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Optimal state-dependent rules, credibility, and inflation inertia[☆]

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Abstract

We use a state-dependent model where pricing rules are optimal to examine the costs of a money-based disinflation under various assumptions about the credibility of the policy change. Our analysis allows us to relate actual credibility and future inflation inertia to the asymmetry of the price deviation distribution. An important implication of our state-dependent setting is that disinflation can be attained without substantial cost even in a situation of low credibility, provided that a mechanism of price alignment eliminates the asymmetry of the price deviation distribution. We also develop an analytical framework for analyzing intermediate imperfect credibility cases.

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1. Introduction

It is largely believed that nominal rigidities have important consequences for the effects of monetary policy. In particular, those rigidities could explain the reluctance of inflation to respond to monetary stabilization policies. Indeed, the view that intermittent and discontinuous staggered adjustment of individual prices is the ultimate cause of inflation inertia became prevalent among New Keynesian economists.

We examine inflation inertia in a model where pricing rules are optimal and individual prices are rigid. Furthermore, we investigate the relationship between credibility and disinflation costs. We claim that preceding work on the importance of nominal rigidities for disinflation costs uses a framework which is inappropriate. The assumption of a given pricing rule which does not respond to changes in monetary policy is not innocuous.¹ As we show, the interaction between optimal pricing rules and credibility is essential in the determination of the costs of disinflation. As a result, substantial inflation inertia is generated only when credibility is low.

The optimal pricing policies in our model are state-dependent, resulting from fixed costs of changing prices.² The literature on the costs of disinflation engendered by inflation inertia has used mostly time-dependent pricing policies.³ In those models each individual price is fixed for a preset amount of time. In this setting, whatever happens during the period in which a price is fixed cannot affect individual behavior, even a drastic change in the policy environment. This ad hoc unresponsiveness of individual prices is the mechanism through which disinflation can be made costly in this setting.⁴ Since the rules are not optimally derived, they are kept invariant to the changes in monetary policy, even the credible ones.⁵

By contrast, when rules are state-dependent, price rigidity does not imply that an individual price is fixed at any moment, notwithstanding what happens in the environment. A price is fixed only to the extent that the optimal price is not driven too far away from it. Moreover, optimal state-dependent pricing rules are affected by the credibility of monetary policy. We believe that those features make optimal state-dependent rules a much better description of individual behavior in the context of a changing policy environment.

Non-credible disinflations can be actually costly in an model with state-dependent rules. However, the mechanism is entirely different from the one that renders disinflation costly in a time-dependent model. As will be shown, an inflationary

¹This criticism applies to most of the literature. The exception is Tsiddon (1991), who analyzes the instantaneous effect of a credible inflation reduction, when pricing policies are one-sided Ss rules.

²Barro (1972) and Sheshinski and Weiss (1977, 1983) are pioneer works on the derivation of optimal state-dependent rules under menu costs.

³Some references are Taylor (1983), Ball (1994,1995), and Ireland (1995). Again, the exception is Tsiddon (1991).

⁴Still, credibility matters because prices are set for a period of time with base on expectations about the environment in this period (see Ball, 1995).

⁵One exception is Bonomo and Carvalho (2001) who use endogenous time-dependent rules to analyze monetary disinflations.

economy is characterized by an asymmetric distribution of deviations of individual prices from optimal ones. More specifically, there is always a much larger number of firms with prices substantially lower than the optimal than firms with prices higher than the optimal. As money growth is stalled, this asymmetry interacts with symmetric idiosyncratic shocks to produce inflation persistence: the symmetric idiosyncratic shocks trigger more upward than downward adjustments. This effect was mentioned by Caballero and Engel (1992), but they did not pursue the issue further since their main concern was the influence of inflation on the asymmetric effects of positive and negative monetary shocks.

When the policy is credible, the change of policy rules results in a narrower inaction range, specially for positive price deviations. Therefore, a substantial number of units are caught with price deviations that exceed the upper bound of the new inaction range, triggering a substantial amount of instantaneous downward adjustments. As a consequence of that, the distribution of price deviations changes abruptly, becoming nearly symmetric. This effect practically annihilates inflation inertia.⁶

Our results imply that credibility is important for the success of monetary stabilizations even in the presence of price rigidity. However, in a given environment, high credibility may not be attainable. This may be due to past failures in stabilization plans, or to underlying fiscal imbalances. In other situations, it may be attainable but at a high cost. In cases where policymakers have to live with low credibility, a fast disinflation could be achieved without substantial costs, provided that it is preceded by a mechanism of price alignment to eliminate distribution asymmetry.

We analyze some disinflation episodes to illustrate the policy implications above. We argue that the Real Plan in Brazil (1994) was an instance of a successful stabilization where credibility was low, and a mechanism of price alignment was implemented. We also argue that a freeze of prices and wages is not an adequate mechanism of alignment, since it freezes the asymmetric price deviation distribution inherited from the high inflation period. The Austral Plan (1985) in Argentina exemplifies the argument.

We proceed as follows: Section 2 presents the optimal pricing rule and the steady state of the model with constant inflation. Section 3 introduces monetary disinflation. We start assuming that the policy change is not credible, and then we analyze the case of full credibility. In Section 4, we study the effects of intermediate levels of credibility. In order to generate those results, we derive the optimal pricing rules in this environment. In Section 5 we discuss policy implications and present anecdotal evidence consistent with our model. Conclusions are presented in Section 6.

⁶A previous article on the consequence of state-dependent pricing rules for disinflation costs is that of Tsiddon (1991). Since there are no idiosyncratic shocks in his model, his analysis is restricted to the instantaneous price change caused by the change of optimal one-sided Ss rule in a credible disinflation. Blanchard (1997) informally develops some of the arguments we make, but his analysis of credible disinflation only takes into account the instantaneous effect of the change in rules.

2. The model and the inflationary steady state

In this section, we characterize the inflationary environment that precedes the disinflation policy. State dependency of pricing rules allows us to summarize the relevant information about the economy in the distribution of price deviations (from the frictionless optimal level).⁷ We find the distribution of price deviations correspondent to a certain inflation rate by aggregating optimal individual pricing rules, derived under the assumption that this inflation rate will last forever.

2.1. Optimal pricing rule in a stable environment

Following Caplin and Leahy (1991), we assume that the individual optimal price, in the absence of adjustment costs, is given by⁸

$$p_i^* = m + e_i. \quad (1)$$

To keep an individual price aligned to its optimal level is costly due to the existence of a lump-sum adjustment cost k . On the other hand to let the price drift away from the optimal entails profit losses that flow at a rate $l(p_i - p_i^*)^2$. Without loss of generality we assume l to be equal to one.⁹ Time is discounted at a constant rate ρ .

Given the stochastic process for the optimal price, each price setter solves for the optimal pricing rule. We assume that e_i follows a driftless Brownian motion and that the money supply has a deterministic constant rate of growth π . Thus, the frictionless optimal price is a Brownian motion with a drift given by the rate of money supply growth:

$$dp_i^* = \pi dt + \sigma_i dw_i, \quad (2)$$

where w_i is a Wiener process.

In this setting, the optimal rule is characterized by three parameters (L, c, U) , where c is the target level for adjustments, and L and U are the levels of price deviation which trigger upward and downward adjustments, respectively.¹⁰

Fig. 1 plots the values of (L, c, U) for different values of the inflation parameter, π , while the other parameters are fixed. The price setters take into consideration that the price will be depreciated soon with high probability and because of that reset their prices at a level higher than the optimal one. Thus, the optimal target point, c , is always greater than zero, and increases with inflation. The size of the upward adjustments, $c - L$, also grows with inflation in order to prevent a too high frequency of adjustments, which will result in a large increase in adjustment costs.

⁷See Dixit (1993) for an excellent exposition of the optimization problem and Bertola and Caballero (1990) for both the individual and the aggregation parts.

⁸This equation precludes strategic complementarities among the price setters. Its inclusion should magnify departures from the natural output level, but should not change the qualitative insights of the simpler model. Caplin and Leahy (1997) include price interdependence among agents and the results are not qualitatively different from Caplin and Leahy (1991).

⁹The optimal rule depends only on k/l .

¹⁰See Dixit (1993) for a derivation of the optimal rule.

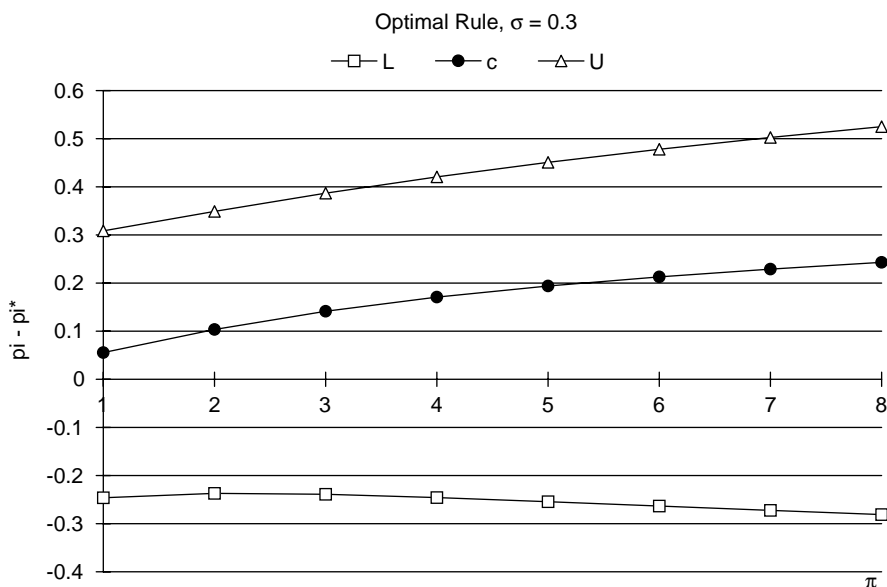


Fig. 1.

In what follows our main objective is to characterize the behavior of the aggregate price level, p , during disinflation. It will be useful to relate it to the money supply and to the average price deviation or disequilibrium, z :

$$p = \int p_i di = \int (p_i^* + z_i) di = \int (m + e_i + z_i) di = m + z. \tag{3}$$

Substituting Eq. (3) into the money quantity equation results that the level of output is the symmetric of the average price deviation:

$$y = -z. \tag{4}$$

2.2. The inflationary steady state

The inflation rate depends not only on the rate of growth of money supply, but also on the distribution of price deviations. Given the change in each individual frictionless optimal price, the distribution of price deviations will govern the proportion of units with positive and negative price adjustments, and will determine the new distribution of price deviations. When the distribution of price deviations is the ergodic one, the average price deviation z is constant.¹¹ Thus, Eq. (4) implies that

¹¹This is true only in the absence of aggregate uncertainty. Whenever aggregate shocks are present, the distribution of price deviations fluctuates through time and the ergodic distribution is only the time average of those distributions. See Bertola and Caballero (1990) for a derivation of the ergodic distribution and its properties.

output is constant, and the inflation rate must be equal to the rate of growth of the money supply.

If a certain rate of money growth is kept constant indefinitely, the distribution of price deviations will converge to the ergodic one. Then, if the rate of change of the money supply is unaltered for a long period of time, it is reasonable to assume that the distribution of the price deviations is ergodic and that the price inflation is equal to the rate of money growth. We can say that the economy is in an *inflationary steady state*.

For example, suppose that inflation has been equal to zero for some time. In this case, the optimal pricing rule of firms entails $L = -U$ and $c = 0$. The ergodic density of price deviations for this case is shown in Fig. 2. It is symmetric around zero and decreases linearly with the absolute size of the price deviation.

Fig. 3 shows the ergodic density for the same volatility of idiosyncratic shocks, but for a high inflation rate ($\pi = 1.5$). With a positive, high inflation the fraction of firms that are close to the lower barrier L is much larger than the fraction of firms close to the upper barrier U . This comes from the fact that the optimal price tends to appreciate, resulting in much more frequent upwards than downwards price adjustments. Thus, the distribution of price deviation becomes more asymmetric with a higher inflation rate. In the next sections we will examine the transition dynamics between a high inflation and a zero inflation steady states using different credibility assumptions. The asymmetry in the price deviation distribution will play an important role in this transition dynamics.

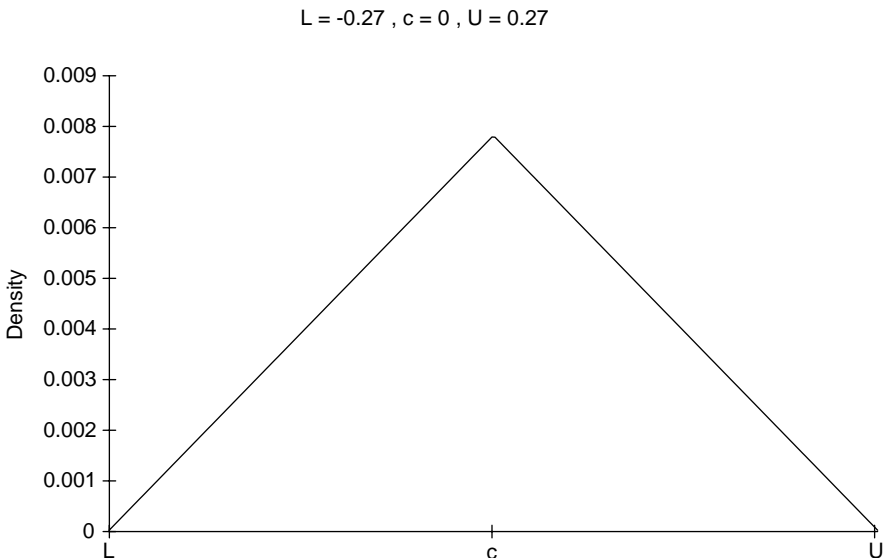


Fig. 2.

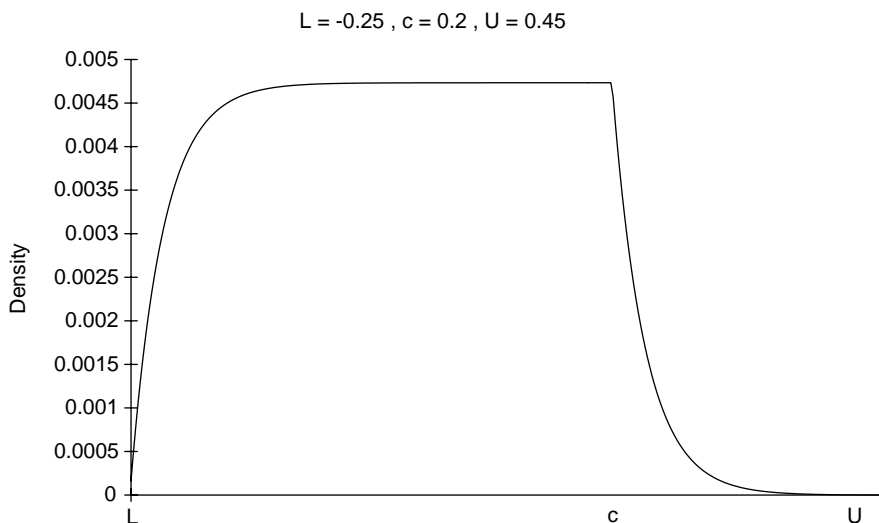


Fig. 3.

3. Disinflation results

3.1. Disinflation with no credibility

Suppose that the economy is initially in a high inflation steady state, such as the one depicted in Fig. 3. Money has been growing at a constant rate, and agents believe that this state will last forever. Then, the monetary authorities decide suddenly to stop printing money and to keep the money supply constant indefinitely. Assume, for simplicity, that the agents never believe in this change, and because of that maintain the same pricing rules they were following before. This does not mean that they will automatically continue to increase their prices: since the rules are state-dependent, any price increase must be triggered by a simultaneous increase in the frictionless optimal price. However, our simulations show that inflation will continue to grow for several months. What is the reason for that?

The substantial asymmetry of the distribution of price deviations associated with the inflationary steady state indicates that there is a large proportion of firms with prices far below their optimal ones. Since their price deviations are close to the trigger levels, a small positive idiosyncratic shock to the optimal price of each one of those firms may be enough to trigger a large price increase from them. Thus, large price increases may be numerous although there are no macroeconomic fundamentals driving them. On the other hand, there are few firms with prices far above their optimal one. Therefore, price decreases will be much less numerous. With the continued incidence of idiosyncratic shocks, the asymmetry of the price deviation distribution is corroded, hence reducing residual inflation. Notice that inflation converges to zero, even though firms never believe the disinflation policy.

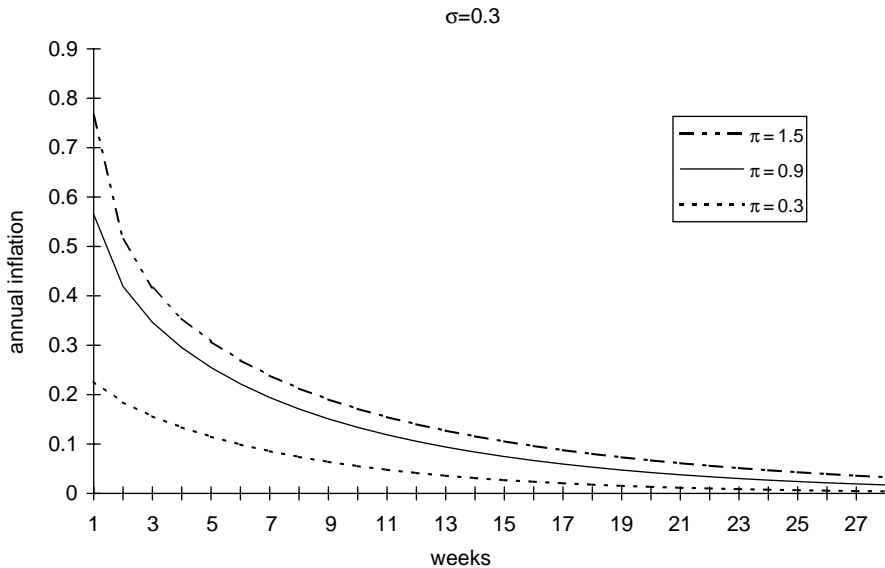


Fig. 4.

Fig. 4 shows the path of inflation after the non-credible policy change starting at different steady-state levels of inflation (see Bertola and Caballero (1990), for the discretization of the continuous time model in which the simulations are based). There is an instantaneous fall in the inflation rate. In order to see that, differentiate Eq. (3) to get $dp/dt = (dm/dt) + dz/dt$. Inflation jumps down since the first component jumps from π to zero.¹² Inflation is then gradually reduced, as the asymmetry of the initial price-deviation distribution decreases. A higher initial inflation results in a large inflation rate after money supply is halted.

The role of idiosyncratic shocks and the timing of their effect are illustrated by the results depicted in Fig. 5. A higher idiosyncratic uncertainty initially causes higher inflation inertia, because a larger proportion of price increases is triggered. However, the asymmetries in the price-deviation distributions are eroded faster in this case, causing a lower residual inflation after some time has elapsed.^{13,14}

¹²This is in contrast to time-dependent models where inflation falls continuously.

¹³The idiosyncratic uncertainty also affects the optimal rules, and as a consequence the steady-state distribution of price deviations. A higher uncertainty will increase the upper barrier and will decrease the lower barrier. This should reduce the overall asymmetry of the distribution, and thereby reduce inflation inertia. However, this effect should be small as compared to the direct effect mentioned in the text.

¹⁴The distribution of price deviations will converge in the long run to an ergodic distribution which is different from the one associated with a no inflation steady state. The distribution is linear, as in the steady state, but asymmetric, because the pricing rules are still associated with the old inflationary state. This result is mentioned as a curiosity since a persistent state of no inflation, in which economic agents are certain that inflation will be high very soon, is not plausible.

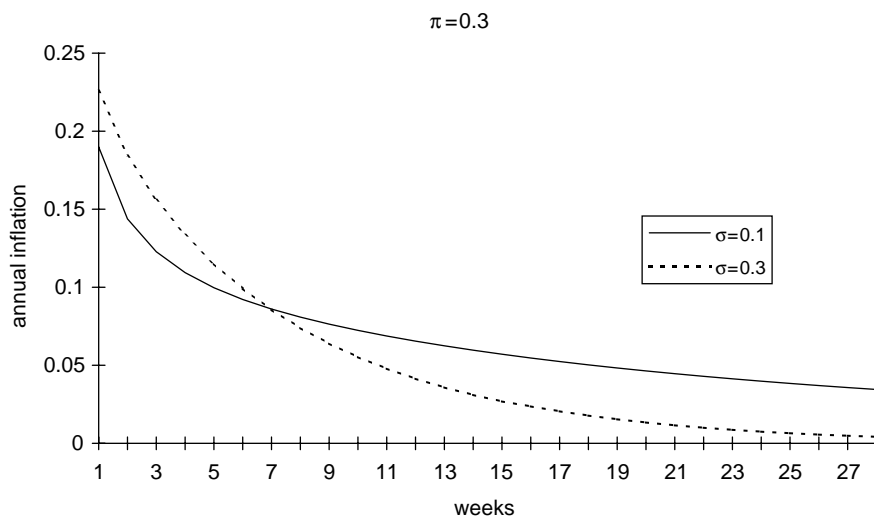


Fig. 5.

It is important to notice that since money supply is constant after the monetary policy change, the rate of change in output is symmetrical to the inflation level. Thus a persistent inflation implies output reductions, and contrary to the intuition based on time-dependent models,¹⁵ the higher the initial inflation, the larger is the output loss caused by disinflation and the longer the period of inflation inertia.

3.2. Disinflation with perfect credibility

In this section we examine the effects of a perfectly credible disinflation. We focus our analysis in the case where money demand is given by the quantitative equation. We then briefly consider the case of Cagan specification, where money demand depends negatively on expected inflation. Although the former does not take into account explicitly the effect of inflation reduction, one can interpret the variable m as the nominal aggregate demand, and assume that the Monetary Authorities set the trajectory of the money supply that corresponds to our path for nominal aggregate demand.¹⁶ Thus, under this interpretation, when the variable m is halted, money supply is increased by an amount just enough to satisfy the higher money demand due to lower inflation expectations and maintain the nominal aggregate demand constant.

¹⁵ In time-dependent models one can imagine that a higher inflation causes a reduction of the periodicity of adjustments, which can reduce inflation inertia. While it is certain that disinflation will be faster, it is not guaranteed that disinflation costs will be absolutely lower, since if the periodicity is fixed, higher initial inflation rates imply higher disinflation costs, as in Ball (1994).

¹⁶ This strategy for modeling monetary disinflations is also followed by Mankiw and Reis (2001).

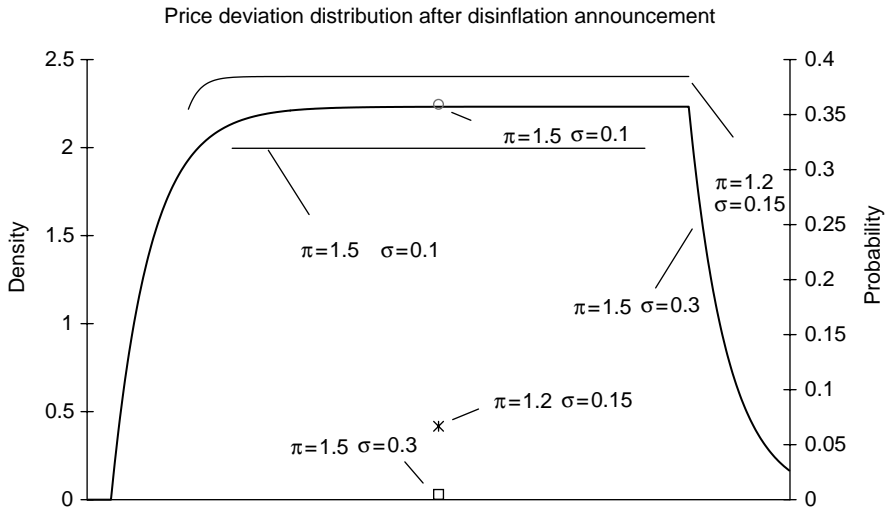


Fig. 6. Obs: The isolated points represent atoms of the distribution (probability values) and the curves are probability density functions.

Suppose monetary authorities credibly announce that money printing will be halted. Because the change of monetary policy is perfectly credible, the agents will change instantaneously their pricing rules, resulting in a sudden change in the price deviation distribution, which will also cause an instantaneous price variation. The inflation inertia will hinge on the asymmetry of the new distribution.

The new distribution will have an atom at the new target level, because of the large number of downward adjustments (and possibly upward adjustments too) instantaneously triggered. It is also substantially less asymmetric than the distribution inherited from the inflationary steady state. The main reason is that the reduction of the upper barrier eliminates the portion with lower density at the right side of the old distribution. Fig. 6 depicts some price deviation distributions immediately after the credible policy announcement.

3.2.1. Instantaneous price variation

A more detailed view of the distribution change is necessary to understand the resulting instantaneous price variation. First observe that a high inflation entails a very large upper barrier. The reason is that agents with prices substantially superior to the frictionless optimal price will not decrease them, because they foresee a fast erosion of this gap. By contrast, when there is no trend in the frictionless optimal price, any difference between the actual price and the frictionless optimal level is expected to remain unaltered, and large price deviations are not tolerated. Therefore, the upper barrier reduces substantially with a credible fall in the money supply growth. This causes a downward adjustment of all prices which were at the interval between the old and the new upper barriers. The effect of inflation reduction on the lower barrier is small and ambiguous, as noticed by Blanchard (1997). If it decreases

Table 1

Cases	Inflation rate		
	$\pi = 1.5; \sigma = 0.3$	$\pi = 1.2; \sigma = 0.15$	$\pi = 1.5; \sigma = 0.1$
Instantaneous ^a	-0.520733	0.344202	-0.308986
1 day	-0.234020	-0.197199	-0.095832
5 days	0.054004	-0.002781	0.000131
10 days	0.026353	-0.000984	0.000214
20 days	0.008312	-0.000044	0.000228
30 days	0.003644	0.000112	0.000211
60 days	0.000747	0.000184	0.000165
120 days	0.000241	0.000115	0.000120

^a Measured as if the effect persisted for a whole day.

with the fall in inflation, the only instantaneous effect results from price decreases caused by the reduction of the upper barrier.¹⁷ This is the case depicted in bold line (initial inflation 1.5 and the standard deviation is 0.3) in Fig. 6. Then, we will have an instantaneous deflation. When it increases, its movement triggers price increases from the units with price deviation between the old and the new lower barrier. Despite the higher density of units at the lower part of the distribution, the net effect is ambiguous.¹⁸ In Fig. 6 we illustrate two cases where the upper barrier moves up. When initial inflation is 1.2 and standard deviation is 0.15 there will be an initial price level increase, as indicated in Table 1. When initial inflation is 1.5 and standard deviation is 0.1 there will be a initial price level decrease, although the movement of the lower barrier leads some units to increase their prices.

3.2.2. Inflation inertia

Table 2 shows that no significant persistent output loss is generated by this instantaneous effect. If some important deviation from the natural output occurs, it will be an output gain, as in the first column of Table 2. For this reason we concentrate on the dynamics that results from the interaction between idiosyncratic shocks and the price deviation distribution. For a given level of idiosyncratic uncertainty, the persistence of inflation hinges solely on the asymmetry of the new distribution of price deviations. As depicted in Fig. 6, the new distribution will be substantially less asymmetric than the distribution inherited from the inflationary steady state. Thus, the abrupt change of rules induced by the credible change of monetary policy destroys the mechanism of inflation reproduction. Despite

¹⁷ As Blanchard (1997) points out, since the target level is reduced when inflation falls, and the inaction range between the lower barrier and the target level should also be reduced, the resulting effect on the lower barrier will depend on which reduction is greater. When inflation reduction is high as compared to the variance, the lower barrier should increase, as in the case of one-sided Ss policies (see Tsiddon, 1991). The combination of high initial money growth rates with much lower idiosyncratic uncertainty in the simulations reported below was chosen to produce cases where the lower trigger increases.

¹⁸ The reason is that the magnitude of the upper barrier reduction may be sufficiently higher than the magnitude of the lower barrier increase to compensate for the difference in densities.

Table 2

Cases	Accumulated output gain		
	$\pi = 1.5; \sigma = 0.3$	$\pi = 1.2; \sigma = 0.15$	$\pi = 1.5; \sigma = 0.1$
Instantaneous ^a	0.000004	-0.000003	0.000002
1 day	0.001477	0.000034	0.000022
5 days	0.006665	0.000221	0.000116
10 days	0.011087	0.000485	0.000233
20 days	0.016783	0.001039	0.000465
30 days	0.020786	0.001598	0.000691
60 days	0.029675	0.003238	0.001345
120 days	0.043744	0.006301	0.002560

^a Measured as if the effect persisted for a whole day.

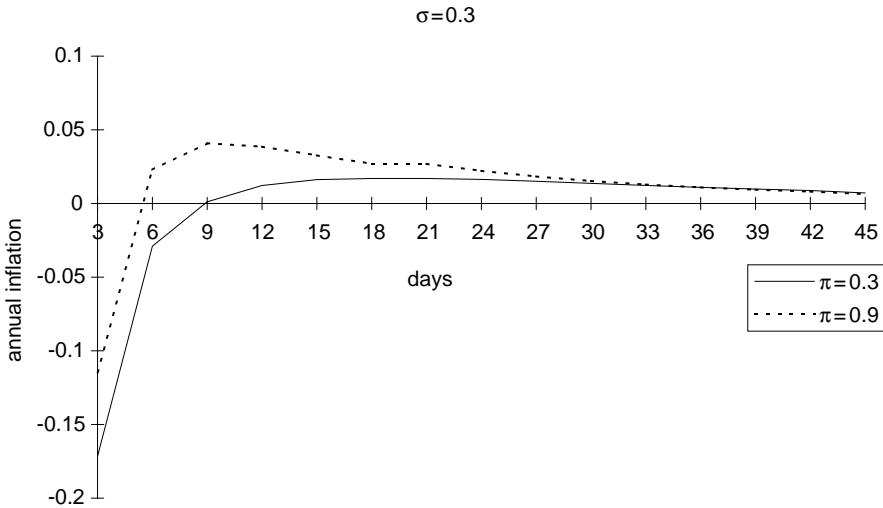


Fig. 7.

substantial price stickiness at the microeconomic level, inflation is eliminated nearly instantaneously, at most with very little output loss.

This is illustrated most clearly in Fig. 7, which depicts the inflation inertia resulting from the simulation of a credible disinflation when the economy has been for a long time in an inflationary steady-state.¹⁹ When the parameter values for the inflation rate and the standard deviation of the idiosyncratic shocks are 1.5 and 0.3, the initial optimal price rule is $(-0.25, 0.2, 0.45)$ and the initial distribution of price deviations is portrayed in Fig. 3. When the money supply growth is credibly stopped, the price rule changes immediately to $(-0.27, 0, 0.27)$ and the distribution changes instantaneously to the base case depicted in Fig. 6. All the units with price deviation between 0.27 and 0.45 decreased their prices to the frictionless optimal level, generating an atom in the new distribution. This also causes an instantaneous deflation, as

¹⁹ This is equivalent to an annual inflation of 348%.

illustrated in Table 1. The distribution in Fig. 6 is much more symmetric than the one in Fig. 3. However, there is a small empty space in the left side because of the decrease of the lower barrier. In the first day subsequent to the policy change, there will be a small deflation: while the space on the left side of the distribution is not filled there will be no upwards price adjustments. According to Table 1 after some time there will be a small inflation until convergence to zero inflation.²⁰ This inflation is negligible, specially if compared to the original level, which leads us to conclude that disinflation can be attained almost instantaneously without costs.²¹

3.2.3. Cagan specification

Consider now the Cagan (1956) specification, where money demand depends negatively on expected inflation.²² In this case, when the variable m is halted, one should interpret that money supply will be kept constant despite the increase in money demand caused by lower inflation expectations. The effect of the instantaneous change in inflation expectations is equivalent to a negative shock to nominal aggregate demand of a size equal to the elasticity of money demand at the inflationary steady state. The negative aggregate shock shifts the distribution to the right, leaving the region close to the lower barrier empty. A substantial number of units adjusts downwards instantaneously, as they are displaced to the right of the upper barrier. Thus, the instantaneous effect is a sizeable fall in both price level and output. As time passes the idiosyncratic shocks causes more downward adjustments as they interact only with the upper part of the price deviation distribution. Hence, the recession is attenuated by the ensuing deflation, as accumulated output loss increases at decreasing rates.

If the Cagan elasticity or initial inflation are very high, the negative shock will be very large and practically all units will adjust downwards instantaneously. The inherited distribution is composed solely of an atom in the zero position, which is of course symmetric. Therefore, there is no ensuing effect on inflation and output.²³

The results above can be summarized as follows. If there is perfect credibility, the government could disinflate instantaneously without cost if it increases money supply immediately after the stabilization announcement. Otherwise, disinflation could be costly even with perfect credibility because of the liquidity squeeze. In any case, as long as there is perfect credibility there will be no inflation inertia.

4. Disinflation with imperfect credibility

The assumption of imperfect credibility is more realistic. The economic agents in general do not fully believe that a change in the monetary policy will last forever. It is

²⁰ While inflation converges to zero, the distribution of price deviations converges to the triangular distribution of Fig. 2, which is associated to the zero inflation steady state.

²¹ Notice that the time unit in Fig. 7 is 1 day, while in Figs. 4 and 5 is 1 week.

²² A more detailed analysis of this case can be found in the working paper version (Almeida and Bonomo, 1999).

²³ See the working paper version (Almeida and Bonomo, 1999) for numerical simulations.

not true, either, that they are absolutely sure that the new policy will be abandoned immediately. Here, we model imperfect credibility as a conjecture that in each finite time interval there is a positive probability that the monetary authorities will renege. For simplicity, we assume that the probability of renegeing at the next time interval is always the same. Thus, we model the rate of growth of the money supply after stabilization as a Poisson process with constant arrival rate ψ . Once the new policy is abandoned, the agents believe that the old policy will be kept forever.²⁴

Specifically, after the stabilization policy is launched, the process for the money supply is

$$dm = (0 + \pi 1_{\{N_t \geq 1\}}) dt, \quad (5)$$

where N is a Poisson counting process with constant arrival rate ψ , and $1_{\{\cdot\}}$ is the indicator function. Then, the drift of the money supply will change from zero to π when an arrival occurs. We assume that stabilization is launched at time zero.

The parameter ψ can be interpreted as a measure of credibility. The extreme cases of perfect and no credibility are associated with zero and infinity values for ψ , respectively. Imperfect credibility is represented by positive finite values, and the higher the ψ , the lower the degree of credibility.

In order to analyze disinflation effects under imperfect credibility, the first step is to derive the optimal pricing rule. Let us define T as the random time of the abandonment. Then, after T , the monetary policy is the same as before, and the optimal pricing rule is exactly as in Section 2. Before T , the money supply is constant, but there is a constant hazard ψ that the old inflationary policy is resumed. So, the price setters have to take that into consideration when choosing their inaction range. We now turn our attention to the characterization of the optimal pricing rule under those conditions.

4.1. Optimal pricing rule under imperfectly credible monetary policy

First, we observe that the probability that the old monetary policy is resumed in the next interval $(t, t + s)$ is independent of t . Then, the optimal rule in the stabilization phase is time-invariant. Let us represent by G the value function after the monetary authorities renege. Then, the differential of the value function before stabilization is abandoned can be represented as

$$dC(z_i) = \left[\frac{\sigma_i^2}{2} C''(z_i) dt + C'(z_i) \sigma_i dw_i \right] + dq[G(z_i) - C(z_i)], \quad (6)$$

where dq , the differential representation of the Poisson process, is one if the monetary authorities renege at this instant and zero otherwise. The first squared brackets expression is the usual formula for the differential of a function of a diffusion. If a Poisson arrival restores the old monetary policy, there will be an

²⁴ For simplicity, we specify a constant money supply growth rate after the stabilization flaw. To choose this inflation rate to be the same as the pre-stabilization level is appealing, if one believes that certain structural features of the economy determine the money supply growth.

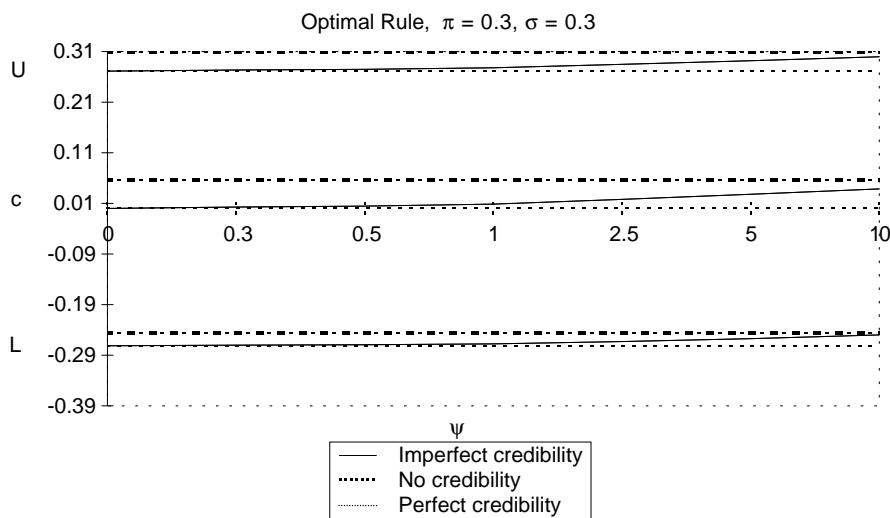


Fig. 8.

instantaneous jump in the value function, captured by the second term. The new value function G will correspond to the case of a steady inflation.

From this, we derive the ODE for the value function C by using (6) in the continuous time Bellman equation, and solve for the optimal pricing rule by imposing the usual smooth pasting and value matching conditions.²⁵

4.2. Disinflation results

We carried out simulations for imperfectly credible disinflations, assuming that the money supply growth before the policy change and idiosyncratic uncertainty were both 0.3. After stabilization is launched, money supply growth falls to zero and idiosyncratic uncertainty remains the same. Hence, the only source of aggregate uncertainty at this stage is the timing of the policy abandonment. We also supposed that firms believe that whenever the monetary authorities renege, money supply growth will return to its pre-stabilization value. In Fig. 8 we show how the optimal trigger and resetting points (L, c, U) respond to different credibility parameters ψ .²⁶ The two horizontal lines for each policy parameter show the values relative to the polar cases of perfect credibility and no credibility. The values for the policy parameters (L, c, U) increase continuously as ψ gets higher, starting from the lower line representing the full credibility case, and growing towards the no credibility line. Recall that the parameter values for the no credibility case also correspond to the

²⁵ See Almeida and Bonomo (1999) for details.

²⁶ For easiness of interpretation observe that the probability that the old policy is not resumed before t is $e^{-\lambda t}$. So, if $\lambda = 0.3$, the probability that the stabilization policy is kept for at least 1 year is approximately 0.74.

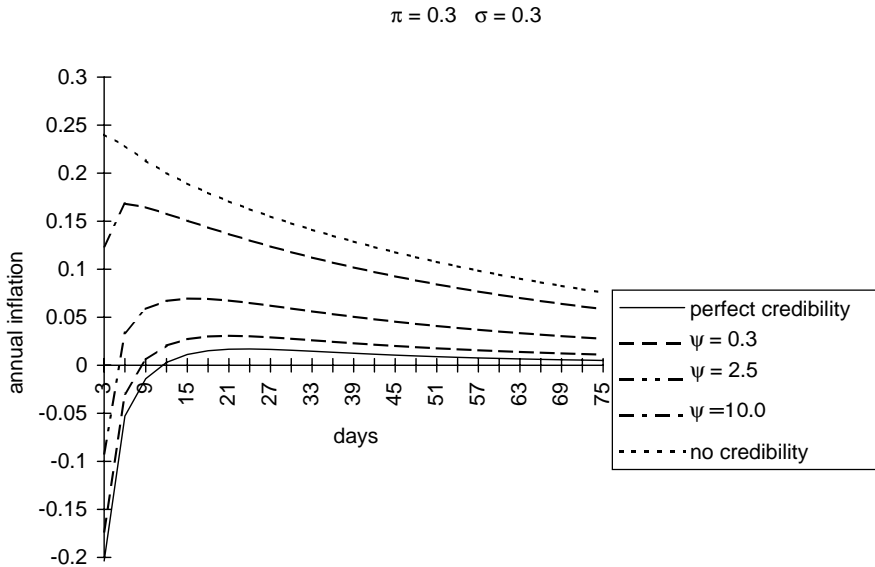


Fig. 9.

pricing policy before stabilization. Then, we see that if ψ is high and credibility is low, the pricing rule will change very little. As argued in Section 4, it is the change in the optimal pricing rule induced by stabilization that potentially reduces inflation inertia. We should consequently expect inflation inertia to be inversely related to credibility of the policy makers, as measured by the parameter ψ .

Fig. 9 shows disinflation paths for various credibility parameters. In the simulations performed, the monetary authorities never renege, although agents attribute a positive probability that it would occur in any time interval. Therefore, inflation must converge to zero in the long run. Our aim is to evaluate how fast is this convergence, for different levels of credibility. In order to focus on the effects of credibility, we fix the remaining parameters of the model ($\pi = 0.3$, $\sigma_i = 0.3$, $\rho = 0.025$, and $k = 0.01$). The simulation results are as expected: inflation inertia increases as the level of credibility is reduced. When $\psi = 10$, which means that the agents assign a probability of 8.2% that the stabilization will last at least one quarter, the inflation path closely resembles that of the no credibility case.

5. Evidence and implications

5.1. Policy implications

According to our model, disinflation can be attained without output losses if there is perfect credibility and the government increases money supply immediately after the stabilization announcement. There are also two types of costly disinflations. The first one is associated with high credibility and little inflation inertia. The price

deviation distribution is symmetric at the beginning of the disinflation, but disinflation is costly because of a liquidity squeeze. In the second one there is low credibility and inflation inertia. The asymmetric distribution of price deviations is the driving force behind output losses and inflation inertia.

Thus, credibility is important for the success of monetary stabilizations even in the presence of price rigidity.²⁷ However, in a given environment, high credibility may not be attainable. In other situations, it may be attainable but at a high cost. Policymakers may need to squeeze liquidity in order to maintain credibility. In such cases our model implies that a fast disinflation could be achieved without substantial costs provided that it is preceded by a mechanism of price alignment to eliminate distribution asymmetry.

5.2. Some anecdotal evidence

There is considerable evidence that our framework is an useful benchmark for the analysis of actual disinflation episodes. We substantiate this claim with evidence on the features of the inflationary environment and on specific disinflation episodes.

5.2.1. Inflation and asymmetry in the distribution of relative prices

Lach and Tsiddon (1992) use disaggregated price data for 26 Israeli foodstuffs, and analyze the cross-sectional distribution of real prices. In the steady state of our model, the asymmetry of the real price distribution is identical to the asymmetry of the price deviation distribution, since the optimal individual price is equal (up to a constant) to the price level plus a symmetric idiosyncratic shock. The authors show that in a period of low inflation (an average monthly inflation of 3.9% in 1978–1979), the hypothesis of symmetry cannot be rejected by the data. However, for the period of high inflation (an average inflation of 7.3% in 1982), the data reject the hypothesis of symmetry in favor of the alternative of skewness to the left (meaning that the upper tail of the distribution is thinner than the lower tail). This is consistent with the steady-state prediction of our model. They also consider the distribution of durations of price quotations. They conclude that the duration data are consistent with the predictions from two-sided menu cost models.

5.2.2. Specific disinflation episodes

One of the novel predictions of our framework is that not only does inflation cause asymmetries, but these asymmetries are a potential cause of residual inflation after an stabilization plan.

The Argentinian Austral Plan (1985). Consider, for example, the case of the Austral Plan in Argentina,²⁸ in the period 1985–1987. The Austral plan was a

²⁷ If credibility is indeed perfect, there is no reason why the government should allow a liquidity squeeze.

²⁸ The Brazilian Cruzado Plan was an experience in several aspects similar to the Austral Plan (see for example Modiano, 1988). The main ingredient was a freeze in prices. There was also a mechanism to realign the wages (to the average of the last 6 months), but not the prices. The plan failed not only due to inflationary pressure caused by the lag of an important fraction of prices, but also due to generalized excess demand.

heterodox stabilization plan, which included both aggregate demand control measures, and direct control of prices and wages. According to Machinea and Fanelli (1988),²⁹ the Argentinian government recognized the importance of a realignment in relative prices for the success of the stabilization plan. Before the plan was actually launched (in June 1985), steps were taken in this direction, such as a flexibilization of controls on industrial prices, and an increase in beef prices, since the prices of foodstuffs were lagging behind average historical levels. However, the authors acknowledge that adjustments in relative prices after the program was launched were an important factor contributing to the comeback of inflation. Inflation (measured by consumer prices) decreased from 30.5% a month in June, to 1.9% a month in October, but climbed back to 4.6% in March of 1986.

According to our model, in an environment of high inflation (such as the Argentinian economy in the period preceding the Austral Plan, where inflation reached 25–30% a month), we should expect the distribution of relative prices to be skewed. The freeze of an important fraction of prices and wages in the economy could explain the initial success of the plan, even under imperfect credibility and relative price misalignment. As the pressure to realign prices increases (even in an environment of low overall inflation, such as the Argentinian economy immediately after the Austral Plan), inflation tends to fight back.

The Brazilian Real Plan (1994). A successful stabilization attempt based on a generalized mechanism of price realignment was the Brazilian Real Plan (1994).³⁰ In March 1994, the government introduced an inflation index (URV) to serve as an optional unit of account for prices and contracts. As the index had stable real value, it was an attractive unit of account. The economy adhered massively to the new unit of account. On July 1st the old money was extinguished and the URV became the new currency (the “real”). At the same time, monetary policy changed to become compatible with stabilization. The inflation rate fell abruptly from 45% a month in June to 6% a month in July, continuing to decrease afterwards. This result was specially striking, given the low degree of credibility that was due both to the failure of several previous stabilization attempts and to structural fiscal imbalances.

Since the conversion to URV was voluntary, the firm would choose a relative price close to its past average. This contributed to eliminate the underlying asymmetry in the distribution of price deviations. Then, when the new currency was launched there was no inflationary pressure due to an inherited asymmetry. In such a scenario it is not surprising that disinflation was fast and costless even without credibility.

6. Conclusion

We used a state-dependent model where pricing rules were optimal to examine the costs of a money-based disinflation under various assumptions about the credibility of the policy change. Our analysis allowed us to relate actual credibility and future

²⁹ See also Canavese and di Tella (1988).

³⁰ For more details, see Franco (1996).

inflation inertia to the asymmetry of the price deviation distribution. Thus, it provides an empirical framework for the investigation of disinflation experiences. Although we investigate some specific episodes, future empirical research should test the predictions of our model in a more systematic way.

An important implication of the state-dependent setting is that disinflation could be attained without substantial cost even in a situation of low credibility, provided that a mechanism of price alignment eliminates the asymmetry of the price deviation distribution. Thus, our model furnishes a criterion to evaluate policies that aim to affect price setting. Policies that do not eliminate the price deviation asymmetry inherited from the inflationary environment should not be effective. Thus, price freezing is not an effective anti-inflationary policy. We analyzed actual experiences of heterodox stabilizations where the facts are in accordance with our criterion.

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