175	0.724	0.665
Korea	11.2	-2.227	2.826	3.637	-5.054	0.762	0.518
Mexico	39.2	-2.534	7.453	6.345	-4.341	0.988	0.843
Netherlands	4.9	-1.219	3.958	8.375	-4.101	0.671	0.444
Norway	8.0	-2.340	2.029	3.321	-4.557	0.688	0.521
Philippines	14.5	-5.047	2.635	1.990	-5.929	0.731	0.855
Spain	12.1	-1.595	2.581	5.607	-4.877	0.668	0.493
Turkey	38.3	-2.675	2.692	3.633	-5.317	0.803	0.617
United Kingdom	10.2	-2.268	3.269	4.515	-4.776	0.751	0.550
United States	6.3	-2.102	4.926	6.050	-3.402	0.848	0.745
Venezuela	41.3	0.990	4.869	17.168	-5.648	2.046	0.591

Source: International Financial Statistics, IMF, various issues
1/ Data end in 1987:4.

Note: I(0) and I(1) = order of integration of inflation equal to 0 and 1, respectively. ADF = Augmented Dickey Fuller. AR(1) and AR(4) = first order and fourth order autoregressive process, respectively. McKinnon critical values (McKinnon, J. (1990), "Critical Values for Cointegration Tests," mimeo, UCSD) for 75 observations are 2.90 and 2.58 at 5 and 10 percent significance levels, respectively.

Let us first consider inflation as a stationary process. There is no long-run persistence, since the effects of a shock even out in the long run. Persistence can be defined, however, in terms of the magnitude and the period of time during which the shock has effects on inflation. Clearly, Case II is more persistent than Case I. At each period of time, the effects of a shock to inflation are greater in Case II than in Case I. Then, a natural measure of persistence is the cumulative sum of the effect of a shock to inflation. In a continuous time representation, the indicator of persistence would be the area under the impulse response function. 1/ In an AR(1) process—$\pi_t = \rho\pi_{t-1} + \upsilon_t$, where π denotes inflation and υ is white noise—the value is $1/(1-\rho)$. According to this definition, a white noise process will have persistence equal to one, a negatively correlated shock will have persistence less than one and a positively correlated shock will have persistence greater than one. Case I has persistence equal to two, while in Case II persistence is equal to ten.

Now, consider the case where inflation has a unit root, as in Cases III and IV. Since shocks have permanent effects, the area under the impulse response function is infinity for any process with a unit root. Hence, the measure of persistence discussed for a stationary process cannot be used. The degree of persistence can, however, be distinguished according to the long-run effect of a shock. In particular, the measure employed in this case is the magnitude of the long-run effect of a unitary shock to the inflation rate at t=0. This measure of persistence corresponds to the value at which the impulse response function converges. In Figure 1, Case IV clearly displays more persistence than Case III, while Case III settles at a value of 0.5, Case IV settles at 1.4. A random walk is an example of unitary persistence. Another interpretation of this measure is the amount by which the long-run forecast of the variable should be changed when it is hit by a unitary shock. Since in Case IV there are additional positive effects in the period following the shock, the long-run forecast should increase by more than one. In Case III, owing to the negative autocorrelation of the first differences, there is some partial reversion in the inflation process, and consequently the long-run forecast rises by less than one. 2/

As should be clear from the previous discussion, the measurement of persistence for I(0) and I(1) variables is not comparable. One measurement refers to the accumulated effects over time, while the other refers to the long-run effects.

2. Evidence on the persistence of inflation

Bearing in mind the low power of unit root tests for roots close to one, the Table for the 29 sample countries presents the results under the

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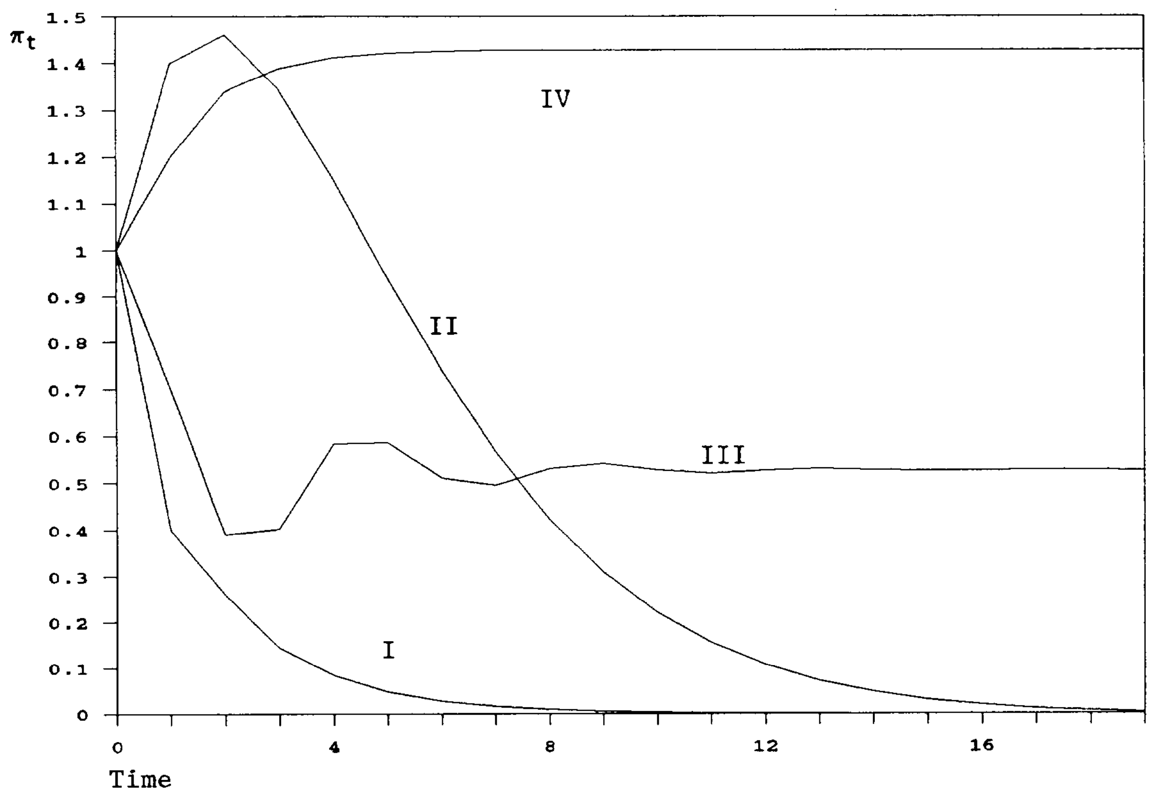
1/ Technically this measure corresponds to the sum of the coefficients of the moving average representation of the process of inflation.

2/ The measure is the sum of the coefficients of the moving average representation of the *first differences*.

Figure 1. Examples of Impulse Response Functions



Equations:

I: $\pi_t = 0.4\ \pi_{t-1} + 0.1\ \pi_{t-2} + \epsilon_t$

II: $\pi_t = 1.4\ \pi_{t-1} - 0.5\ \pi_{t-2} + \epsilon_t$

III: $\Delta\pi_t = -0.3\ \Delta\pi_{t-1} - 0.4\ \Delta\pi_{t-2} - 0.2\ \Delta\pi_{t-3} + \epsilon_t$

IV: $\Delta\pi_t = 0.2\ \Delta\pi_{t-1} + 0.1\ \Delta\pi_{t-1} + \epsilon_t$

assumption that all the inflation rates have the same order of integration. 1/ The first part of the Table assumes stationarity of inflation rates, while the second part assumes that inflation rates have a unit root.

The Augmented Dickey-Fuller tests suggest that in 25 of the 29 sample countries inflation is well represented by a difference-stationary process at a 5 percent significance level. At a 10 percent significance level, the number of countries where the null hypothesis of first difference stationarity is rejected against stationarity in levels increases to 8.

An AR(1) and an AR(4) process are fitted to each series in levels and in first differences. By all different measures, inflation appears to be persistent for most of the countries. For the stationary case, a unitary shock has significant effects, averaging 3.7 for the AR(1) process, and 4.9 for the AR(4) process (excluding the two outliers). Thus, a shock to inflation appears to have about four times greater impact than in the case where inflation is a pure white noise.

In the I(1) case, shocks to inflation rates have a permanent effect. It is interesting to note, however, that there is a certain degree of reversion toward zero. Except for Venezuela, the long-run effect of a unitary shock is less than one. The cross-country average for the AR(1) Case is 0.8, while for the AR(4) Case it is 0.6.

Most theories of the optimal inflation tax--the approach that views inflation as part of a public finance problem--conclude that inflation should follow a random walk. 2/ The evidence suggesting that in most countries inflation rates have a unit root could be interpreted as evidence in favor of the optimal inflation tax. Nevertheless, the result from the optimal inflation tax literature refers to a particular process with a unit root: a random walk. The results from the table are contrary to that conclusion; they show that after a shock there is some reversion of inflation toward its mean, and that a random walk is not the best univariate representation for inflation.

Finally, it is interesting to see if there is some relationship between persistence and the average rate of inflation. One could expect, a priori, a relationship between persistence and the average rate of inflation since the structure of an economy depends on its inflationary experience. Hence, the degree of persistence should be affected by the history of inflation. The figures from the table show, however, that none of the measures of persistence has a strong correlation with average inflation. There are, for example, both low (e.g., Belgium and France) and high inflation countries (e.g., Mexico and Brazil) that display high persistence.

1/ For further discussion on unit roots, see Campbell and Perron (1991).

2/ See Barro (1979) and Mankiw (1987). An exception is Calvo and Guidotti (1990).

To have a closer look, Figures 2 and 3 plot the persistence indicators of the AR(1) processes of the I(0) and I(1) cases, respectively, against the logarithm of average inflation. 1/ If anything, Figure 2 shows a weak positive correlation. Further detailed statistical analysis could provide some stronger correlations, but the weak correlation found here suggests that the sources of persistence are different across countries.

III. Indexation

A traditional argument given for why disinflations are costly is that there are rigidities in the adjustment of prices and wages. One case that has been extensively discussed, in the context of rational expectations models, is indexation of wages (Fischer, 1977; and Gray, 1976). In particular, the indexation of wages to past inflation makes a steep reduction of inflation too costly.

The model in this section is a monetary policy game that follows from the Barro and Gordon (1983) model. It incorporates indexation as the key factor that prevents an inflation-averse policymaker from setting a zero inflation rate target in the short run, because it would be too costly to reduce inflation abruptly. Instead, disinflation will occur gradually. The government minimizes the present value of a loss function (L_t) given by:

$$L_t = \frac{a}{2}(y_t - y^*)^2 + \frac{b}{2}\pi_t^2. \tag{1}$$

As a normalization, b is assumed to be equal to one, so that a=0 is the case in which the policymaker does not care about unemployment, and 1/a=0 is the case in which he/she does not care about inflation. The level of output at time t is y_t, where y^* is the level of output at the natural rate of unemployment, and π_t is inflation at time t. Note that the global minimum of L_t is attained when $y_t=y^*$ and $\pi_t=0$. For this reason, this kind of preference can be referred to as the case of a government without an inflationary bias. It has also been called a "strong" government. In contrast, the traditional assumption is to write the term for output as $(y_t-ky^*)^2$, where k is greater than one. In this case, the targeted output is greater than full employment, which generates the temptation for the government to create inflationary surprises. Then, in equilibrium, people internalize this temptation by setting positive inflationary expectations, and as a consequence, the actual rate of inflation is positive. When k=1, the government can be considered as benevolent.

In the Barro and Gordon (1983) framework, a government with a loss function as in equation (1) that inherits a high rate of inflation will produce zero inflation in one period. However, the equilibrium is quite different once some degree of indexation is assumed. For this purpose, consider the following expectations-indexation augmented Phillips curve:

1/ Similar figures appear for the AR(4) processes.

Figure 2. Persistence and Average Inflation ARIMA(1,0,0)

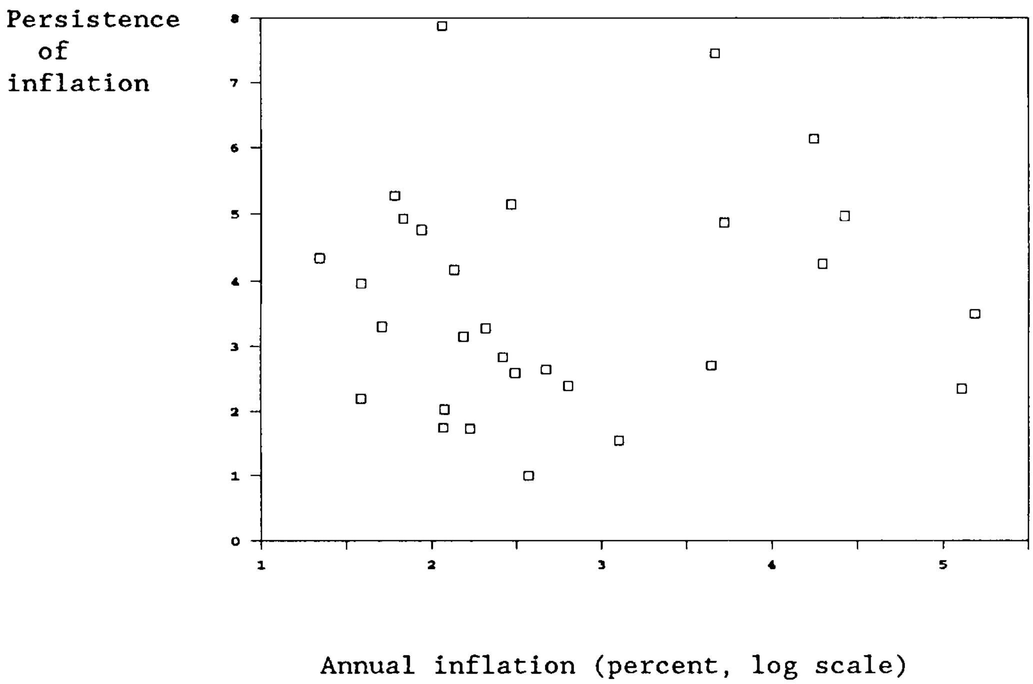
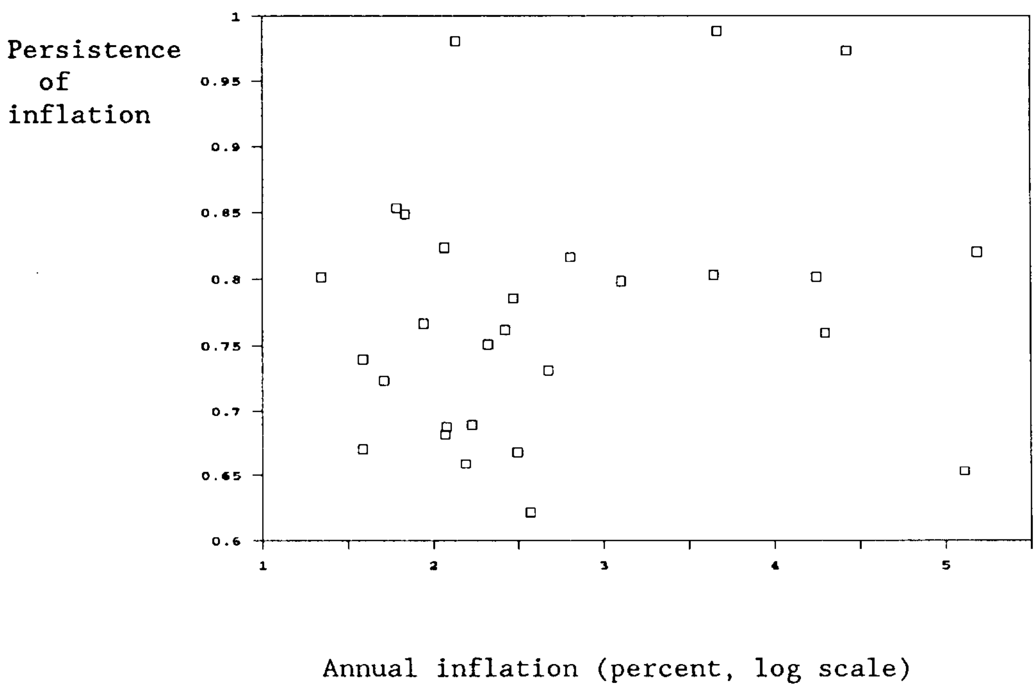


Figure 3. Persistence and Average Inflation ARIMA(1,1,0)



$$y_t - y^* = \theta(\pi_t - (1-\alpha)\pi_t^e - \alpha\pi_{t-1}) + \epsilon_t, \tag{2}$$

where α measures the degree of indexation and it takes values between zero and one. The traditional case is α equal to zero. The steepness of the Phillips curve is represented by $1/\theta$ and π_t^e is expected inflation as of period t. Although the Phillips curve is assumed rather than derived from labor or goods market behavior, it conveys simple intuition about the role of indexation. The value of α reflects the extent to which past inflation provides information about current wage contracts and price decisions. A large value of α can be interpreted as representing an economy where there is widespread indexation. 1/ An additional interpretation for α is the extent of staggering of price and wages decisions, which can also be responsible for the persistence of inflation (Taylor, 1980). In this case, past inflation conveys information about wages and prices set before the current period and are still relevant for current decisions. 2/

The random shock ϵ is i.i.d. with zero mean and variance σ_ϵ^2. It represents real shocks, such as shocks to the terms of trade or productivity. A negative realization of ϵ can be interpreted, for example, as a negative terms of trade shock. It will be assumed that the government observes the shock before deciding on the rate of inflation, but people nevertheless form expectations without knowing the realization of ϵ (as in Rogoff, 1985, and Flood and Isard, 1989).

This game has a state variable that may enhance considerably the set of equilibrium strategies. However, the paper will follow the simplest case: the one-shot Nash equilibrium. Under this approach, the government chooses inflation and people rationally form their expectations. The equilibrium can be computed by solving the optimum rate of inflation for the government as a function of π^e (given for the government) and then taking expectations that are conditional on all of the information available to individuals at time t to find an expression for π^e. The first order condition of the government minimization problem is: 3/

$$\pi = \frac{1}{a\theta^2+1}\left[(1-\alpha)a\theta^2\pi^e + \alpha a\theta^2\pi_{-1} - a\theta\epsilon\right]. \tag{3}$$

1/ Traditionally, indexation has been considered as affecting the value of b, that is, the tolerance to inflation, e.g., Fischer and Summers (1988). Assuming that indexation affects the Phillips curve, however, is consistent with models in the spirit of the Fischer-Gray framework.

2/ However, as shown in Helpman and Leiderman (1990), staggering does not necessarily imply that there is inflationary inertia. Calvo and Végh (1991) also show that staggering itself does not preclude instantaneous adjustment of inflation.

3/ Subscripts for time are omitted except for one period lag or lead, where subscripts -1 and +1 respectively are used.

Taking the expectations of equation (3), and solving for π^e we have:

$$\pi^e = \frac{1}{1+\phi}\pi_{-1}, \tag{4}$$

where

$$\phi \equiv \frac{1}{a\theta^2\alpha}. \tag{5}$$

Then, the rate of inflation is obtained by substituting π^e back into equation (3). The expression for π as a function of past inflation and the realization of ϵ is:

$$\pi_t = \frac{1}{1+\phi}\pi_{t-1} - \frac{1}{1+\phi\alpha\theta}\epsilon_t. \tag{6}$$

Inflation follows an AR(1) process with an asymptotic mean of zero and a variance of $(1+\phi)^2\sigma_\epsilon^2/(1+\alpha\phi\theta)^2(2\phi+\phi^2)$. In the extreme case that unemployment does not matter to the policymaker (a=0) the value of ϕ goes to infinity and hence inflation is a white noise process around zero. In this case, stabilization takes place in one period. At the other extreme when ϕ is equal to zero (1/a=0), inflation follows a random walk. In this case, since inflation does not matter from a welfare point of view, the policymaker will never have the incentive to reduce it. In general, the autoregressive structure arises despite the government not wanting to create inflationary surprises and people knowing that. The rate at which inflation converges toward zero is $1/(1+\phi)$.

Now, let us consider stabilization. Assume that the government inherits π_{-1} at a rate that is higher than zero, and from then on ϵ is zero. Starting from a high rate of inflation the policymaker will decide to reduce it gradually, accommodating indexation with monetary policy to reduce the recessionary costs of the stabilization. As expected, the degree of persistence (which is inversely related to the speed of disinflation) is increasing in the degree of indexation. It decreases with the steepness of the Phillips curve and the relative aversion to inflation (1/a). If the government does not care about unemployment, the adjustment will be instantaneous.

Although expectations are rational, the indexation component of the Phillips curve will also produce a recession while the disinflation is taking place. Substituting $\pi^e=\pi$ in equation (2), and still assuming ϵ to be zero, the path followed by output is:

$$y-y^* = -\frac{\theta\alpha}{1+a\theta^2\alpha}\pi_{-1}. \tag{7}$$

Starting from a high inflation rate, the stabilization will begin with a recession and then the output gap will slowly converge to zero. The government will not disinflate in one period because the recessionary costs would be too high.

The government is assumed to last for only one period since it only considers the losses in the current period. Because the stickiness is only one period, one may ask whether the result of gradual disinflations is robust to a government that has a forward-looking strategy. For example, it could be optimal for the government to reach inflation equal to zero in the first period, but from then on the expected values of the rate of inflation and of the output gap would be zero. The first period loss would be offset by a permanent gain in the future. De Gregorio (1991) studies the certainty case of a government with infinite horizon, and shows that the above presumption does not hold. The reason for this result is the convexity of the government's loss function which induces a smooth optimal policy. As in the static case, disinflations are also gradual and another parameter that affects the speed of adjustment is the discount rate.

This simple model shows that a gradual disinflation may be caused by the existence of indexation, despite the government's and individuals' dislike of inflation and of deviations of output from full employment. The failure to achieve the first best conditions relies on an economic structure that is characterized by the parameter α. Further work could provide additional insights on how α is determined, and consequently how it could be influenced by the government to reduce the costs of disinflation. In fact, it can be conjectured that if α were endogenously chosen by private agents, it might be chosen according to the policymaker's past inflationary performance. The choice of α might also be affected by some institutional characteristics of the economy, for example, by the degree of independence of the central bank.

IV. Uncertainty About the Policymaker: The Cukierman-Liviatan Model

This model was developed by Cukierman and Liviatan (1990) and is based on the uncertainty that individuals have about the preferences of policymakers. There are two types of government that can be in office. One has no inflationary bias, and is called strong. The other, called weak, has an inflationary bias; that is it attempts to create inflationary surprises to achieve its targeted output, which is above full employment. The intuition for the persistence of inflation is that when there is a positive probability that the policymaker is weak, people will have higher inflationary expectations than when they have no doubt that the government is strong. This bias in inflationary expectations causes a strong government to partially accommodate these expectations, because it also dislikes recessions. Thus, the driving force of this model is the lack of credibility that individuals have about the intentions of the policymaker. Note that credibility in this framework refers to people's lack of knowledge about the preferences of the policymaker in office.

The per-period loss functions of strong (S) and weak (W) policymakers are, respectively:

$$L^S = \frac{a}{2}(y-y^*)^2 + \frac{1}{2}\pi^2, \tag{8}$$

and,

$$L^W = \frac{a}{2}(y-ky^*)^2 + \frac{1}{2}\pi^2. \tag{9}$$

The only difference between the two types of government is the output target. The strong government output target is the natural rate. In contrast, the weak government wants output to be larger than under full employment.

Output is determined by the following Phillips curve (equation (2) for $\alpha=0$ and no real shocks):

$$y-y^* = \theta(\pi-\pi^e). \tag{10}$$

If the type of the government were known with certainty, the Nash equilibrium rate of inflation could be computed by deriving the first order conditions of the minimization problem of each government, taking π^e as a constant, and then setting expected inflation equal to actual inflation. In this case the rate of inflation for S would be:

$$\pi^S = 0, \tag{11}$$

and for W:

$$\pi^W = \theta a(k-1)y^*. \tag{12}$$

However, when people do not know with certainty what type of policymaker is in office, their expectations will condition government's action. In order for the two types of government to be unable to signal their preferences (guaranteeing the existence of pooling equilibrium), Cukierman and Liviatan (1990) assume that they cannot control inflation perfectly (Canzoneri, 1985). Policymakers choose planned inflation, π_p, but actual inflation deviates from desired inflation according to:

$$\pi^I = \pi_p^I + \eta^I. \tag{13}$$

The specific shock, η^I, is assumed to be i.i.d. and is uniformly distributed:

$$\eta^I \sim U[-a^I, a^I] \qquad I=S,W, \tag{14}$$

then the probability for inflation to be π (in the range $\pi^I \pm \epsilon^I$), conditional upon knowing that government type I (S or W) is in office, is:

$$Pr(\pi/I) = \frac{1}{2a^I} \qquad I=S,W. \tag{15}$$

A key assumption to impede the strong government from signaling its type is $a^S < a^W$. That is, a strong government has more control over the inflation rate. Under some additional conditions the whole range of possible inflation rates produced by S is contained in the range of W. In that case--when S is in office--all realizations of inflation may come about under either type of government, with a strictly positive probability. Hence, despite the strong government's desire to signal its preferences, it is not able to do so. Therefore, a reputational equilibrium as in Barro (1986) is not possible. 1/

The Nash equilibrium can now be computed. Each type of government minimizes expected losses, given that output and inflation are linked through the Phillips curve and inflationary expectations are taken as given. The first order conditions for the minimization of losses, for S and W, are, respectively:

$$\pi_p^S = \frac{\theta^2 a}{1+\theta^2 a}\pi^e, \tag{16}$$

and,

$$\pi_p^W = \frac{\theta^2 a}{1+\theta^2 a}\pi^e + \frac{\theta a}{1+\theta^2 a}y^*(k-1). \tag{17}$$

The probability of a type S government being in office will be denoted as q. Therefore, the expected inflation will be:

$$\pi^e = q\pi_p^S + (1-q)\pi_p^W. \tag{18}$$

Substituting equations (16) and (17) in equation (18), and then solving for inflationary expectations, we obtain:

$$\pi^e = (1-q)a\theta(k-1)y^*. \tag{19}$$

Finally, q is updated according to the Bayes rule. Therefore, starting with a prior belief of q_0 at t=0, q will evolve according to:

1/ If the strong government can be separated from the weak government, it may end up choosing a lower inflation rate than when its type is known (π^S in equation (18)) with certainty in order to provide an unequivocal signal about its type (Vickers, 1986).

$$q_{t+1} = \frac{\Pr(\pi_t/S)\, q_t}{\Pr(\pi_t/S)\, q_t + \Pr(\pi_t/W)\,(1-q_t)} = \frac{q_t}{q_t + \frac{a^S}{a^W}(1-q_t)} . \tag{20}$$

The planned rate of inflation for the strong government is obtained after replacing equation (20) in equation (16):

$$\pi^S_{Pt} = \frac{\theta^3 a^2}{1+\theta^2 a}(1-q_t)(k-1)y^* . \tag{21}$$

When the policymaker is of the strong type, q_t is increasing asymptotically toward one since $a^S < a^W$. Thus, people slowly learn that the government is strong. This slow adjustment of expectations ("lack of credibility") forces the government to validate the people's inflationary expectations, which in the case of q_t=1 would not arise. Using equation (21), it is possible to show that inflation adjusts gradually to zero according to the following process:

$$\pi^S_t = \delta_t \pi^S_{t-1} + \eta^S_t - \delta_t \eta^S_{t-1} , \tag{22}$$

where,

$$\delta_t = \frac{1-q_t}{1-q_{t-1}} = \frac{a^S}{a^W} \frac{1}{q_t + \frac{a^S}{a^W}(1-q_t)} . \tag{23}$$

Note that this process is similar to the AR(1) process derived in the previous section for the case of indexation, although it is highly nonlinear. Starting from a high inflation rate, the policymaker will partially validate high inflationary expectations, because he/she dislikes recessions. As time passes and the government persists in reducing inflation, people revise upward their belief that the government is a strong type, converging asymptotically to zero inflation.

V. Fixed Costs of Stabilization and "Exogenous Credibility"

This section considers the case in which a policymaker faces a fixed cost of changing the inflation rate. This cost could be proportional to the size of the adjustment (Dornbusch, 1991), but to simplify the model, it is assumed to be fixed. The main intuition should hold in the more general cases. The cost embodies the fact that in a status quo situation the policymaker faces only the standard costs of inflation and unemployment. When the policymaker decides to implement a stabilization program, however, he/she faces additional costs in order to generate support for the measures of the specific program. 1/ For example, concessions in the budget laws have to be made in order to obtain Congress approval. Experience in most high inflation countries also suggests that failing to stabilize after a program has been launched leads to a change in the policymaker. Thus, the fixed cost could be interpreted as a proxy for the cost of failing, although, for simplicity, the model presented below assumes that the fixed cost is incurred regardless the outcome of the stabilization.

The fixed cost of implementing a stabilization only makes sense when inflation is being reduced, so that it is assumed to be zero when inflation is increased to alleviate the recessionary impact of negative real shocks. Most of the discussion that follows will concentrate on the case of a reduction in the rate of inflation.

Using the same preferences as before, when a stabilization program is announced, the loss function is:

$$L^P = \frac{a}{2}(y - y^*)^2 + \frac{1}{2}(\pi^P)^2 + K, \qquad (24)$$

where K denotes the fixed cost. When there is no stabilization ($\pi=\pi_{-1}$) the loss is given by:

$$L^N = \frac{a}{2}(y-ky^*)^2 + \frac{1}{2}\pi^2_{-1}. \qquad (25)$$

The superscripts P and N represent, respectively, when a stabilization program is undertaken and when it is not.

As before, the Phillips curve describing the economy contains a real shock, which, in this model, makes people uncertain about whether or not a stabilization program will be implemented:

$$y-y^* = \theta(\pi-\pi^e) + \epsilon . \qquad (26)$$

The structure of the model is the same as before: people choose π^e without knowing the realization of ϵ. The government, in contrast, observes ϵ before deciding on its policy actions--whether or not to stabilize, and if it chooses to stabilize, determining which rate of inflation will be targeted. Therefore, there is no uncertainty for the government, it just compares L^P, at the optimal value of π^P, and L^N, and chooses the one that yields the lowest cost. Both the public and the government are assumed to choose their actions simultaneously, although the government has more information about the environment.

1/ Orphanides (1991) presents a model of stabilization with fixed costs which focuses on the optimal timing of stabilizations and the possibility that a program may be abandoned.

To rule out the possibility that the government is prevented from reducing inflation under the best external conditions—because of very large expansions—the loss associated with deviations of output from full employment is assumed to be zero when the gap $y-y^*$ is positive. Then, the expression $a(y-y^*)^2/2$ only penalizes recessions.

Since the public is uncertain about ϵ, it is also uncertain about which is smaller, L^P or L^N. They assign a probability p to a stabilization being undertaken ($L^P < L^N$) and 1-p to inaction ($L^P \geq L^N$). This probability can be interpreted as credibility, and it corresponds to the probability of a program being launched (all programs succeed with a probability of one). As is shown later, credibility depends on the realization of the exogenous random variable ϵ. In contrast, the concept of credibility in the previous section is based on uncertainty about preferences and could be influenced by the government through the actions it takes. Expected inflation is given by:

$$\pi^e = p\pi^P + (1-p)\pi_{-1}. \qquad (27)$$

Again, there is an expectational bias, since $\pi^P < \pi^e < \pi_{-1}$. The first inequality implies that stabilizations always occur with recessions. In turn, the second inequality implies that when inflation is kept constant, there is an expansion in output. Therefore, the loss L^N will be equal to $\pi_{-1}{}^2/2$, since expansions are not penalized.

The equilibrium of this model is characterized by π^P and p, both as a function of the parameters of the model and the predetermined variable π_{-1}. But because the government takes π^e as given, p is considered to be fixed when deriving the behavior of the government. Proceeding as usual, that is, by replacing the Phillips curve in equation (24), then taking the first order conditions to obtain π^P as a function of π^e, and finally substituting in equation (27), the following value is obtained for π^P:

$$\pi^P = \frac{a\theta^2(1-p)}{a\theta^2(1-p)+1}\pi_{-1} - a\theta\epsilon, \qquad (28)$$

provided π^P is positive; otherwise π^P is equal to zero. Substituting equation (28) in equation (24), the following expression for the costs is obtained when a stabilization program is implemented:

$$L^P(\epsilon,p) = \frac{1}{2}\left[\frac{a\theta^2(1-p)}{a\theta^2(1-p)+1}\pi_{-1} - a\theta\epsilon\right]^2\left[\frac{a\theta^2+1}{a\theta^2}\right] + K. \qquad (29)$$

It can be verified that the partial derivatives of L^P, with respect to ϵ and p, are both negative. When ϵ rises and stabilization occurs, inflation and the ensuing recession will both be lower. On the other hand, an increase in p, will reduce the expectational bias, allowing stabilization to a lower value of inflation and with less recessionary costs.

Now, all that remains is to show how p is computed. For this, it is assumed that the parameters are such that for all p in the interval [0,1] there is an ϵ, denoted as $\hat{\epsilon}$, that satisfies:

$$L^P(\hat{\epsilon},p) = L^N. \tag{30}$$

Since L^P is strictly decreasing in ϵ and L^N is equal to $\pi_{-1}^2/2$, $\hat{\epsilon}$ is unique. Moreover, for all $\epsilon > \hat{\epsilon}$, L^P is smaller than L^N. Therefore, assuming some regularity conditions in the distribution function of ϵ and some restrictions for the parameters of the model, a unique fixed point of ϵ^* exists, for which the following equality holds:

$$L^P(\epsilon^*, 1-F(\epsilon^*)) = \frac{\pi_{-1}^2}{2}. \tag{31}$$

Since the conditions for existence and uniqueness do not give additional insights, they are simply assumed to hold. Then, in equilibrium, p (the probability that a reduction in inflation is initiated) is equal to $1-F(\epsilon^*)$, that is, the probability that ϵ is larger than ϵ^*. Hence, stabilizations occur only when a positive real shock is strong enough to dampen the recession that accompanies the disinflation. 1/ When ϵ equals ϵ^*, the policymaker is indifferent about stabilizing or not.

Equation (31) also shows a negative relationship between ϵ^* and π_{-1}. Therefore, the size of the real shock that triggers a stabilization is negatively related to the starting level of inflation. This may explain why in countries with high inflation policymakers may decide to stabilize regardless the realization of the terms of trade or other relevant external variable. In contrast, in low inflation countries, the decision to reduce inflation may be more sensitive to the external conditions.

According to the previous discussion, the evolution of the inflation rate, starting at t-1 from a high inflation rate, is governed by:

$$\pi_t = \begin{cases} \pi_{t-1} & \text{for } \epsilon<\epsilon^* \\ \dfrac{a\theta^2F(\epsilon^*)}{a\theta^2F(\epsilon^*)+1}\pi_{t-1} - a\theta\epsilon_t & \text{for } \epsilon>\epsilon^*, \end{cases} \tag{32}$$

hence, for bad states of nature, inflation remains constant no matter what the realization of ϵ is, as long as $\epsilon < \epsilon^*$. In good economic conditions, inflation will follow an AR(1) process. Therefore, stabilizations will

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1/ It is possible, unless the support of $F(\epsilon)$ is restricted, that ϵ could be so large that a stabilization to zero inflation will not be costly in terms of output. At the value of ϵ when this starts occurring, L^P becomes flat and is always smaller than L^N.

occur gradually. In the case where stabilizations are always implemented, for example because K is small enough, $F(\epsilon^*)$ equals zero, and π is always equal to $-a\theta\epsilon$. That is, inflation is used only to offset negative real shocks and is zero in expected value.

This model shows that after inflation has reached a certain high level, for example, because of a succession of negative shocks to output, it will be reduced slowly. The stabilization does not occur in one period, because the policymaker partially accommodates inflationary expectations, which depend, as in the previous models, on past inflation.

Since there are no costs connected with rising inflation, the model predicts that when there is a negative shock, the policymaker will use inflation to stabilize output. By creating an inflationary surprise, the recession will be dampened. This analysis, however, assumes that the government does not look far enough forward to consider that the posterior reduction of inflation could be costly, by generating long periods of high inflation. The model could be extended to consider a policymaker who looks beyond one period. Qualitatively, the results should be the same, except for the use of inflation to offset negative shocks. According to the discussion above, the policymaker will be more reluctant to use inflation to stabilize negative shocks to output since he/she can be trapped in a high inflation equilibrium.

Finally, the dynamics of this model can also be considered as being caused by a lack of "credibility". However, contrary to the model of Section IV, credibility is not associated with the uncertainty about government preferences, or about the dynamics of a reputational game. Rather, it comes from the uncertainty about an "objective" exogenous variable, which in this model is a real shock. Thus, this notion of credibility resembles that of Dornbusch (1991), where the probability of undertaking stabilization (succeeding in Dornbusch's case) depends on the realization of a variable that is not under the policymaker's control.

VI. Concluding Remarks

The theories described in this paper provide an explanation about why governments stabilize gradually, based on an inflationary bias of private agents. This inflationary bias is an optimal response of people to government's choice of inflation. Although the government may dislike inflation as much as people do, it also dislikes unemployment. Therefore, after internalizing this fact, private agents will form their expectations knowing that the policymaker will prefer to partially accommodate the inflationary bias rather than to produce a large recession. Thus, in equilibrium there will be an inflationary bias.

The inflationary bias arising from these models is different from that of Barro and Gordon (1983). In their analysis, there is a bias that is independent of the history of inflation, which arises as a result of the government's intentions to generate inflationary surprises in order to increase output above the natural rate. In the models discussed in this paper, however, government's output target is full employment. But the inflationary bias arises because people do not know what the realization of a real shock or the preferences of the government will be. Or, the inflationary bias may simply be caused by indexation, which makes past inflation a determinant of current output. In all of these cases, the government will gradually reduce inflation and the time series of inflation will display persistence.

The discussion has focused mainly on the reduction of inflation, avoiding reference to increases in inflation to offset negative real shocks. The reason for this is that slow reductions of inflation are done to avoid large recessions. However, the converse is rather unappealing: increasing inflation slowly is done to avoid large expansions. The symmetry relies on the quadratic loss function around the natural rate of unemployment. Except for the model in Section V, the distinction between recessions and expansions was not made. Therefore, one can think of the models as being a better description of disinflations than of inflationary expansions.

The empirical evidence has documented the fact that inflation is persistent across countries, and that the degree of persistence appears to be unrelated to the history of inflation. As emphasized in Section II, theories based on an optimal inflation tax can also account for these facts. Moreover, the evidence cannot disentangle what is causing persistence, or in other words, how much persistence is left after the tax smoothing component is extracted from the data on inflation. Further research could try to decompose the time series of inflation in its different sources and focus on how the decomposition varies across countries.

The models in this paper are also related to the discussions of delayed stabilizations by Alesina and Drazen (1991) and Labán and Sturzenegger (1991). In these papers, there is a period of time during which desirable stabilization is not being implemented because of coordination problems. In the former study the delay is due to a concession game among different groups and in the latter study it is due to uncertainty about the outcome of the stabilization program.

In this paper, there is delay (see equation (32) in Section V) when the government waits to stabilize only in good states of nature. In the models of Sections III and IV, there is no delay, only slow adjustment. The delays and slow adjustments are also caused by coordination problems. If people were able to set inflationary expectations equal to zero, the government would have an incentive to reduce inflation at a faster speed. In the two models where credibility induces accommodation, inflation would be immediately set at zero if expected inflation were zero. In the model of indexation, there would still be some slow adjustment because past inflation affects current output for any rate of expected inflation. A reduction in inflationary expectations, however, would speed up the disinflation.

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