Elections, Heterogeneity of Central Bankers and Inflationary Pressure:
The case for staggered terms for the president and the central banker[1]

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Abstract

This paper analyzes a signaling model of monetary policy when inflation targets are not set by the monetary authority. The most important implication of the model's solution is that a higher ex-ante dispersion in central bankers' preferences, referred to as heterogeneity in policy orientation, increases the signaling cost of commitment to inflation targets. The model allows for a comparison of two distinct institutional arrangements regarding the tenure in office of the central banker and the head of government. We find that staggered terms yield superior equilibria when opportunistic political business cycles can arise from presidential elections. This is a consequence of a reduction of information asymmetry about monetary policy and gives theoretic support to the observed practice of staggered terms among independent central banks.

Keywords: Elections, inflation targeting, exogenous inflation targets, credibility, central bank heterogeneity, opportunistic political business cycles on inflation, staggered terms.

JEL Classification: E52, E58, C72

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[1] The views expressed in the papers are those of the authors and do not necessarily reflect those of the Banco Central do Brasil or the University of Brasilia.

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1. Introduction

"Staggered terms for the president and the central banker is the most important aspect of central bank autonomy"

Ilan Goldfajn, December 2018.[2]

One fundamental characteristic of the inflation targeting (IT) regime is that inflation targets are announced in advance to society. Therefore, inflation expectations based on target announcements and credibility about the central banker's ability and willingness to deliver the targeted inflation rate play a crucial role in the success of an IT regime.

Most IT central banks do not have the autonomy to choose inflation targets[3,4]. Notwithstanding, the literature of central bank reputation and monetary policy[5] traditionally assumes that inflation targets are set by the monetary authority, disregarding important strategic behavior by the players.

In this paper, we show that relaxing the assumption that the central banker chooses the inflation target has important implications for the conclusions drawn in this literature. We extend the signaling models of Vickers (1986) and Cukierman and Liviatan (1991) by introducing exogenously determined inflation targets and not imposing *a priori* that central bankers, even very hawkish types, achieve the *exact* target at all times. From a theoretical perspective, our main innovation is on the solution of the game. We show that the method Vickers (1986) employs to find sequential equilibria fails to encompass certain central bank choices that cannot be ruled out in a perfect Bayesian equilibrium. We apply Cho and Kreps (1987) intuitive criterion as an equilibrium refinement and show that under this criterion,

[2] According to Reuters, December 5, 2018, available at: https://br.reuters.com/article/businessNews/idBRKBN1O41NZ-OBRBS, viewed in March 6,2019.

[3] In a survey with 19 inflation targeters, Horváth and Mateju (2011) show that only 7 central banks could independently choose inflation targets. For some countries, inflation targets are set by a committee in which the central banker participates.

[4] In the case of Brazil, for instance, inflation targets are decided and set by the Monetary Policy Council (CMN), comprised, until 2018, of the Finance Minister, the Minister of Budget and Planning and the Central Bank of Brazil's Governor. In 2019, the new President changed the composition of the CMN, assigning two seats to the Economics Ministry (which was a fusion of the former Finance Ministry and the Ministry of Budget and Planning) and one seat to the Central Bank of Brazil.

[5] Vickers, 1986 and Cukierman & Liviatan, 1991 are the fundamental references. See also: Walsh, 2000; Mishkin & Schmidt-Hebbel, 2001; Bugarin & Carvalho, 2005.

greater heterogeneity in central bankers' types makes disinflationary policies costlier. It is important to highlight that our results are not a generalization of the ones Vickers obtains.

The most important implication of the model is that higher *ex-ante* dispersion[6] in central bankers' preferences, which we refer to as heterogeneous policy orientation, causes a strong-type central banker, whose policy orientation is private information, to adopt very tight monetary policies in order to be credible. Naturally, the fact that a player may overshoot, choosing a strategy above the efficient threshold is well known since the seminal work of Spence (1973) on education choice; the main contribution of the present paper is to relate the overshooting with the spread of the uncertainty about the central banker's type and its effect on the cost of signaling. In a separating equilibrium, monetary policy may consistently induce realized inflation to a level below the target.

The framework analyzed in this paper also relates to the literature of opportunistic political business cycles on inflation. Our framework allows for a comparison of two distinct institutional arrangements regarding the term in office of the central banker and the head of government. The main result is that macroeconomic adjustment to the pressures from the political process is less costly when the head of government and the central banker serve in staggered terms. This result originates from the reduction of asymmetric information about monetary policy since society already knows the type of the central banker when the new head of government takes office. This finding is in line with the results in Waller (1989) and gives support to a framework that is common among independent central banks: staggered terms to central banker and the head of government.

The paper is organized as follows. Section 2 presents a brief review of the game-theory literature underlying our model. Section 3 builds the game-theoretic model of credibility of an inflation-targeting monetary policy. Section 4 discusses the equilibria. Section 5 extends the model in order to be able to compare the two distinct institutional frameworks: one where the head of government nominates a new central banker at the beginning of the presidential mandate; and the other where the head of government has to maintain the previous central banker for two additional years. Finally, the last section concludes the paper.

[6] Under a reasonable support of the discount factor (i.e., greater than 0.5)

2. A brief review of the literature

Kydland and Prescott (1977) and Barro and Gordon (1983a, b) pioneered the study of the role of inflation expectations in short-run output variations. A vast literature has built on their contributions to analyze the effects of asymmetric information on the outcome of monetary policy games played between the central bank and society.

Canzoneri (1985) presents an infinite repeated game between society and a central bank. At each period *t*, society first sets inflation expectations, and the central banker next chooses inflation. However, realized inflation in period t is affected by a stochastic component to money demand $\delta_t = e_t + \varepsilon_t$. The model focuses on *imperfect* asymmetric information on δ_t the central banker observes e_t before choosing the inflation rate, but society only observes δ_t at the end of the period. Because society does not distinguish between e_t and ε_t, the central banker can create unexpected inflation and attribute it to the unexpected shock ε_t. The solution to the model follows Green and Porter (1984) and finds a trigger strategy equilibrium in which society sets an inflation threshold so that, if realized inflation is below that threshold, society expects the Pareto-superior low inflation, but if realized inflation is above that threshold, society expects the higher Nash inflation for a punishment period. The model explains periods of high inflation and low employment (stagflation) triggered by the stochastic component of money demand, rather than by the traditional time inconsistency incentives.

Backus and Driffill (1985) focus on *incomplete* asymmetric information about the type of the central banker, who could be *wet* or *hard-nosed*. A *wet* central banker cares both about controlling inflation and employment whereas a *hard-nosed* central banker only cares about controlling inflation. The paper considers a finite horizon game between society – who sets inflation expectations − and the central banker − who chooses inflation − and finds a mixed-strategy partially pooling equilibrium in which the *wet* central banker mimics the *hard-nosed* one with positive probability. In their model, inflation may be lower than expected in the initial periods of the game and higher in the final period.

Vickers (1986) presents a more general game where all types of central banker care both about low inflation and high employment, but they have different relative preferences for inflation and unemployment. The paper focuses on a signaling, separating equilibrium in which the central banker who most values employment (*wet*) is not able to mimic the central banker who most values low inflation (*dry*). The game consists of two periods and in equilibrium there will be recession in the first period if the central banker is *dry* and there will be expansion if he is *wet.* Moreover, there will be no surprises in the last period, as all relevant information becomes public by the end of the first period. In that paper, as well as in Backus and Driffill (1985), the central banker cannot commit to an announced target. Therefore, there are no explicit inflation targets.

Cukierman and Liviatan (1991) extend Vickers's model by letting the central banker announce inflation targets before society sets its inflation expectations, in a two-period setup. In their model, a *strong* central banker will always achieve the exact announced inflation target, whereas a *weak* may deviate from the announced target. Walsh (2001) and Bugarin and Carvalho (2005) analyze the monetary equilibria of an extension of Cukierman and Liviatan's setup to an infinite game where a central banker has a fixed two-period nonrenewable term of office.

Cukierman and Liviatan (1991), Walsh (2001) and Bugarin & Carvalho (2005) allow for announcements of inflation targets, with the assumptions that the announcement is a *strategic* variable chosen by the central banker and that the *strong* central banker always delivers on his announced target. Therefore, there is a somewhat artificial, reduced strategic role for the *strong* central banker, since she cannot deviate from the announced policy.

In light of that, the novelties of the present paper are fourfold. First, it considers exogenous inflation targets in a game-theoretic set-up to explicitly analyze the role of credibility in inflation targets and the role of heterogeneity in the inflation-output tradeoff. Second, there is no exogenous assumption that one type of central banker must follow a specific target, as it is the case in Cukierman & Liviatan (1991). The third novelty is the use of Cho and Kreps (1987) intuitive equilibrium refinement in monetary policy games. Finally, this paper analyses the effect of two competing institutional arrangements on monetary stabilization policy: when the central banker's term coincides with the head of government's term and when their terms are staggered.

3. A model of credibility and inflation expectations formation with exogenous inflation targets

We extend the models of Vickers (1986) and Cukierman and Liviatan (1991) by introducing exogenously determined inflation targets and not imposing that any type of central banker achieve the exact target. These assumptions allow us to analyze the role of inflation targets and credibility in inflation expectations' formation when society is imperfectly informed about the central banker's characteristics. Our main innovation is on the solution of the game. In the next section, we argue that Vickers left out possible equilibrium choices with important implications for the model's predictions and we apply Cho and Kreps (1987)'s intuitive criterion for equilibrium selection.

The generic central banker i's utility function in period t is:[7]

$$v^i(\pi_t, \bar{\pi}_t, \pi_t^e) = -\frac{1}{2}(\pi_t - \bar{\pi}_t)^2 + \lambda(\pi_t - \pi_t^e) \qquad (1)$$

where π_t is the inflation rate in period t set by the central banker, $\bar{\pi}_t$ is the inflation target in period t that is exogenously set by the government, and π_t^e is market inflation expectation in period t.

The parameter $\lambda \geq 0$ reflects the importance the central banker attributes to output expansion above trend levels, which, following the related literature, is obtained from (positive) inflationary surprises, relative to the importance he attributes to achieving the inflation target.

The first term on the right represents the (possibly political) cost the central banker faces from not achieving the target. In certain countries, this could even lead to appointing a new central banker.[8] Inflation targeting countries usually adopt target bands that are symmetric around the center of the target. Hence, assuming a cost function that is quadratic in the deviation of inflation from the target is a suitable simplification to the common inflation targeting design.

[7] This is the simplest way to introduce the traditional trade-off between inflation and growth and follows the seminal articles by Vickers (1986) and Cukierman and Liviatan (1991). For a more detailed derivation of such a reduced form model see, for example, Walsh (2000).
[8] See New Zealand's institutional framework in Walsh (1995).

With only one type of central banker and exogenously set targets, the model will predict an inflation bias. The first order condition yields $\pi_t = \overline{\pi}_t + \lambda$, which means that the central banker will always inflate above target levels. Assuming that expectations are rational, in this one-period game agents will anticipate the inflationary bias and thus no inflation surprises will arise, as $\pi_t^e = \overline{\pi}_t + \lambda = \pi_t$. This is a standard result in the literature.

Let us now allow for two possible types of central bankers, μ and λ, $\mu \geq \lambda$, who differ from each other because of the relative importance each one privately attributes to output growth with respect to inflation stabilization. Therefore, a central banker that attributes weight λ to output expansion cares relatively more about achieving the exogenous inflation target than the central banker that attributes weight μ, who values relatively more generating inflationary surprise. The λ-type central banker is said to be *strong*, whereas the μ-type is said to be *weak*.

In a one period game, the outcome will be an inflation rate of $\pi_t^S = \overline{\pi}_t + \lambda$ for the strong type and $\pi_t^W = \overline{\pi}_t + \mu$ for the weak type. If society believes that the incumbent is of a strong type with probability ρ, inflation expectations will be a weighted average of inflation rates chosen by the strong and the weak type: $\pi_t^e = \rho\pi_t^S + (1-\rho)\pi_t^W = \overline{\pi}_t + \rho\lambda + (1-\rho)\mu$.

This simple analysis allows us to draw the following conclusions. If central bankers cannot pre-commit to an inflation target, and if this target is exogenously set, then inflation expectations will be biased upwards from the target. Realized inflation will also exceed the target, even if the central banker is of a strong type. Of course, the weaker the central banker is, the higher the deviation of realized inflation from targets. However, as expected inflation is an average of inflation rates optimally chosen by a weak and a strong central banker, realized inflation under a strong type will be lower than the one expected by society.

Note that inflation targets, in spite of not being fulfilled or not having been chosen to maximize social welfare, have a very important role in this model. As realized inflation is directly related to them, targets guide inflation expectations, thus working as a nominal anchor for the economy.

Plugging in realized and expected inflation into strong- and weak-type central bankers' utilities yields respectively $v_t^S = -\frac{1}{2}\lambda^2 - \lambda(1-\rho)(\mu-\lambda)$ and $v_t^W = -\frac{1}{2}\mu^2 -$

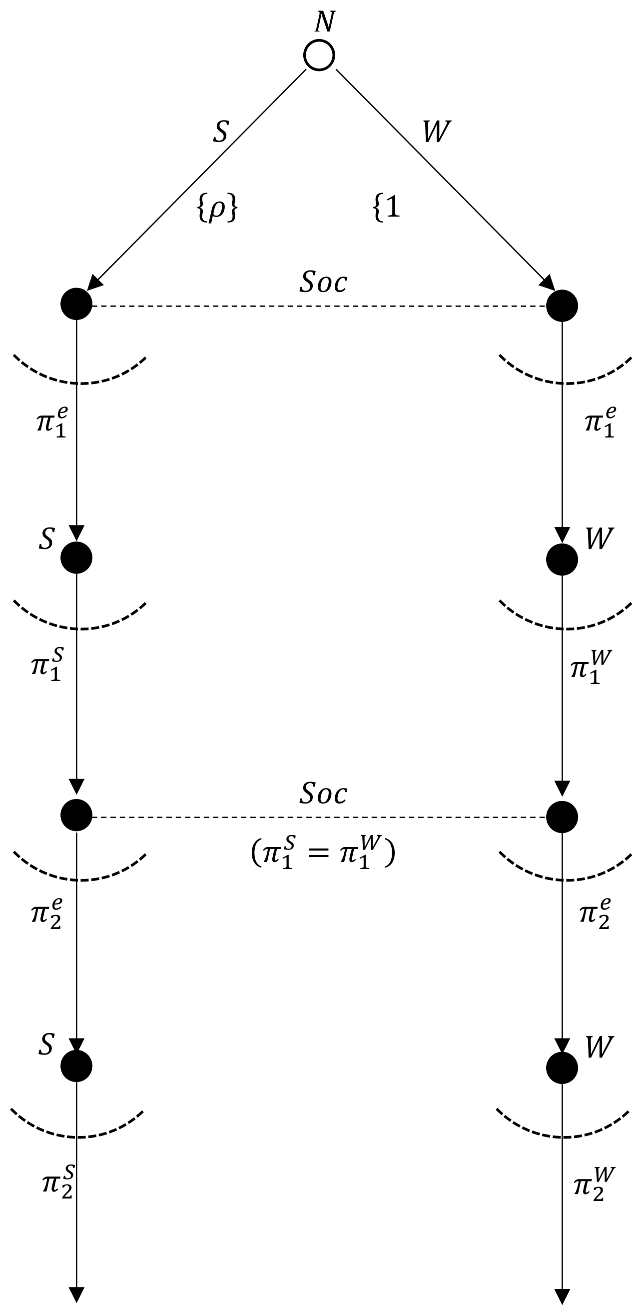
$\mu\rho(\mu - \lambda)$. Notice that both types gain with higher central banker credibility, which is modeled here as the parameter ρ, i.e., the higher ρ, the more society believes that the central banker is strong. Indeed, if society attributes a higher probability that the central banker is strong, a strong type benefits from the reduction in society's "pessimism", and the model predicts lower inflation expectations and weaker recession. Moreover, the weak-type central banker benefits from higher inflationary surprise.

Let us now analyze a two-period game between society and the central banker. Let the central banker be chosen at random at the beginning of period 1, according to the distribution $(\rho, 1 - \rho)$, for a two-period term. A time invariant inflation target is concomitantly set by the head of government for periods 1 and 2: $\overline{\pi}_1 = \overline{\pi}_2 = \overline{\pi}$. As before, the central banker may be either weak or strong, and this is his private information. Society will thus form expectations based on its belief on the type of the central banker. After expectations are formed, the central banker delivers the inflation rate for period 1. By observing realized inflation, society updates its belief about the type of the central banker and forms inflation expectations for period 2. After expectations are formed, the central banker delivers inflation for the second period and the game finishes. Society's payoff is a function of the accuracy of its inflation expectations.

Figure 1 depicts the extensive form of the game. The stochastic determination of the central banker's type (S: strong, W: weak) is modeled by the use of nature (N) in the top decision node. The dotted straight lines represent information sets for society (Soc). The top dotted straight line indicates that society does not know the central banker's type when setting inflation expectations in period 1. The one at the bottom indicates that if both central bankers' types choose the same inflation in period 1 in equilibrium, society cannot identify their types. The curved dotted lines indicate that the central banker (respectively society) has infinitely many possible choices for inflation (respectively, for inflation expectations), only one of which is represented in the game tree.

Next section discusses the model's equilibria and refinements. For the sake of exposition, all proofs are presented in the Appendix.

Figure 1: The extensive form game



$$\begin{pmatrix} -(\pi_1^S - \pi_1^e)^2 - \delta(\pi_2^S - \pi_2^e)^2 \\ -\frac{1}{2}(\pi_1^S - \bar{\pi})^2 + \lambda(\pi_1^S - \pi_1^e) + \\ +\delta\left[-\frac{1}{2}(\pi_2^S - \bar{\pi})^2 + \lambda(\pi_2^S - \pi_2^e)\right] \end{pmatrix} \quad \begin{pmatrix} -(\pi_1^W - \pi_1^e)^2 - \delta(\pi_2^W - \pi_2^e)^2 \\ -\frac{1}{2}(\pi_1^W - \bar{\pi})^2 + \mu(\pi_1^W - \pi_1^e) + \\ +\delta\left[-\frac{1}{2}(\pi_2^S - \bar{\pi})^2 + \mu(\pi_2^W - \pi_2^e)\right] \end{pmatrix}$$

Source: the authors.

4. Equilibria

All propositions' proofs are presented in the Appendix.

4.1. Separating Equilibrium

In the separating perfect Bayesian equilibrium, the weak central banker reveals his type to society at the end of the first period. Therefore, he chooses to inflate at its optimal rate in every period and inflation surprises occur only in the first period of the game. In this equilibrium, realized inflation in periods 1 and 2 under a weak type central banker is $\pi_1^W = \pi_2^W = \overline{\pi} + \mu$.

On the other hand, a strong central banker may have incentives to deviate from its optimal complete information inflation rate if this is necessary to induce the weak central banker not to mimic his chosen inflation. Let π_1^S be the inflation chosen by the strong central banker in period 1. Then, the consistent beliefs society holds in period 2, π_2^e, are the following: if realized inflation in period 1 is lower than or equal to π_1^S, then the central banker is strong; if it is above π_1^S, then the central banker is weak. Moreover, society's expected inflation in period 1 is $\pi_1^e = \rho\pi_1^S + (1-\rho)(\overline{\pi} + \mu)$. We can now characterize the separating equilibria.

Proposition 1: In a separating perfect Bayesian equilibrium, if $\frac{\lambda}{\mu} \leq 1 - \frac{1}{2\delta}$, then inflation delivered by the strong type central banker satisfies $\pi_1^S \in \left[\overline{\pi} + \lambda - \left(2\delta\lambda(\mu-\lambda)\right)^{\frac{1}{2}}, \overline{\pi} + \lambda\right]$. Otherwise $\pi_1^S \in \left[\overline{\pi} + \lambda - \left(2\delta\lambda(\mu-\lambda)\right)^{\frac{1}{2}}, \overline{\pi} + \mu - \left(2\delta\mu(\mu-\lambda)\right)^{\frac{1}{2}}\right]$.

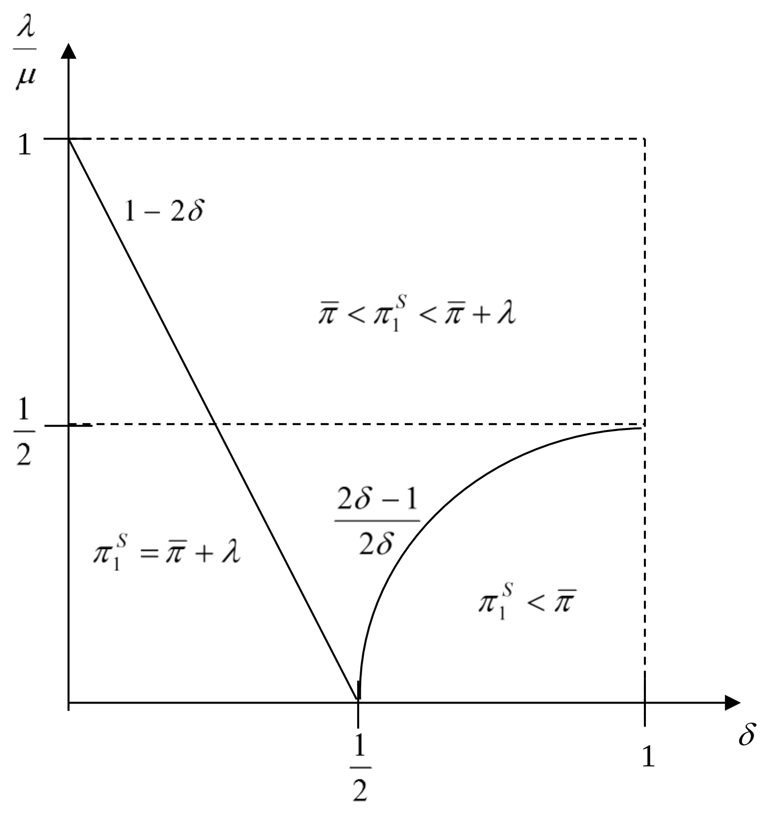
Vickers claims to adopt a method similar to the one that finds sequential equilibria. Although the structure of our model is a direct generalization of that in Vickers, and Fundenberg and Tirole (1991) show an equivalence of sequential equilibria and perfect Bayesian equilibria for classes of games to which our model belongs, our results are not a generalization of the ones Vickers obtain. We show in the Appendix the possible equilibrium choices that Vickers disregarded in his solution of the game.

We now apply Cho and Kreps (1987) intuitive criterion for equilibrium selection.

Proposition 2: If $\frac{\lambda}{\mu} \leq 1 - \frac{1}{2\delta}$, the only choice of inflation by the strong central banker that fulfills the intuitive criterion is $\pi_1^S = \overline{\pi} + \lambda$. Otherwise, $\pi_1^S = \overline{\pi} + \mu - \left(2\delta\mu(\mu - \lambda)\right)^{\frac{1}{2}}$.

Note that $\overline{\pi} > \overline{\pi} + \mu - \left(2\delta\mu(\mu - \lambda)\right)^{\frac{1}{2}} = \pi_1^S$ if and only if $\frac{\lambda}{\mu} < 1 - \frac{1}{2\delta}$. Therefore, if $\frac{\lambda}{\mu} > 1 - \frac{1}{2\delta}$, then $\pi_1^S > \overline{\pi}$, i.e., inflation delivered by a strong central banker, although below his preferred level $(\overline{\pi} + \lambda)$, will still be above the target. On the other hand, if $\frac{\lambda}{\mu} < 1 - \frac{1}{2\delta}$, then $\pi_1^S < \overline{\pi}$, i.e., in order to signal his type, the strong central banker will keep inflation below the target $\overline{\pi}$. Figure 2 summarizes this analysis.

Figure 2: Intuitive separating equilibria



Source: The authors.

The ratio $\frac{\lambda}{\mu}$ can be interpreted as the level of homogeneity of a society. Indeed, if λ is very close to μ, so that the ratio is close to one, there is not much divergence in the way different types of central banker value output relatively to achieving the inflation target. This corresponds to the upper right corner of the figure when the discount factor δ is high enough (bigger than 0.5). Conversely, if μ is much bigger than λ, then different types of central bankers diverge strongly, and society is heterogeneous. This last case corresponds to the lower right corner of Figure 2.

This suggests that the greater the heterogeneity of central bankers' types in a society the more conservative will be the strong central bank's approach to monetary policy conduct in order to convince society that he really is strong.

A parallel with the recent Brazilian history is in order. On December 2, 2015 the Brazilian Chamber of Deputies started the impeachment process of President Dilma Roussef, which concluded with the effective impeachment on August 31 2016, when Michel Temer was declared president. During the impeachment process vice president Michel Temer took the Executive office. The inflation target for the years 2015, 2016 and 2017 was 4.5%. However, inflation accelerated and reached 10.67% in 2015. On June 9, 2016 acting president Temer nominated Ilan Goldfajn to be the governor of the Brazilian Central Bank, amidst growing speculation that the new central banker would announce adjusted inflation targets given that inflation expectations, even for longer horizons, were unanchored and economic activity had been slowing down. As he took office, Governor Goldfajn announced his commitment to the official targets[9] and communicated that monetary policy would be conducted so as to bring inflation projections back to the inflation target in the relevant monetary policy horizon. Right after the first Monetary Policy Committee (MPC) meeting chaired by Governor Goldfajn, survey expectations for the policy interest rate adjusted upwards and medium-term inflation expectations started to recede. Actual inflation fell to 6.29% in 2016, within the target's tolerance interval (below 6.5%) and in 2017 actual inflation was 2.95%, 1.55p.p. below the target[10]. This suggests that the central banker

[9] See, for instance, http://g1.globo.com/economia/noticia/2016/06/presidente-do-bc-descarta-usar-meta-ajustada-e-quer-ipca-de-45-em-2017.html.

[10] The inflation rate in 2017 was also affected by disinflationary food-price shocks, in a context of slow economic recovery.

signaling was strong, bringing inflation below the target, which could be interpreted as illustrating the third case of our equilibrium analysis. Ever since, with anchored inflation expectations, Brazil has had inflation within target tolerance intervals.

4.2. Pooling Equilibrium

In a pooling equilibrium, the weak central banker mimics the strong type in the first period of the game. As society observes a first-period rate of inflation that does not allow it to infer which type of central banker is in office, expectations for the second period will be a weighted average of likely inflation rates: $\pi_2^e = \rho\pi_2^S + (1-\rho)\pi_2^W = \overline{\pi} + \rho\lambda + (1-\rho)\mu$. Let π_1^P be inflation chosen by both types of central bankers in period 1. Then, society will anticipate that actual inflation rate and set: $\pi_1^e = \pi_1^S = \pi_1^W = \pi_1^P$.

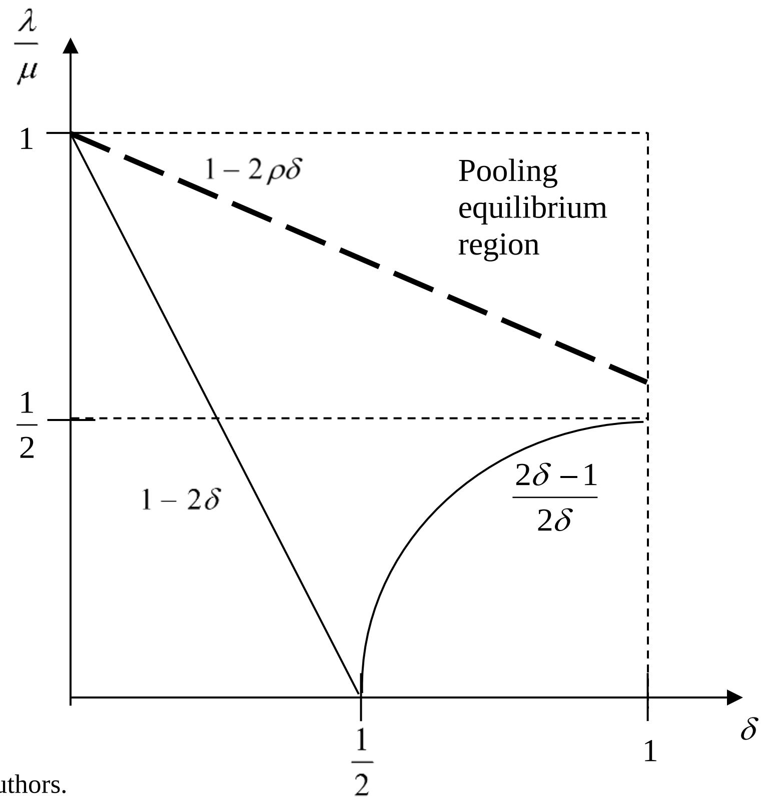
The consistent beliefs in period 2 are as follows: if realized inflation in period 1 is lower than or equal to π_1^P, then there is no updating in beliefs, i.e., society still believes that the central banker is strong with the same probability ρ ; if it is above π_1^P, then society concludes the central banker is weak. We now characterize the regions for pooling to occur.

Proposition 3: If $\frac{\lambda}{\mu} < 1 - 2\delta\rho$, there will be no pooling equilibrium. On the other hand, if $\frac{\lambda}{\mu} \geq 1 - 2\delta\rho$, then any inflation level $\pi_1^P \in \left[\overline{\pi} + \mu - \left(2\delta\mu\rho(\mu-\lambda)\right)^{\frac{1}{2}},\ \overline{\pi} + \lambda\right]$ corresponds to a perfect Bayesian pooling equilibrium.

Pooling will be more likely to occur in the following situations: 1) if the difference between the weak and the strong types is not significant (μ close to λ), which would correspond to a more homogeneous society; 2) the weak type significantly values the future (δ very high, close to 1); and 3) credibility is high (society expects the central banker is of type λ with high probability, i.e., ρ is high).

Figure 3 adds to Figure 2 the bold dotted line $\frac{\lambda}{\mu} = 1 - 2\delta\rho$ (with $\rho < \frac{1}{4}$). The region above that dotted line corresponds to the model's pooling equilibria.

Figure 3: Pooling equilibrium region



Source: The authors.

We employ the intuitive criterion to refine the perfect Bayesian pooling equilibria obtained. This results in the following proposition:

Proposition 4: The perfect Bayesian pooling equilibrium in Proposition 3 satisfies the intuitive criterion.

Vickers (1986) also compares payoffs of deviations from the pooling equilibrium, but states that "it can be demonstrated for a large set of parameter values – roughly speaking, when the relevant inflation rates are positive – that for all pooling equilibria there exists an x (*inflation rate*) satisfying": "(a) A wet (*weak in our terminology*) prefers his pooling equilibrium payoff to the payoff that he would obtain if he chose $\pi_1 = x$ and were believed to be dry; and (b) A dry (*strong in our terminology*)'s pooling equilibrium payoff is worse for him than the payoff he would get if he chose $\pi_1 = x$ and were believed to be dry”[11]. As detailed in the Appendix, Vickers’ method fails to consider equilibrium regions that could not be ruled out in a sequential equilibrium approach.

Equilibrium refinements that eliminate equilibrium multiplicity might be desirable from a theoretical perspective. However, the elimination of all pooling equilibria that results in Spence’s signaling model presented in Cho and Kreps (1987) and in the signaling model of monetary policy presented in Vickers (1986) may not be a social optimum. From the point of view of society, it is better to form correct inflation expectations in the first period of a two-period game than in the discounted second period.

The fact that the intuitive criterion fails to eliminate the pooling equilibria in the model presented here implies that the elimination of all pooling equilibria in Spence’s signaling model is not to be indiscriminately evoked for every signaling game. This contrasts with Vickers (1986), who adopts dominance and evokes standard stability results for equilibrium refinement.

5. The role of the institutional framework

In order to better understand how a country’s institutional framework affects the cost of macroeconomic stabilization when a new head of government takes office, let us introduce a few frictions to the present model. First, we model separately the head of government and the central banker as two different agents that may have different preferences over the inflation-output trade-off, i.e. both the head of government and the central banker may be either weak or strong. Second, we allow the head of government to have, potentially, some influence on the central banker, which is reflected in the central banker’s utility. Third, we allow for two possible types of institutional arrangements: the “Type I” institutional arrangement, in which the head of government nominates the central banker when he takes office; and the “Type II” institutional arrangement where the central banker has a fixed term of the same length of the head of government’s term, but where the head of government and the central banker’s terms are staggered in such a way that, when the new head of government

[11] Italicized comments are ours.

takes office, the central banker is in the middle of its term. Finally, both the head of government and the central banker have four-year terms.

The rest of this section extends the previous results to these new institutional arrangements.

5.1. Monetary policy preferences in the presence of head of government and central banker heterogeneity

Suppose, as previously discussed, that both the head of government and the central banker can be of a strong-type or of a weak-type. Let $\theta_P,\ \theta_{CB} \in \{\lambda, \mu\}$ be respectively the head of government's and the central banker's types. Then, the central banker's utility is given by the expression below.

$$v(\pi_t, \overline{\pi}_t, \pi_t^e; \gamma, \theta_{CB}, \theta_P) = -\frac{1}{2}(\pi_t - \overline{\pi}_t)^2 + \gamma\theta_P(\pi_t - \pi_t^e) + (1-\gamma)\theta_{CB}(\pi_t - \pi_t^e)$$

The parameter $\gamma \in [0,1]$ reflects the strength of the influence of the head of government on the central banker. If $\gamma = 0$, then are in the previous model where only the central banker preferences affect his utility. However, as γ increases, the more the head of government's preferences affect the central banker's utility. In the extreme case where $\gamma = 1$, then the central bankers' utility reflects entirely the preferences of the head of government. Our main challenge now is to understand which value of the parameter γ corresponds to each one of the institutional frameworks we wish to analyze.

5.2. Institutional framework I: The case of simultaneous terms

Suppose that the head of government has the prerogative of nominating a new central banker when he takes office. Then, the head of government is able to select a central banker that totally reflects his own preferences regarding the inflation-output trade-off. Therefore, we assume that, in this case[12], $\gamma = 1$ or, equivalently, that $\theta_P = \theta_{CB}$. In that case, the central

[12] The present model does not consider the case where the president, in spite of being of a certain type, would choose a central banker of a different type, for signaling reasons, for example. Although this is a relevant situation, and, indeed, one might argue that this is what happened when Brazilian president's Lula was first elected in 2002, that type of signaling is left as a suggestion for future research.

banker's utility becomes $v(\pi_t, \overline{\pi}_t, \pi_t^e; \gamma, \theta_P, \theta_P) = -\frac{1}{2}(\pi_t - \overline{\pi}_t)^2 + \theta_P(\pi_t - \pi_t^e)$ where $\theta_P \in \{\lambda, \mu\}$. Hence, the uncertainty about the type of the central banker, modeled here as the parameter δ, remains identical to the one in the original model.

Therefore, we return to the equilibrium analyzed in the first part of the paper, in which the political uncertainty generates equal uncertainty about monetary policy. In particular, we obtain again a higher signaling cost for the strong-type central banker when *ex-ante* heterogeneity of central bankers (now seen as *ex-ante* heterogeneity of heads of government) is higher.

5.3. Institutional framework II: The case of staggered terms

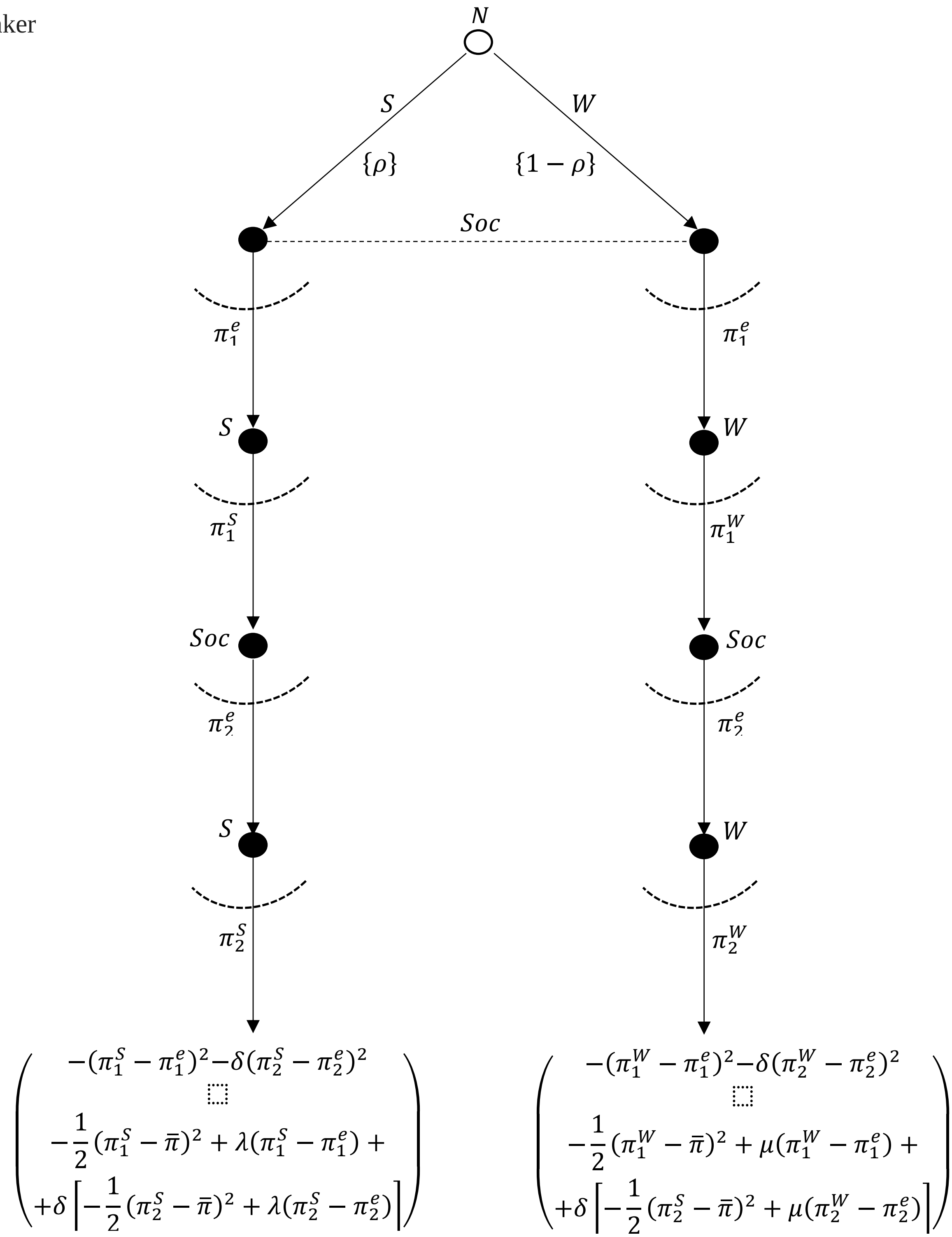
Suppose now that the central banker has a fixed, four-year term and that, when the head of government takes office, the central banker is starting the third year of his term. Then, the head of government does not have the prerogative of nominating a new central banker. Therefore, we might expect that either $\gamma = 0$, or that it is very small[13]. For the sake of simplicity, we assume $\gamma = 0$. In this case, the central banker's utility becomes $v(\pi_t, \overline{\pi}_t, \pi_t^e; \gamma, \theta_{CB}, \theta_{CB}) = -\frac{1}{2}(\pi_t - \overline{\pi}_t)^2 + \theta_{CB}(\pi_t - \pi_t^e)$ where $\theta_{CB} \in \{\lambda, \mu\}$.

Furthermore, since the central banker has been in office for at least two periods, we assume that society has had enough information to extract the real type of central banker. This is the most important feature of the staggered terms mechanism and implies that there is no uncertainty what-so-ever regarding the conduct of monetary policy for the following year. Therefore, the game displayed in Figure 1 must be replaced by the complete information game in Figure 4.

In this complete information game, realized inflation rate will still depend on the type of the central banker: a weak central banker will allow for the higher inflation rate $\pi_1^W = \pi_2^W = \overline{\pi} + \mu$ in both periods, whereas a strong central banker will deliver lower inflation $\pi_1^S = \pi_2^S = \overline{\pi} + \lambda$ in both periods, as they were already doing in the previous year.

[13] If the central banker can be reappointed by the new head of the government, this could create an incentive for the central banker to align his objective function to that of the new head of government, which could result in a high value of γ.

Figure 4. The monetary policy game when Society knows the type of the central banker



Source: the authors.

However, due to the complete information framework, society completely anticipates each respective inflationary bias and, therefore, there is no effect on growth[14].

Hence, in this extreme case where $\gamma = 0$ there will be no asymmetric information about monetary policy related to the electoral process and, therefore, there will be no additional inflationary pressure nor macroeconomic stabilization cost at the political transition.

It is noteworthy that two years after the election, the new head of government will appoint a new central banker, which could potentially cause the same type of uncertainty that we discussed earlier in the paper. However, after two years of the head of government's term, we expect that the head of government will have revealed his type to society, so that society will be able to predict with reasonable accuracy the type of the new central banker. Therefore, the later succession of the central banker will not cause the type of high-cost macroeconomic adjustment that the model predicts to occur in the institutional framework I.

5.4. Overall remarks

The extension presented here allows us to isolate the role of uncertainty about the type of the head of government from that about the type of the central banker. It also enables to understand how simultaneous terms affect signaling in a monetary policy game with exogenous inflation targets. The main conclusion is the superiority, in terms of macroeconomic stabilization, of fixed but staggered mandates for the head of government and the central banker. Indeed, with staggered terms, since the central banker has been in office for two years when the new head of government takes office, society already knows with relative accuracy the type of the central banker, so that monetary policy will be predictable and there should be low costs associated with society's expectations. On the other hand, when terms are simultaneous, the political uncertainty translates into uncertainty on monetary policy, which increases the signaling cost for a new, strong central banker, the more so the more *ex ante* heterogeneous society is.

[14] The complete information game is solved by backwards induction and reduces to solving separately typical monetary policy games of complete information, one for each possible type of the central banker. The authors can send the detailed solution upon demand.

A parallel can be drawn by comparing monetary policy and inflation around presidential elections in the US in 2000 and in Brazil in 2002. In the 2000 US elections, the shift from a Democrat (Bill Clinton) to a Republican president (George W. Bush) did not put pressure on inflation. During most of the election year, the Federal Reserve System (Fed) kept the federal funds rate at 6.5%, gradually reducing it to 4% until May 2001[15]. Notwithstanding the flexibilization of monetary policy, inflation dropped[16]. Two years later in Brazil, a far left-wing party won the presidential election against the candidate supported by the incumbent. During the election year, the Central Bank of Brazil raised interest rates by 6.5 p.p., further increasing it by 1.5 p.p. after the new president took office. Notwithstanding the monetary policy tightening, inflation accelerated around the election period and started to recede only around the second quarter of the new president's term[17].

In the US, the election process had no effect on either the downward trajectory of interest rates or on the downward trajectory of inflation[18], whereas in Brazil both interest rates and inflation surged around the election period. This suggests that the electoral process may have had a higher impact on monetary policy and inflation control in Brazil than in the US.

During those episodes, the US had not yet adopted an explicit inflation targeting regime[19], but the central banker served a fixed-term mandate staggered with the President's. Brazil, on the other hand, had already adopted a full-fledged inflation-targeting regime, but traditionally a new central banker is nominated by the President at the beginning of the presidential term[20].

Figure 5 juxtaposes the path of policy interest rates around those election periods.

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[15] https://www.federalreserve.gov/monetarypolicy/openmarket.htm

[16] The inflation rates were 3.38% in 2000, 2.83% in 2001 and 1.57% in 2002 (http://inflationdata.com/Inflation/Inflation_Rate/HistoricalInflation.aspx).

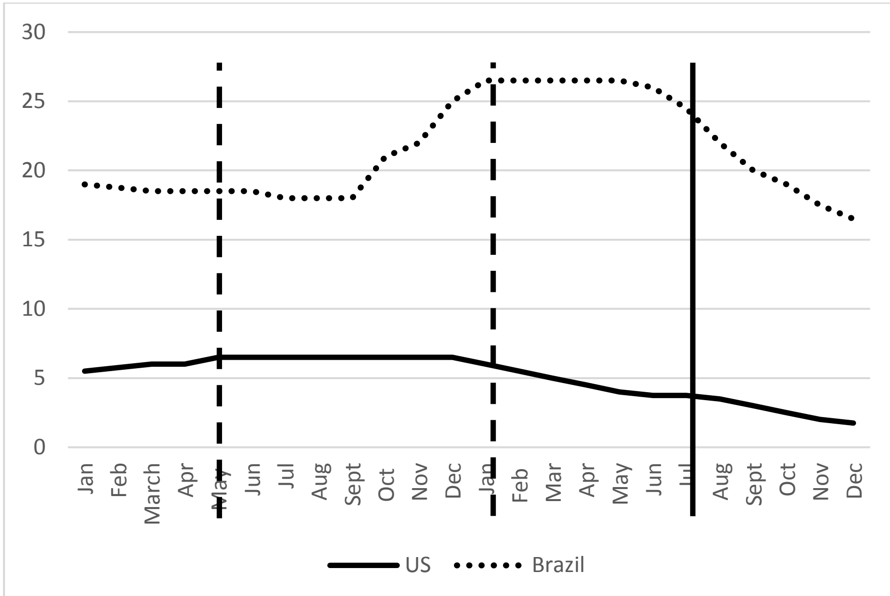
[17] Inflation was 12.53% in 2002, 9.3% in 2003 and 7.6% in 2004.

[18] Drazen (2001) argues that there is no evidence of opportunistic political business cycles on inflation in the US since 1979. Garriga and Rodriguez (2017) state that in most OECD countries, the effect of elections on inflation is contrary to the opportunistic political business cycle theory, with evidence of monetary expansions before elections.

[19] In 2012, the US Federal Reserve started to adopt formal and explicit inflation targets, but the target decision is not exogenous to the Fed.

[20] Although the central bank governor has to be approved by the Senate, the President has the prerogative of nominating the central bank governor.

Figure 5. Central bank interest rates during the 2000-2001 electoral process in the USA and the 2002-2003 electoral process in Brazil



Source: The authors.

According to the model analyzed in this paper, staggered terms for the central banker and the head of government in Brazil, where institutions are of a type II, could have reduced the signaling cost faced by the monetary authority.

6. Conclusion

In this paper, we investigate the role of uncertainty regarding the type of a central banker on optimal monetary policy and formation of inflation expectations, in an environment where inflation targets are exogenously set by a government agency that is not the central bank. We apply Cho and Kreps (1987)'s intuitive criterion on an extended version of Vickers (1986)'s signaling model of monetary policy. In contrast to Vickers (1986), we find a range of possible pooling equilibria that survive the intuitive criterion.

The model shows that "social stability" has important implications for monetary policy. Under reasonable values of the discount factor, in more heterogeneous societies, monetary policy has to be more restrictive so as to build credibility. On the other hand, in more homogeneous societies, the very presence of an inflationary bias will not be grounds for such a restrictive monetary policy stance.

Furthermore, our framework allows for a comparison of two distinct institutional arrangements regarding the tenure in office of the central banker and the head of government. The main result is that macroeconomic adjustment to the pressures due to the political process are much less costly when the head of government and the central banker serve in staggered terms, due to the reduction of asymmetric information about monetary policy when society already knows the type of the central banker when the new head of government takes office.

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APPENDIX

Proof of Proposition 1.

In order for the weak central banker not to mimic S's choice, it must be the case that choosing his preferred inflation rate $\pi_1^W = \overline{\pi} + \mu$ and revealing his type to society yields a higher utility than choosing π_1^S, inducing society to believe he is strong, and gaining from the inflationary surprise at period 2. So, the weak central banker will not deviate from the separating equilibrium if and only if:

$$v^W\left(\overline{\pi} + \mu, \overline{\pi}, \rho\pi_1^S + (1-\rho)(\overline{\pi} + \mu)\right) + \delta v^W(\overline{\pi} + \mu, \overline{\pi}, \overline{\pi} + \mu)$$
$$\geq v^W\left(\pi_1^S, \overline{\pi}, \rho\pi_1^S + (1-\rho)(\overline{\pi} + \mu)\right) + \delta v^W(\pi_2 + \mu, \overline{\pi}, \overline{\pi} + \lambda)$$

This will be the case if and only if the following condition holds:

$$\pi_1^S \leq \overline{\pi} + \mu - \left(2\delta\mu\rho(\mu - \lambda)\right)^{\frac{1}{2}} \qquad (2)$$

In regard to the strong central banker, any deviation from his optimal complete information policy to signal his type brings forward deeper economic recession. Therefore, in a separating equilibrium he must still be better off choosing $\pi_1^S \leq \overline{\pi} + \lambda$. If he chooses $\pi_1^S > \overline{\pi} + \lambda$, society infers that the central banker is weak. The strong central banker will thus be better off signaling his type and separating if and only if

$$v^S\left(\pi_1^S, \overline{\pi}, \rho\pi_1^S + (1-\rho)(\overline{\pi} + \mu)\right) + \delta v^S(\overline{\pi} + \lambda, \overline{\pi}, \overline{\pi} + \lambda)$$
$$\geq v^S\left(\pi_1^S + \lambda, \overline{\pi}, \rho\pi_1^S + (1-\rho)(\overline{\pi} + \mu)\right) + \delta v^S(\pi_2 + \lambda, \overline{\pi}, \overline{\pi} + \mu)$$

and this implies that the following condition should hold in the separating equilibrium:

$$\pi_1^S \geq \overline{\pi} + \lambda - \left(2\delta\mu\rho(\mu - \lambda)\right)^{\frac{1}{2}} \qquad (3)$$

It is straightforward to check that $\overline{\pi} + \lambda - \left(2\delta\mu\rho(\mu - \lambda)\right)^{\frac{1}{2}} \leq \overline{\pi} + \mu - \left(2\delta\mu\rho(\mu - \lambda)\right)^{\frac{1}{2}}$. Therefore, there is a range of values for π_1^S compatible with a separating perfect Bayesian equilibrium.

Note now that the upper bound on the condition for the weak-type not to deviate from the separating equilibrium is higher than the strong-type optimal complete information choice, i.e., $\overline{\pi} + \lambda \leq \overline{\pi} + \mu - \left(2\delta\mu\rho(\mu - \lambda)\right)^{\frac{1}{2}}$, if and only if $\frac{\lambda}{\mu} \leq 1 - \frac{1}{2\delta}$. Therefore, if this condition is satisfied, then inflation choices $\pi_1^S \in \left[\overline{\pi} + \lambda - \left(2\delta\mu\rho(\mu - \lambda)\right)^{\frac{1}{2}},\ \overline{\pi} + \lambda\right]$ are the only strong-type choices to belong to a perfect Bayesian equilibrium.[21] ■

Proof of Proposition 2.

If $\frac{\lambda}{\mu} \leq 1 - \frac{1}{2\delta}$, the perfect Bayesian equilibria are $\pi_1^S \in \left[\overline{\pi} + \lambda - \left(2\delta\mu\rho(\mu - \lambda)\right)^{\frac{1}{2}},\ \overline{\pi} + \lambda\right]$. Consider any choice π_1^S in the interval $\pi_1^S \in \left[\overline{\pi} + \lambda - \left(2\delta\mu\rho(\mu - \lambda)\right)^{\frac{1}{2}},\ \overline{\pi} + \lambda\right)$. If the strong central banker can still convince society that he is strong, he can increase his utility by choosing an inflation rate closer to the right-hand side of the interval. At any point in the interval being analyzed, the weak central banker still prefers not to mimic the strong type's policy. Therefore, $\pi_1^S = \overline{\pi} + \lambda$ is the only equilibrium inflation rate not to require costly signaling on the part of the strong central banker, and thus it is the only one to fulfill the intuitive criterion.[22]

If $\frac{\lambda}{\mu} > 1 - \frac{1}{2\delta}$, then $\overline{\pi} + \mu - \left(2\delta\mu\rho(\mu - \lambda)\right)^{\frac{1}{2}} < \overline{\pi} + \lambda$ and any perfect Bayesian equilibrium will require an inflation rate below the strong type's preferred policy. In that case, every inflation rate $\pi_1^S \in \left[\overline{\pi} + \lambda - \left(2\delta\lambda(\mu - \lambda)\right)^{\frac{1}{2}},\ \overline{\pi} + \mu - \left(2\delta\mu(\mu - \lambda)\right)^{\frac{1}{2}}\right]$ belongs to a perfect Bayesian equilibrium. However, only the choice $\pi_1^S = \overline{\pi} + \mu - \left(2\delta\mu(\mu - \lambda)\right)^{\frac{1}{2}}$ satisfies the intuitive criterion[23]. ■

Proof of Proposition 3.

Given the consistent beliefs in period 2, there cannot be a pooling equilibrium with $\pi_1^P > \overline{\pi} + \lambda$, as the strong central banker would prefer to choose $\pi_1^S = \overline{\pi} + \lambda$. Therefore, the equilibrium is $\pi_1^P \leq \overline{\pi} + \lambda$.

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[21] Since for any $\pi_1^S \in \left(\overline{\pi} + \lambda,\ \overline{\pi} + \mu - \left(2\delta\mu\rho(\mu - \lambda)\right)^{\frac{1}{2}}\right]$ the strong central banker would prefer to choose his optimal complete information inflation $\overline{\pi} + \lambda$, which would also signal his type.

[23] The argument is the same presented in the previous footnote.

In a pooling equilibrium, the strong central banker will choose π_1^P as long as this gives him a higher utility than selecting his preferred policy $\overline{\pi} + \lambda$ and allowing society to believe that he is weak. Thus, the strong type will not deviate from the pooling equilibrium if and only if:

$$v^S\big(\pi_1^P, \overline{\pi}, \rho\pi_1^P + (1-\rho)(\overline{\pi}+\mu)\big) + \delta v^S\big(\overline{\pi}+\lambda, \overline{\pi}, \rho(\overline{\pi}+\lambda) + (1-\rho)(\overline{\pi}+\mu)\big)$$
$$\geq v^S\Big(\pi_1+\lambda, \overline{\pi}, \rho\pi_1^S + (1-\rho)(\overline{\pi}+\mu)\Big) + \delta v^S(\overline{\pi}\ +\lambda, \overline{\pi}, \overline{\pi}+\mu)$$

and this condition implies that:

$$\pi_1^P \geq \overline{\pi} + \lambda - \big(2\delta\lambda(\mu-\lambda)\big)^{\frac{1}{2}} \tag{4}$$

Likewise, the weak central banker will choose not to deviate from the pooling equilibrium if his utility of mimicking the strong type in the first period is higher than the utility of delivering inflation at his optimal discretionary rate in the first period, thus revealing his type. So the weak type will not deviate from the pooling equilibrium if and only if:

$$v^W\Big(\pi_1^P, \overline{\pi}, \rho\pi_1^S + (1-\rho)(\overline{\pi}+\mu)\Big) + \delta v^W\big(\overline{\pi}+\mu, \overline{\pi}, \rho(\overline{\pi}+\lambda) + (1-\rho)(\overline{\pi}+\mu)\big)$$
$$\geq v^W\Big(\pi_1+\mu, \overline{\pi}, \rho\pi_1^S + (1-\rho)(\overline{\pi}+\mu)\Big) + \delta v^W(\pi_2+\mu, \overline{\pi}, \overline{\pi}+\mu)$$

and this implies that the following condition should be fulfilled:

$$\pi_1^P \geq \overline{\pi} + \mu - \big(2\delta\mu(\mu-\lambda)\big)^{\frac{1}{2}} \tag{5}$$

It follows that $\overline{\pi} + \lambda - \big(2\delta\lambda(\mu-\lambda)\big)^{\frac{1}{2}} \leq \overline{\pi} + \mu - \big(2\delta\mu(\mu-\lambda)\big)^{\frac{1}{2}}$. Therefore, both conditions (4) and (5) will be satisfied if and only if $\pi_1^P \geq \overline{\pi} + \mu - \big(2\delta\mu(\mu-\lambda)\big)^{\frac{1}{2}}$. Furthermore, one must have $\pi_1^P \leq \overline{\pi} + \lambda$. But $\overline{\pi} + \lambda \geq \overline{\pi} + \mu - \big(2\delta\mu(\mu-\lambda)\big)^{\frac{1}{2}}$ if and only if $\frac{\lambda}{\mu} \geq 1 - 2\delta\rho$.

Thus, if $\frac{\lambda}{\mu} < 1 - 2\delta\rho$, there will be no pooling equilibrium. On the other hand, if $\frac{\lambda}{\mu} \geq 1 - 2\delta\rho$, then any inflation level $\pi_1^P \in \Big[\overline{\pi} + \mu - \big(2\delta\mu\rho(\mu-\lambda)\big)^{\frac{1}{2}},\ \overline{\pi} + \lambda\Big]$ corresponds to a perfect Bayesian pooling equilibrium. ■

Proof of Proposition 4.

To apply the intuitive criterion, we first analyze the hypothetical situation in which a central banker can convincingly signal his type by choosing a very low inflation rate in the first period. The question to be posed to find the intuitive equilibria is: under which conditions does the weak central banker refrain from deviating from the pooling equilibrium?

Should the weak central banker not deviate from the pooling equilibrium, he attains utility:

$$\nu_N^W = \nu(\pi^P, \overline{\pi}, \pi^P) + \delta\nu(\pi^W, \overline{\pi}, \rho\pi^S + (1-\rho)\pi^W)$$
$$= \nu(\pi^P, \bar{\pi}, \pi^P) + \delta\nu(\overline{\pi} + \mu, \overline{\pi}, \overline{\pi} + \rho\pi^S + (1-\rho)\pi^W)$$
$$= -\frac{1}{2}(\pi^P - \overline{\pi})^2 - \frac{1}{2}\delta\mu^2 + \delta\rho\mu(\mu - \lambda)$$

An out-of-equilibrium strategy to the weak central banker would be to choose an inflation rate $\pi^D < \pi^P$ so low as to convincingly signal to be strong and attain utility:

$$\nu_D^W = \nu(\pi^P, \overline{\pi}, \pi^P) + \delta\nu(\pi^W, \overline{\pi}, \pi^S)$$
$$= \nu(\pi^P, \bar{\pi}, \pi^P) + \delta\nu(\overline{\pi} + \mu, \overline{\pi}, \overline{\pi} + \lambda)$$
$$= -\frac{1}{2}(\pi^D - \overline{\pi})^2 + \mu(\pi^D - \pi^P) - \frac{1}{2}\delta\mu^2 + \delta\mu(\mu - \lambda)$$

The weak type does not deviate from pooling if and only if $\nu_D^W < \nu_N^W$, which implies:

$$\mu\delta[(1-\rho)(\mu - \lambda)] < \left(\overline{\pi} - \frac{\pi^D + \pi^P}{2}\right)(\pi^P - \pi^D) \tag{6}$$

If the strong type does not deviate from the pooling equilibrium, his utility is:

$$\nu_N^S = \nu(\pi^P, \overline{\pi}, \pi^P) + \delta\nu(\pi^S, \overline{\pi}, \rho\pi^S + (1-\rho)\pi^W)$$
$$= -\frac{1}{2}(\pi^P - \overline{\pi})^2 - \frac{1}{2}\delta\lambda^2 - \delta\lambda(1-\rho)(\mu - \lambda)$$

If he deviates to $\pi^D < \pi^P$ and fully convinces society of his type, his utility is:

$$\nu_D^S = \nu(\pi^D, \overline{\pi}, \pi^P) + \delta\nu(\pi^S, \overline{\pi}, \pi^S)$$
$$= -\frac{1}{2}(\pi^D - \overline{\pi})^2 + \lambda(\pi^D - \pi^P) - \frac{1}{2}\delta\lambda^2$$

Thus, the strong type deviates to convincingly signal his type if and only if $\nu_D^S > \nu_N^S$, or yet

$$\lambda\delta[(1-\rho)(\mu - \lambda)] < \left(\overline{\pi} - \frac{\pi^D + \pi^P}{2}\right)(\pi^P - \pi^D) \tag{7}$$

Note that, for:

i. the weak type central banker not to deviate from the perfect Bayesian pooling equilibrium, and

ii. the strong type central banker to deviate

it must be the case that conditions (6) and (7) are mutually satisfied, which is impossible given that $0 < \lambda < \mu$.

Therefore, whenever the strong type has incentives to deviate to signal that he is strong, the weak type will also follow. As a result, society cannot update its out-of-equilibrium beliefs, and thus the perfect Bayesian equilibrium obtained satisfies the intuitive criterion. ■

Analysis of Vickers (1986).

There are two differences between our theoretical model and that of Vickers (1986):

1. In our model, we allow for an explicit inflation target ¯ in central bank's utility function; in Vickers the implied target is zero.
2. In the intertemporal utility, we add a time discount factor δ that may take any value between (0,1]; in Vickers the implied discount factor is 1.

However, the solutions we find are not an extension of those found in Vickers. Vickers claims to adopt a methodology to find separating and pooling equilibria very similar to the one that finds sequential equilibria. We shall argue below that under the methodology he employed, some equilibrium intervals were improperly disregarded.

Hereafter, we shall use the terminology adopted in our paper.

<u>Separating equilibria in Vickers</u>

To find the separating equilibria, Vickers adopts the following procedure:

1. Define K_i as the lowest level of inflation the central banker i chooses in the first period such that he is indifferent between
   a. choosing $\pi_i = K_i$ and being believed to be dry – in which case $\pi_2^e = \lambda$ – and

b. choosing $\pi_i = c_i$, where c_i is his optimal discretionary inflation choice, and being believed to be wet – in which case $\pi_2^e = \mu$.

2. He calculates K_i for each central banker: $K_S = \lambda\left[1 - \sqrt{2\lambda(\mu - \lambda)}\right]$ and $K_W = \mu\left[1 - \sqrt{2\mu(\mu - \lambda)}\right]$. The calculations are as follows:

   To find K_i, Vickers compares the 2-period utility that a generic central banker *i* obtains in 1.a and 1.b:

$$\nu(K_i, \rho K_i + (1-\rho)c_i) + \nu(c_i, \lambda) = \nu(c_i, \rho K_i + (1-\rho)c_i) + \nu(c_i, \mu) \qquad \text{A.1}$$

$$\Leftrightarrow \frac{1}{2}K_i^2 + c_i[\rho K_i + (1-\rho)c_i - K_i] + \frac{1}{2}c_i^2 + c_i(\lambda - c_i)$$

$$= \frac{1}{2}c_i^2 + c_i[\rho K_i + (1-\rho)c_i - c_i] + \frac{1}{2}c_i^2 + c_i(\mu - c_i)$$

$$\Leftrightarrow (K_i - c_i)^2 = 2c_i(\mu - \lambda)$$

Assuming that $\mu \geq \lambda > 0$, the possibility that $K_i = c_i$ should be ruled out as an indifferent choice of inflation, as the term on the right-hand side of the last equality cannot be zero. He is thus left with two cases:

i. $K_i - c_i > 0$, in which case $K_i = c_i\left[1 + \sqrt{2\left(\frac{\mu-\lambda}{c_i}\right)}\right]$

ii. $K_i - c_i < 0$, in which case $K_i = c_i\left[1 - \sqrt{2\left(\frac{\mu-\lambda}{c_i}\right)}\right]$

The solution Vickers finds suggests that the only possible case to analyze is "ii", i.e., $K_i < c_i$,. However, there is no reason to rule out the possibility that $K_i - c_i > 0$ for the strong type; in particular, it should be noted that this region encompasses the strong type's optimal discretionary choice, $\pi_1^S = \lambda$, as a possible choice for a separating equilibrium.

<u>Pooling equilibrium in Vickers</u>

To build the pooling equilibrium, Vickers tries to find an interval for inflation choices that would make a generic central banker *i* indifferent between:

i. choosing $\pi_1 = L_i$, and the public cannot infer his type, that is, $\pi_2^e = \bar{c} = \rho\lambda + (1-\rho)\mu$.

ii. choosing $\pi_1 = c_i$, and the public believes that he's weak, that is, $\pi_2^e = \mu$.

He breaks down the interval into L_i^+, which is the highest level of inflation that sustains the central banker's indifference, and L_i^- the lowest level of inflation to also sustain the indifference.

Using the central bank's utility, we can express i and ii as follows:

$$\frac{1}{2}L_i^2 + c_i(L_i - L_i) + \frac{1}{2}c_i^2 + c_i(\lambda - c_i) = \frac{1}{2}c_i^2 + c_i(L_i - c_i) + \frac{1}{2}c_i^2 + c_i(\mu - c_i) =$$

$$\Leftrightarrow (L_i - c_i)^2 = 2\rho c_i(\mu - \lambda)$$

Two cases arise:

$L_i - c_i > 0$, in which case, $L_i = c_i + \sqrt{2\rho c_i(\mu - \lambda)}$, or

$L_i - c_i < 0$, in which case, $L_i = c_i - \sqrt{2\rho c_i(\mu - \lambda)}$.

For Vickers, L_i^+ will be obtained when $L_i - c_i > 0$,, for every central banker, and L_i^- will be obtained when $L_i - c_i < 0$. Pooling equilibria will be in the region $L = [L_S^-, L_S^+] \cap [L_W^-, L_W^+]$ when $\frac{\lambda}{\mu} \geq \frac{1-4\rho^2}{1+4\rho^2}$.

However, as we argue in our paper, the pooling equilibrium does not hold when $L_S > c_S$, since, in this case, the strong type will prefer his optimal discretionary choice, c_S.