Endogenous Time-Dependent Rules and Inflation Inertia*

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Abstract

When policy rules are changed, the effect of nominal rigidities should be modelled through endogenous pricing rules. We endogenize Taylor (1979) type pricing rule to examine the output effects of monetary disinflations. We derive optimal fixed-price time-dependent rules in inflationary steady states and during disinflations. We also develop a methodology to aggregate individual pricing rules which vary through disinflation. This allows us to reevaluate the output costs of monetary disinflation, including aspects as the role of the initial level of inflation and the importance of the degree of credibility of the policy change.

1 Introduction

It is largely believed that nominal rigidities have important consequences for the effect of monetary policy. Among several alternatives, the primary dynamic specification of nominal rigidity used in monetary models is a fixed price time-dependent rule, due to Taylor (1979). In this model each price setter chooses the price that will be fixed during a predetermined period of time. Since this rule is usually postulated rather than derived, the time period between adjustments is exogenous. This way of proceeding is clearly inadequate when there are changes in the environment, as it is the case when policy rules are changed. When monetary authorities launch a disinflationary program they usually claim that the monetary rule will be changed.

This paper analyzes the effect on output after a disinflationary monetary policy is announced. For this purpose we endogenize the fixed price time-dependent

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1 One exception is Ball, Mankiw and Romer (1988).
rules followed by price setters and aggregate them. This endeavour is straightforward when it is assumed that the economy is in an inflationary steady state. However, when analyzing the cost of disinflation, one is interested in the output effects during the transition between steady states. This requires solving less trivial optimization problems and developing a more general aggregation methodology.

In order to derive fixed price time-dependent rules optimally, it is necessary to understand the hypotheses that support its optimality. Either the costs of changing prices or information gathering costs taken individually would not be enough. The former would generate a rule with fixed prices but state-dependent (see for example Almeida and Bonomo 1999) while the latter would generate a time-dependent rule with preset price path rather than a fixed price (Caballero, 1989). If we assume the two types of costs are present, then the optimal rule is both time-and-state dependent (Bonomo, Garcia and Rocha, 1999). In order to justify the fixed price time-dependent rule it is necessary to assume that those two kinds of costs are borne together. For example, one cannot choose to incur the cost of information and after the optimal price is known to decide whether to incur the adjustment cost and change the price. The hypothesis here is that once the only type of cost is incurred one can get informed and change the price without any extra cost. The assumption is made not for its appeal, but because it rationalizes the fixed price time-dependent rule.

Qualitatively, the costs of disinflation are higher with endogenous rules than with exogenous rules. The intuition is straightforward: when a new and perfectly credible monetary rule is announced, expectations are revised and the new prices are set for a longer period. Thus, when the endogeneity of rules is taken into consideration it is not as easy to disinflate under perfect credibility as in the paper of Ball (1994).

The period between adjustments becomes longer when the decrease in inflation rate is larger. The issue of whether it is easier to disinflate when the initial inflation is high than when it is low becomes more complex. If on one hand the degree of nominal rigidity is lower when inflation is high (as mentioned by Blanchard, 1998), on the other hand the increase in the length of contracts is larger. Then the effect of a given disinflation policy when the initial inflation is higher is a more intense, but shorter recession.

The endogeneity of rules also allows us to examine in a proper way the effect of credibility on the output costs of disinflation. This issue is examined by Ball (1995) in a fixed price time-dependent model with exogenous rules. His conclusion is that lack of credibility and nominal rigidity with staggering jointly explain disinflation costs. However, the endogeneity of contracts decreases the magnitude of this effect, since credibility is directly related to the length of the contracts during disinflation.

The remaining part of the paper is organized as follows. Section 2 derives optimal pricing rules under steady state and during some types of disinflation paths under alternative credibility assumptions. A methodology for aggregating individual pricing rules out of the steady state is outlined in section 3. Section 4 describes and interprets the results obtained by simulation of some specific
types of disinflations under alternative credibility assumptions. The last section concludes.

2 Optimal Fixed Price Time-Dependent Rules

2.1 The Model

Our economy is populated by an infinite collection of identical (in all aspects other than the timing of adjustments and realization of idiosyncratic shocks) imperfectly competitive firms indexed in the interval \([0, 1]\). We assume that the optimal level of the individual relative price, in the absence of frictions, is given by:

\[
   p_i^* - p = \theta y + e_i
\]

where \(p_i^*\) is the individual frictionless optimal price, \(p\) is the average level of prices, \(y\) is aggregate demand and \(e_i\) is an idiosyncratic shock to the optimal price level (all variables are in log)\(^2\). Since firms are identical (although they can have different prices and supply different quantities), for simplicity we evaluate \(p\) at any time \(t\) according to:

\[
   p(t) = \int_0^1 x_i(t) \, di
\]

where \(x_i(t)\) is the price charged by the firm \(i\) at time \(t\).

Nominal aggregate demand is given by the quantity of money:

\[
   y + p = m
\]

Substituting the above equation into equation 1 yields\(^3\):

\[
   p_i^* = \theta m + (1 - \theta)p + e_i
\]

If there were no costs to adjust prices and/or obtain information about the frictionless optimal price level, each firm would choose \(x_i(t) = p_i^*(t)\) and the resulting aggregate price level would be \(p(t) = m(t)\). Thus aggregate output

\(^2\)Equation 1 states that the relative optimal price depends on aggregate demand and on shocks specific to the firm. It can be derived from utility maximization in an yeoman farmer economy, as in Ball and Romer (1989).

\(^3\)This equation can also be derived directly from other specifications, such as Blanchard and Kiyotaki (1987), where real balances enter the utility function.
and individual prices would be given by $y(t) = 0$ and $x_i(t) = m(t) + e_i(t)$, respectively.

We assume that the firm cannot either observe the stochastic components of $p_i^*$ or to adjust its price with base on the known components of $p_i^*$ without paying a lump-sum cost $F$. On the other hand to let the price drift away from the optimal entails profit losses, that flow at rate $\alpha(p_i - p_i^*)^2$. Without loss of generality we assume $\alpha$ to be equal to one. Time is discounted at a constant rate $\rho$.

Given the stochastic process for the optimal price, each price setter solves for the optimal pricing rule. The cost function resulting from the minimization problem at a certain time $t_0$ can be written in the following way:

$$V = \min_{t_0} \left\{ E_0 \sum_{j=0}^{\infty} e^{-\rho(t_j-t_0)} \left[ \int_0^{t_j+1-t_j} e^{-\rho s} (x(t_j) - p^*(t_j + s))^2 ds + F \right] \right\}$$

where $t_j$'s are the times of adjustment/information gathering and $x(t_j)$'s are the prices chosen at those moments.

We assume that $\theta$ is equal to one. This evades strategic complementarities in prices, simplifying aggregation substantially. Thus, the aggregate component of the frictionless optimal level of individual price is always reduced to the money supply, that is:

$$p_i^* = m + e_i$$

### 2.2 Optimal pricing rule in steady state

We assume that $e_i$ follows a driftless Brownian motion with coefficient of diffusion $\sigma_e$ and that the money supply has a deterministic constant rate of growth $\mu$. Thus, the frictionless optimal price is a Brownian motion with a drift given by the rate of the money supply growth:

$$dp_i^* = \mu dt + \sigma_e dw_i$$

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4 Observe that this form corresponds to a second order Taylor approximation to the profit loss whenever the second derivative of the profit function is constant.

5 The optimal rule depends only on $F/\alpha$.

6 The inclusion of strategic complementarities should magnify departures from the natural output level, but should not change the qualitative insights of the simpler model. Caplin and Leahy (1997) is one of the few articles to include price interdependence among agents in the state dependent literature. Their results are not qualitatively different from Caplin and Leahy (1991), where each individual optimal price depends only on the money supply.

7 In later sections we deal with alternative assumptions about $m$. 

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Given the Markovian nature of the stochastic process we postulated for the frictionless optimal price and lump-sum type of adjustment/information cost, the problem of the firm after paying this cost does not depend either on the specific time when the problem is solved or on the realization of the frictionless optimal price at that time. Thus we can formalize the optimization problem through the following Bellman Equation:

$$V_{\mu} = \min_{\tau} E_t \int_0^\tau [x - p^*(t + s)]^2 e^{-\rho \tau} ds + F e^{-\rho \tau} + V e^{-\rho \tau}$$

(6)

where $E_t$ represents the conditional expectation operator with respect to the information set at $t$. The first order conditions are:

$$x = \frac{\rho}{1 - e^{-\rho \tau_{ss}}} \int_0^\tau E_t p^*(t + s) e^{-\rho \tau} ds$$

(7)

$$V = \frac{1}{\rho} \{ E_t [x - p^*(t + \tau_{ss})]^2 - \rho F \}$$

(8)

We find $\tau_{ss}$ numerically in the following way. First we use the process for $p^*$ given by equation 5 into all three above equations. Then we substitute equation 7 into the Bellman equation to find an explicit expression for $V$. Finally we substitute this expression in expression 8, arriving at an equation which has $\tau_{ss}$ as its only unknown. We solve the resulting nonlinear equation numerically. Since $\tau_{ss}$ is independent of time, assuming that price adjustments are distributed uniformly in time\(^8\), the price level will be given by:

$$p(t) = \frac{1}{\tau_{ss}} \int_0^{\tau_{ss}} x(t - r) dr$$

$$= \mu + \mu \left\{ \frac{1 - e^{-\rho \tau_{ss}}(1 + \rho \tau_{ss})}{\rho(1 - e^{-\rho \tau_{ss}})} - \frac{\tau_{ss}}{2} \right\}$$

Thus, the inflation rate is $\mu$ and the output level is given by:

$$y_{\mu} = -\mu \left\{ \frac{1 - e^{-\rho \tau_{ss}}(1 + \rho \tau_{ss})}{\rho(1 - e^{-\rho \tau_{ss}})} - \frac{\tau_{ss}}{2} \right\}$$

Figures 1 and 2 show the behavior of the optimal contract for several values of $\mu$, $\sigma$, $\rho$, $F$ and $\alpha$. We follow Ball, Mankiw and Romer (1988) by calibrating $F$ in such a way that with $\mu = 3\%$, $\sigma = 0$ and $\rho = 2.5\%$ a year, a firm chooses to collect information and adjust its price once a year. This is consistent with

\(^8\)This is a natural assumption for the steady state since the uniform distribution is the only time invariant distribution.
the findings of Blinder's (1991) survey for the American economy, where the median firm adjusts its price once a year. As a result we set \( F = 0.00015 \). As a test for that configuration of parameters we can assess if the adjustment intervals generated for high inflation are plausible. With \( \mu = 0.75 \) (annual inflation of 113%) prices are adjusted once every 1.5 months; with \( \mu = 1.15 \) (annual inflation of 217%) adjustments occur once a month, and with \( \mu = 2.5 \) (annual inflation of 1120%), the frequency of adjustments increases to twice a month. Those implications seem to fit roughly the empirical evidence for Brazil during the period 1981-1985 (see Ferreira, 1994).

The optimal time between adjustments, \( \tau_{ss} \), has the expected features. It is increasing in \( \mu \) and \( \sigma_e \) since a higher inflation or idiosyncratic uncertainty would result in larger quadratic deviations from the frictionless optimal price if \( \tau_{ss} \) were kept constant. An increase in \( F \) increases the adjustment costs associated to a given contract length, resulting in a higher \( \tau_{ss} \).

### 2.3 Optimal pricing rule during disinflation

Most articles which used time-dependent rules in order to analyze the effect of a disinflation, assumed that the pricing rules inherited from the inflationary steady state do not change during disinflation. In this section we relax this simplifying assumption by deriving optimal pricing rules for cold turkey and linear disinflations, and for various degrees of credibility\(^9\). When the length of the period between individual price adjustments is kept constant, credibility affects the output level during a disinflation only through expectations. When pricing rules become endogenous, price rigidity is increased during disinflation\(^10\).

#### 2.3.1 Disinflation with Perfect Credibility

**Cold Turkey** A cold turkey disinflation is announced at \( t = 0 \), and the announcement is perfectly credible. The money supply path is given by:

\[
\begin{align*}
m(t) &= \mu t, \quad t < 0; \\
&= 0, \quad t \geq 0.
\end{align*}
\]

When strategic complementarities are absent, the optimization problem for the firms which readjust/collect information after the announcement is the same as the one under steady state with \( \mu = 0 \). Figure 3 shows the value of \( \tau \) chosen by firms before and after the announcement for several parameter combinations.

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\(^9\) Other examples can be found in Viana de Carvalho (1997).

\(^10\) It is plausible that the announcement of a very important change in policy becomes widely known immediately. This is in contrast to our assumption that every information is only known after the payment of the information/adjustment cost. It could cause firms to evaluate the benefit of adjusting at the time of the announcement even if they had not planned to do so. An important modification in the model would be necessary to incorporate that possibility.
If the initial inflation is 10% a year, the money supply stabilization leads to an increase in the time between adjustments from 4.5 months to 7 months. As expected the decrease in the frequency of adjustments is larger when initial inflation is higher as compared to the variance of idiosyncratic shocks.

**Linear disinflation** Suppose that the Central Bank announces that money supply growth will be reduced linearly until it is halted at time \( k \):

\[
m(t) = \left\{ \begin{array}{ll} \mu t - \frac{\mu t}{k}, & 0 \leq t < k; \\
0, & t \geq k.
\end{array} \right.
\]

We continue to assume that \( m(0) = 0 \), as in the subsection before. By integrating equation 9 one obtains the money stock path between 0 and \( k \):

\[
m(t) = \mu t - \frac{\mu t^2}{2k}, \quad 0 \leq t < k;
\]

\[
m(t) = \frac{\mu k}{2}, \quad t \geq k.
\]

Assuming that a firm will collect information at most once during the transition phase\(^{11}\), the problem of the firm gathering information/adjusting price at a time between 0 and \( k \) can be written as:

\[
V(p^*(t), t) = \min_{\{T(t), z(t)\}} E_t \int_t^k e^{-\rho(s-t)} [z(t) - p^*(s)]^2 ds + \int_t^{t+T(t)} e^{-\rho(s-t)} [z(t) - p^*(s)]^2 ds + e^{-\rho T(t)} F + e^{-\rho T(t)} V_{\mu=0}
\]

where \( V_{\mu=0} \) is the cost function for the steady state problem with \( \mu = 0 \). The first order conditions are:

\[
z(t) = \frac{\rho}{1 - e^{-\rho T(t)}} \int_T^t E_t p^*(t + s) e^{-\rho s} ds
\]

\[
E_t [z(t) - p^*(t + \tau(t))]^2 - \rho F - \rho V_{\mu=0} = 0
\]

\(^{11}\)This is indeed the optimal behavior for a relatively fast disinflation. The general case has to be solved through another method that involves a partial differential equation (see Bonomo, Garcia and Rocha, 1998).
We found numerical solutions by first substituting $p^*$ in both equations for the corresponding money supply process, solving for $x(t)$ in the second equation and substituting back in the first equation to find $\tau(t)$.

Figure 4 shows the optimal time between adjustments during the transition between steady states for disinflations with different durations (from 4.5 months, $k = 0.374$, to 5.8 months, $k = 0.48$). Figure 5 depicts the optimal contract length during a linear disinflation which takes 5.8 months for two different initial inflation rates. Since for both initial inflation rates the contract length has to converge to its steady state level under zero inflation rate, the change is more abrupt under a higher initial inflation rate.

2.3.2 Disinflation with Imperfect Credibility

The assumption of imperfect credibility is more realistic. Economic agents in general do not fully believe that a change in the monetary policy will last forever. It is 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 reneging 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 $h$. Once the new policy is abandoned, the agents believe that the old policy will be kept forever\textsuperscript{12}.

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

$$dm = (0 + \mu \ind(N_1 \geq 1))dt$$

where $N$ is a Poisson counting process with constant arrival rate $h$, and $\ind(.)$ is the indicator function. Then, the drift of the money supply will change from zero to $\mu$ when an arrival occurs. We assume that stabilization is launched at time zero.

The parameter $h$ can be interpreted as a measure of credibility. The extreme cases of perfect and no credibility are associated with zero and infinity values for $h$, respectively. Imperfect credibility is represented by strictly positive finite values, and the higher is $h$, the lower the degree of credibility. Observe that the probability that the monetary authorities will not renege until $T$ periods after the stabilization is given by $e^{-hT}$. Thus, if $h = 0.5$, the probability that the stabilization will continue after one year is 61%.

\textsuperscript{12}For simplicity, we specify a constant money supply growth rate after the stabilization law. 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.
Cold Turkey  In this case the problem of the firm while the stabilization is not reneged may be written as:

\[ V_h = \min_{x(t), r} e^{-hr} \left\{ E_t \int_0^\tau [x(t) - e(t + s)]^2 e^{-\rho s} ds + F e^{-\rho \tau} + V e^{-\rho \tau} \right\} + \int_0^\tau \left\{ E_t \int_0^\tau [x(t) - e(t + s)]^2 e^{-\rho s} ds + + E_t \int_0^\tau [x(t) - \mu(s - r) - e(t + s)]^2 e^{-\rho s} ds + e^{-\rho s} F + e^{-\rho s} V e^{-\rho \tau} \right\} e^{-hr} dr \]

where \( V_\mu \) is the cost function for the steady state problem. The first line of the expression refers to the probability that the stabilization will be kept during the next contract multiplied to the cost in this case. The second line is the cost if abandonment occurs at time \( t + \tau \) (between curly brackets) weighted by the probability that it would occur at that time. Observe that if abandonment occurs at a time before the subsequent contract, the same will be reset under conditions identical to the inflationary steady state. This results in the cost function \( V_\mu \).

The first order conditions are cumbersome, but derived in a straightforward way. From them and \( 11 \) we arrive at a nonlinear equation for \( r \) which can be solved numerically.

Figure 6 shows the contract length function for different credibility levels. \( h = 0 \) corresponds to the case of perfect credibility, while \( h = \infty \) corresponds to the case where stabilization is reneged instantaneously. As expected the higher \( h \) (the lower the credibility level), the smaller is the increase in contract length.

3 Aggregation

In most models in the literature the time-dependent rule is assumed to be exogenous, or the economy is assumed to be in an inflationary steady state (as in Ball, Mankiw and Romer, 1988). In those cases an uniform distribution of adjustment times is assumed and aggregation is straightforward: \( p(t) = \frac{1}{\tau} \int_0^\tau x(t - s) ds \), where \( x(s) \) is the price of furos which set prices at \( s \).

With endogenous rules in a changing environment, the contract length changes through time. As a consequence the distribution of price adjustments will be changing accordingly, and aggregation will require the monitoring of the evolution of this distribution. We develop here a methodology for accompanying distributions. For simplicity, we assume that the initial distribution is uniform, which is the invariant distribution in the inflationary steady state. However, our methodology could be applied to any initial distribution.

Let \( g(.) \) be the function of time which gives the next adjustment time. Then \( g(t) = t + \tau(t) \). During credible disinflations \( g \) is nondecreasing, since the contract length will not decrease. In the case of imperfect credibility, \( g \) decreases at the moment the disinflation policy is abandoned.
In order to calculate the price level at a time after stabilization we use the function \( g \) to relate the measure of firms which set their actual prices at a specific time \( u \) as the measure of firms at times before \( u \) that would have their next adjustment at \( u \) (those times are \( g^{-1}(u) \)). Let \( E(t) \) be the correspondence that assigns to \( t \) the set of times where the actual prices had their last adjustment. Formally:

\[
E(t) = \{ s : s \leq t \text{ and } g(s) > t \}
\]

Let \( g^{-1}(S) \) be the inverse image of the set \( S \) under \( g \). Then, \( g^{-1}(E(t)) \) is the set of adjustment times for which the next adjustment would be in \( E(t) \). To evaluate the average price at \( t \) we need to know the probability measure \( \nu \) of the firms which adjust at subsets of \( E(t) \). We can easily relate this measure to the measure \( \mu \) in subsets \( g^{-1}(E(t)) \), since \( \nu \) is the image measure of \( \mu \) under \( g \). Then we have:

\[
\int_{E(t)} \pi(s) \nu(ds) = \int_{g^{-1}(E(t))} \pi(g(s)) \mu(ds)
\]

We apply the above formula recursively by relating distributions and adjustment times sets during disinflation to distributions and sets at preceding times. We proceed in that way until we arrive at a set \( g^{-n}(E(t)) \) where the measure of firms adjusting at the subset of times of this set corresponds to the uniform distribution of the inflationary steady state.

4 Disinflation Costs

In this section we analyze the disinflation costs in terms of output losses with endogenous fixed price time-dependent rules for perfectly and imperfectly credible disinflations. We compare the results with those obtained with exogenous rules.

4.1 Perfectly Credible Disinflation

We study the cases of cold turkey and linear disinflations.

4.1.1 Cold Turkey

If there are no strategic complementarities in price, as the money stock is constant after the stabilization, all the firms will choose the same price, except for idiosyncratic shocks. Thus the aggregate effect of disinflation hinges on the prices set before the announcement. As a consequence the effect is identical to that under exogenous rule. When there are strategic complementarities (\( \theta < 1 \)), the equivalence is not true anymore, since the optimal price will not be constant (neglecting the idiosyncratic component) after \( t = 0 \), being influenced by the prices set before \( t = 0 \). In this case the increase in the contract length will render disinflation more difficult.

Even if we neglect strategic complementarities, the model with endogenous rules allows us to appropriately compare the cost of disinflation for different
initial inflation levels. If we keep rules fixed the length of the recession is invariant, and the initial inflation level only affects the intensity of the recession, as in Ball (1994) (see Figure 7). When the change in contract length is taken into consideration, a higher initial inflation will make the recession more severe, but shorter (see Figure 8). The intuition is straightforward. A higher initial inflation implies shorter contracts and prices that are set forelooking a higher inflation. The hangover effect of fixed prices is higher initially inducing a stronger recession. When all the prices are reset after the announcement, the recession is over. Thus, the recession is shorter when the initial inflation is higher because the time between adjustments is smaller. The recession ends after a period of time equal to the contract length has elapsed.

We conclude that there is a trade-off between intensity and duration of the recession. As a consequence the commonly held belief that it is easier to disinflate when inflation is higher because the degree of nominal rigidity is lower (see, for example, Blanchard 1998) must be qualified. This is only true if it is easier for the economy to bear the cost of a short but very intense recession.

How those results compare to the effects generated by an endogenous state-dependent rule model? Almeida and Bonomo (1999) show that under perfect credibility the change of rules instantaneously destroy the asymmetry of the price deviation which in that model would cause inflation inertia. Hence, under perfect credibility disinflation can be achieved without costs. The comparison illustrates that the specific type of nominal rigidity is not a superfluous modelling issue.

4.1.2 Linear Disinflation

Figure 9 depicts a simulation of a linear disinflation which lasts 4.5 months starting at an initial inflation of 10% for both endogenous and exogenous rules. The duration of the disinflation corresponds to the contract length. This corresponds to one of Ball's (1994) cases where disinflation causes a boom. We see that with endogenous rules the boom is attenuated by the recessive effect of a longer contract length after the disinflation announcement. Also the economy takes a longer time to converge to the new steady state.

4.2 Imperfect Credibility

4.2.1 Cold Turkey

When credibility is imperfect, the output path will depend on the moment stabilization is abandoned. The level of output is lower than the natural one before stabilization is abandoned and higher than the natural one just afterwards. Then, if stabilization is reneged soon, there is little recession and a substantial boom. If on the other hand it is maintained for a long time, the prevalent effect is recessive. We quantify the overall result by averaging each individual path according to its likelihood.

Figure 10 shows the average output path for both invariant and endogenous rules for a given level of credibility ($h = 0.5$). The recession is larger when
rules are endogenous. Because the contract length gets larger, the possibility of abandonment leads to price setting at higher levels, when compared to the exogenous rules case. In the case of endogenous rules, we can also notice that after some time the product oscillates between boom and recessions. This is because after all prices are reset for the first time, there is a time interval where no adjustment takes place and price is constant, first causing an average boom. This is compensated by the concentration of adjustments afterwards generating an average recession, and so on. This kind of dynamics is not generated under invariant rules because the distribution of adjustments is always uniform.

Figure 11 depicts the average output path for various degrees of credibility. The effect is not monotonic in the degree of credibility. The recession increases when the degree of credibility increases, starting from zero, decreasing after some point. At the extreme case of no credibility \((h = \infty)\) there is no recession, since the stabilization is abandoned instantaneously and the inflationary steady state is kept.

There is, however, an important monotonic relationship between credibility and disinflation costs, when the disinflation is kept. The lower the degree of credibility, the larger the recession generated. However, this case corresponds to an event of zero probability in the prior assessment of the firms. One could argue that when the stabilization is maintained, firms update their beliefs attenuating the recession.

5 Conclusion

One of the main methodological weaknesses in the literature which relates nominal rigidities and costs of disinflation is that pricing rules are invariant to policy regimes. This paper tried to fill this gap. For that we had to proceed in four steps. First it was necessary to rationalize fixed-price time-dependent rules as optimal rules. Second, to derive the optimal rules during disinflation experiments. Third, to develop a methodology of aggregation of those rules under non-steady state conditions. And finally, to use the methodology of aggregation in the disinflation experiments to evaluate their results.

The results showed that the effort was not vain, that is, the endogeneity of the rules matters. We can summarize our main findings in three items: i) the cost of disinflation is higher than when assessed with invariant rules; ii) A higher initial inflation generates a deeper and shorter recession; iii) credibility matters less for the cost of disinflation than when assessed with invariant rules.

There are still some important methodological improvements to be done. First, by assuming that there were no strategic complementarities in price setting we avoid the much more complicated question of simultaneously solving the individual optimization and aggregation problems. Second, credibility should be endogenized, which would mean that agents should update their beliefs about the stabilization continuity and the Central Bank should act optimally given the agents' beliefs.
References


FIGURE 3

Linear Disinflation

$\tau_{ss}: \rho=2.5\%, \alpha=1, F=0.00015$

FIGURE 4

Linear Disinflation

$\mu=10\%, \sigma=3\%, \rho=2.5\%, \alpha=1, F=0.00015$
Linear Disinflation
\[ \sigma = 3\%, \ \rho = 2.5\%, \ \alpha = 1, \ \mathcal{F} = 0.00015, \ \kappa = 0.48 \]

\[ \mu = 3\% \]

\[ \mu = 10\% \]

FIGURE 5

Cold Turkey - Imperfect Credibility
\[ \mu = 10\%, \ \sigma = 3\%, \ \rho = 2.5\%, \ \alpha = 1, \ \mathcal{F} = 0.00015 \]

\[ h = 0 \]

\[ h = 0.5 \]

\[ h = 1 \]

\[ h = \infty \]

FIGURE 6
Cold Turkey - Perfect Credibility

**Figure 7**

- $\sigma = 3\%$, $\rho = 2.5\%$, $\alpha = 1$, $F = 0.00015$
- $\mu = 3\%$ (benchmark)
- $\mu = 10\%$, invariant rules

**Figure 8**

- $\sigma = 3\%$, $\rho = 2.5\%$, $\alpha = 1$, $F = 0.00015$
- $\mu = 3\%$
- $\mu = 10\%$, endogenous rules
- $\mu = 100\%$, endogenous rules
Linear Disinflation

$k=1$, $\mu=10\%$, $\sigma=3\%$, $\rho=2.5\%$, $\alpha=1$, $F=0.00015$

Invariant rules

Endogenous rules

FIGURE 9
Cold Turkey - Imperfect Credibility

\[ \mu = 10\%, \sigma = 3\%, \rho = 2.5\%, \alpha = 1, F = 0.00015 \]

**FIGURE 10**

Average effect, endogenous rules \((h=0.5)\)

Average effect, invariant rules \((h=0.5)\)

**FIGURE 11**

Cold Turkey - Imperfect Credibility

\[ \mu = 10\%, \sigma = 3\%, \rho = 2.5\%, \alpha = 1, F = 0.00015 \]

Average effect, invariant rules

\(h=0\)
\(h=0.5\)
\(h=1\)
\(h=4\)
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