Elections, Heterogeneity of Central Bankers and Inflationary Pressure:

The case for staggered terms for the president and the central banker

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Abstract
This paper investigates the role of the degree of heterogeneity of central bankers’ preferences in the output-inflation tradeoff. It refines the solution of a game theoretic model of monetary policy when inflation targets are not set by the monetary authority and with uncertainty about the preferences of the central banker. The model’s solution implies that greater dispersion in the distribution of central bankers’ preferences increases the signaling cost of commitment to inflation targets. The model is also extended to allow for heterogeneity in preferences of the agent that chooses the inflation target. In this setup, the paper compares two distinct institutional environments regarding the tenure in office of the central banker and the head of government and finds that macroeconomic adjustments 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 a reduction of asymmetric information about monetary policy. This gives support to the observed practice of staggered terms when central banks have legal independence.

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1. Introduction

Republican George W. Bush was sworn into office as the 43rd President of the USA on January 20, 2001. He succeeded the highly popular Democrat president Bill Clinton, who ruled the country for 8 consecutive years. During the election year of 2000, the Federal Reserve System, the FED, kept their yearly target federal funds rate at 6.5% from May 16 on. Then, on 2001 the FED initiated a
gradual reduction in interest rates to reach 4.0% in May 2001. Notwithstanding the flexibilization of monetary policy, inflation dropped throughout this period.

Two years later, Labor Party (PT)’s Lula was sworn into office as the 35th President of Brazil on January 1st, 2003. During the election year of 2002 the Brazilian Central Bank raised interest rates steadily from 18.5% in May to 25% in December. Lula’s government increased interest rates further, keeping them at the very high level of 26.5% until May 2003. Notwithstanding the dramatic interest rate shocks, inflation accelerated around the election period and started to recede only around the second quarter of the new president’s term.

A comparison between the two countries’ episodes indicates that in the US the election process had no effect on either the downward trajectory of interest rates or on the downward trajectory of inflation, whereas in Brazil there was a clear surge both in interest rates and inflation around the election period. This suggests that the electoral process in Brazil may have had a much higher impact on monetary policy and inflation control in Brazil than in the US.

When we look at the institutional characteristics of both countries at that particular moment, we can see, among other differences, that Brazil had adopted a full-fledged inflation-targeting regime with a central banker appointed by the president at the beginning of his term, whereas the US still had no explicit targeting regime, with a fixed-term central banker whose term is staggered with the president’s.

One fundamental characteristic of the inflation targeting regime is that inflation targets are announced in advance to society. Therefore, inflation expectations based on the announcements

1 https://www.federalreserve.gov/monetarypolicy/openmarket.htm
2 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)
4 Inflation was 12.53% in 2002, 9.3% in 2003 and 7.6% in 2004 (http://www.ibge.gov.br/home/estatistica/indicadores/precos/inpc_ipca/defaultseriesHist.shtm).
5 In 2012, the US Federal Reserve started to adopt formal and explicit inflation targets, but the target decision is not exogenous to the FRB.
and credibility about the central banker’s ability and willingness to deliver the publicized inflation rate play a crucial role in the workings of the system.

It has been standard in the theoretic literature of central bank reputation and monetary policy\(^6\) to assume that inflation targets are set by the monetary authority. However, analyzing inflation targeting (IT) countries’ monetary institutions, one can easily verify that in most cases the central banker does not have the autonomy to set inflation targets. Indeed, according to Mishkin and Schmidt-Hebbel (2001), only 5 out of 19 IT countries allowed their central bankers to independently choose the inflation targets\(^7\). For some countries, inflation targets are set by a committee in which the central banker participates. The existence of institutional frameworks that enforce mutual understanding among potentially conflicting members of the government implies that the standard assumption that central bankers set inflation targets can disregard important strategic behavior by the agents in monetary policy models.

In the case of Brazil, for instance, inflation targets are decided and set by the Monetary Policy Council (CMN), comprised of the Finance Minister, the Minister of Budget and Planning and the Central Bank’s governor. A clear case of exogenous determination of the target took place in Brazil in 2007. In that year inflation was under control at around 3.5% and the official target was set at 4.5%. It was time for the CMN to set the 2009 target, and the president of the Central Bank, Henrique Meirelles, openly advocated for a reduction to 4%. However, the CMN decided to maintain the 4.5% target, which was kept for almost a decade\(^8\).

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\(^6\) Vickers, 1986 and Cukierman & Liviatan, 1991 are the fundamental references. See also: Walsh, 2000; Mishkin & Schmidt-Hebbel, 2001; Bugariin & Carvalho, 2005.

\(^7\) In fact, that study appoints Poland as a country in which the Central Bank sets the target independently, which is not formally the case according to Horská, 2001. Therefore, the study appoints 6 rather than 5 countries with Central Bank’s goal autonomy. Moreover, only 7 out of the 25 countries listed in footnote 1 allow their central bankers to independently set the inflation targets.

\(^8\) See, on this matter, http://www1.folha.uol.com.br/folha/colunas/brasiliaonline/ult2307u308541.shtml. The inflation target was recently reduced to 4.25% for 2019 and to 4.0% for 2020; see: https://www.bcb.gov.br/Pec/metase/TabelaMetaseResultados.pdf.
In order to better understand the monetary equilibrium when the central banker does not set 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. 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. Under the intuitive criterion, the model implies that greater heterogeneity in central bankers’ types requires costlier disinflationary policies. It is important to highlight that our results are not a generalization of the ones Vickers obtains.

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.
The most important implication of the model is that a higher (ex-ante) dispersion in central bankers’ preferences causes a strong-type central banker to be tougher on its delivered inflation rates so as to signal his type to society. 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 other words, in countries where different types of central bankers have very distinct preferences for monetary policy, disinflation policies will be costlier. The present paper’s result suggests that the monetary policy may consistently induce realized inflation below the target in the separating equilibrium. A straightforward implication of the model is to predict that in countries where policy orientation is more heterogeneous, central bankers with a more hawkish yet only privately known policy orientation will need to adopt very tight monetary policies in order to be credible.

Furthermore, the framework analyzed in this paper allows a comparison of two distinct institutional environments 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. This finding 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

10 Under a reasonable support of discount factor (i.e., greater than 0.5)
in order to be able to compare the two distinct institutional frameworks: one where the president
nominates a new central banker when he takes office; and the other where the president has to
maintain the previous central banker for two additional years. Finally, the last section concludes
the paper.

2. A brief review of the literature

Kydland and Prescott (1977) and Barro and Gordon (1983a, b) pioneered in the study of the
role of inflation expectations in short-run output variations. With the advent of the economics of
information, several models have analyzed 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 real inflation in period $t$ is affected by a stochastic component to money demand
$\delta_t = e_t + \epsilon_t$. The model focuses on imperfect asymmetric information on $\delta_t$: the central banker
observes $e_t$ before choosing the inflation rate, but society only observes $\delta_t$ at the end of the period.
Because society does not distinguish between $e_t$ and $\epsilon_t$, the central banker can create unexpected
inflation and attribute it to the unexpected shock $\epsilon_t$. 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 a 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 in equilibrium. 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 threefold. 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.

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 will be 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:

$$v(\pi_i, \bar{\pi}_i, \pi^e_i) = -\frac{1}{2} (\pi_i - \bar{\pi}_i)^2 + \lambda (\pi_i - \pi^e_i)$$

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11 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 see, for example, Walsh (2000).
where $\pi_t$ 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 $\pi^e_t$ 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 incurs by not achieving the target. In inflation targeting regimes the farther away realized inflation is from the target, the stronger the social reaction to central banker’s policies. In certain countries, this could even lead to appointing a new central banker.$^{12}$ Inflation targeting countries usually adopt target bands that are symmetric around the center of the target. 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.

With only one type of central banker and targets exogenously set, the model will predict an inflation bias. The first order condition yields $\pi_t = \bar{\pi}_t + \lambda$, 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 $\pi^e_t = \bar{\pi}_t + \lambda = \pi_t$. This is a standard result in the literature.

Let us now allow for two possible types of central bankers, $\mu$ and $\lambda$, $\mu \geq \lambda$, 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 $\lambda$ to output expansion cares relatively more about achieving the exogenous target than the central banker that

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$^{12}$ See New Zealand’s institutional framework in Walsh (1995).
attributes weight $\mu$, who values relatively more generating inflationary surprise. The $\lambda$-type central banker is said to be strong, whereas the $\mu$-type is said to be weak.

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

This simple analysis allows us to draw the following preliminary 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 to the economy.

Plugging in realized and expected inflation into strong- and weak-type central bankers’ utilities yields respectively $v_i^s = -\frac{1}{2} \lambda^2 - \lambda (1 - \rho) (\mu - \lambda)$ and $v_i^w = -\frac{1}{2} \mu^2 + \rho (\mu - \lambda) \mu$. Notice that both types gain with higher credibility in the central banker, which is modeled here as the parameter $\rho$, i.e., the higher $\rho$, 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: \(\bar{\pi}_1 = \bar{\pi}_2 = \bar{\pi}\). 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 on 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.

The next section discusses the model’s equilibria and refinements.
4. Equilibria

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 $\pi_1^w = \pi_2^w = \bar{\pi} + \mu$.

On the other hand, a strong central banker may have incentives to deviate from its optimal complete information rate if this is necessary to induce the weak central banker not to mimic his chosen inflation. Let $\pi_1^s$ be the inflation chosen by the strong central banker in period 1. Then, the consistent beliefs society holds in period 2, $\pi_2^c$, are the following: if realized inflation in period 1 is lower than or equal to $\pi_1^s$, then the central banker is strong; if it is above $\pi_1^s$, then the central banker is weak. Moreover, society’s expected inflation in period 1 is $\pi_1^c = \rho \pi_1^s + (1 - \rho)(\bar{\pi} + \mu)$.

We can now characterize the separating equilibria.

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

**Proof**: In order for the weak central banker not to mimic $S$’s choice, it must be the case that choosing his preferred inflation rate $\pi_1^w = \bar{\pi} + \mu$ and revealing his type to society yields a higher utility than choosing $\pi_1^s$, 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

$$v(\bar{\pi} + \mu, \bar{\pi}, \rho \pi_1^s + (1 - \rho)(\bar{\pi} + \mu)) + \delta v(\bar{\pi} + \mu, \bar{\pi}, \bar{\pi}_2 + \mu) \geq v(\pi_1^s, \bar{\pi}, \rho \pi_1^s + (1 - \rho)(\bar{\pi} + \mu)) + \delta v(\pi_2 + \mu, \bar{\pi}, \bar{\pi}_2 + \lambda)$$
This will be the case if and only if the following condition holds:

\[ \pi_i^s \leq \bar{\pi} + \mu - (2\delta \mu (\mu - \lambda))^{\frac{1}{\beta}} \]  

(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 \( \pi_i^s \leq \bar{\pi} + \lambda \). If he chooses \( \pi_i^s > \bar{\pi} + \lambda \), 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

\[
\begin{align*}
\nu(\pi_i^s, \bar{\pi}, \rho \pi_i^s + (1 - \rho)(\bar{\pi} + \mu)) + \delta \nu(\bar{\pi} + \lambda, \bar{\pi}, \bar{\pi}_2 + \lambda) & \geq \\
\nu(\pi_1 + \lambda, \bar{\pi}, \rho \pi_i^s + (1 - \rho)(\bar{\pi} + \mu)) + \delta \nu(\pi_2 + \lambda, \bar{\pi}, \bar{\pi}_2 + \mu)
\end{align*}
\]

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

\[ \pi_i^s \geq \bar{\pi} + \lambda - (2\delta \lambda (\mu - \lambda))^{\frac{1}{\beta}} \]  

(3)

It is straightforward to check that \( \bar{\pi} + \lambda - (2\delta \lambda (\mu - \lambda))^{\frac{1}{\beta}} \leq \bar{\pi} + \mu - (2\delta \mu (\mu - \lambda))^{\frac{1}{\beta}} \). Therefore, there is a range of values for \( \pi_i^s \) 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.,

\[ \bar{\pi} + \lambda \leq \bar{\pi} + \mu - (2\delta \mu (\mu - \lambda))^{\frac{1}{\beta}} \], if and only if \( \frac{\lambda}{\mu} \leq 1 - 2\delta \). Therefore, if this condition is satisfied
\( \frac{\lambda}{\mu} \leq 1 - 2\delta \), then inflation choices in the interval \( \pi^S_1 \in \left[ \bar{\pi} + \lambda - \left(2\delta \mu (\mu - \lambda) \right)^{\frac{1}{2}}, \bar{\pi} + \lambda \right] \) are the only strong-type choices to belong to a perfect Bayesian equilibrium.\(^{13}\)

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 \( \frac{\lambda}{\mu} \leq 1 - 2\delta \), the only choice of inflation by the strong central banker that fulfills the intuitive criterion is \( \pi^S_1 = \bar{\pi} + \lambda \). Otherwise, \( \pi^S_1 = \bar{\pi} + \mu - \left(2\delta \mu (\mu - \lambda) \right)^{\frac{1}{2}} \).

**Proof:**

If \( \frac{\lambda}{\mu} \leq 1 - 2\delta \), the perfect Bayesian equilibria are \( \pi^S_1 = \left[ \bar{\pi} + \lambda - \left(2\delta \mu (\mu - \lambda) \right)^{\frac{1}{2}}, \bar{\pi} + \lambda \right] \). Consider any other choice \( \pi^S_1 \) in the interval \( \pi^S_1 = \left[ \bar{\pi} + \lambda - \left(2\delta \mu (\mu - \lambda) \right)^{\frac{1}{2}}, \bar{\pi} + \lambda \right] \). 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, \( \pi^S_1 = \bar{\pi} + \lambda \)

\(^{13}\) Since for any \( \pi^S_1 = \left[ \bar{\pi} + \lambda, \bar{\pi} + \mu - \left(2\delta \mu (\mu - \lambda) \right)^{\frac{1}{2}} \right] \) the strong central banker would prefer to choose his optimal complete information inflation \( \bar{\pi} + \lambda \) which would also signal his type.
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.\textsuperscript{14}

If $\frac{\lambda}{\mu} < 1 - 2\delta$, then $\pi + \mu - \left(2\delta\mu(\mu - \lambda)\right)^{\frac{1}{2}} < \pi + \lambda$ and any perfect Bayesian equilibrium will require an inflation rate below the strong type’s preferred policy. In that case, every inflation rate $\pi^S_1 \in \left[\bar{\pi} + \lambda - \left(2\delta\lambda(\mu - \lambda)\right)^{\frac{1}{2}}, \pi + \mu - \left(2\delta\mu(\mu - \lambda)\right)^{\frac{1}{2}}\right]$ belongs to a perfect Bayesian equilibrium.

However, only the choice $\pi^S_1 = \pi + \mu - \left(2\delta\mu(\mu - \lambda)\right)^{\frac{1}{2}}$ satisfies the intuitive criterion\textsuperscript{15}. □

Note that $\pi > \pi + \mu - \left(2\delta\mu(\mu - \lambda)\right)^{\frac{1}{2}} = \pi^S_1$ if and only if $\frac{\lambda}{\mu} < \frac{2\delta - 1}{2\delta}$. Therefore, if $\frac{\lambda}{\mu} > \frac{2\delta - 1}{2\delta}$, then $\pi^S_1 > \pi$, i.e., the inflation level chosen by a strong central banker, although below his preferred level $(\pi + \lambda)$, will still be above the target. On the other hand, if $\frac{\lambda}{\mu} < \frac{2\delta - 1}{2\delta}$, then $\pi^S_1 < \pi$, i.e., in order to signal his type, the strong central banker will keep inflation below the target $\pi$. Figure 2 summarizes the present analysis.

\textsuperscript{15} The argument is the same presented in the previous footnote.
The ratio \( \frac{\lambda}{\mu} \) can be interpreted as the level of homogeneity of a society. Indeed, if \( \lambda \) is very close to \( \mu \), 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 \( \delta \) is high enough (bigger than 0.5).

Conversely, if \( \mu \) is much bigger than \( \lambda \), 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.
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: \( \pi_2^e = \rho \pi_2^S + (1 - \rho) \pi_2^w = \pi + \rho \lambda + (1 - \rho) \mu \). Let \( \pi_1^p \) 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 the realized inflation in period 1 is lower than or equal to \( \pi_1^p \), then there is no updating in beliefs, i.e., society still believes that the central banker is strong with the same probability \( \rho \); if it is above \( \pi_1^p \), then society concludes the central banker is weak. We now characterize the regions for pooling to occur.

**Proposition 3:** If \( \frac{\mu}{\lambda} < 1 - 2\delta \rho \), there will be no pooling equilibrium. On the other hand, if

\[
\frac{\mu}{\lambda} \geq 1 - 2\delta \rho,
\]

then any inflation level \( \pi_1^p \in \left[ \bar{\pi} + \mu - (2\delta \mu \rho (\mu - \lambda) \frac{1}{2}, \bar{\pi} + \lambda \right) \) corresponds to a perfect Bayesian pooling equilibrium.

**Proof:**

Given these beliefs, there cannot be a pooling equilibrium with \( \pi_1^p > \bar{\pi} + \lambda \), as the strong central banker would prefer to choose \( \pi_1^S = \bar{\pi} + \lambda \). Therefore, the equilibrium is \( \pi_1^p \leq \bar{\pi} + \lambda \).
In a pooling equilibrium, the strong central banker will choose $\pi^p_i$ as long as this gives him a higher utility than selecting his preferred policy $\bar{\pi} + \lambda$ and allowing society to believe that he is weak. Thus, the strong type will not deviate from the pooling equilibrium if and only if:

$$v(\pi^p_i, \bar{\pi}, \rho \pi^p_i + (1 - \rho)(\bar{\pi} + \mu)) + \delta v(\bar{\pi} + \lambda, \bar{\pi}, \rho(\bar{\pi}_2 + \lambda) + (1 - \rho)(\bar{\pi} + \mu)) \geq v(\pi_i + \lambda, \bar{\pi}, \rho \pi^p_i + (1 - \rho)(\bar{\pi} + \mu)) + \delta v(\bar{\pi}_2 + \lambda, \bar{\pi}, \bar{\pi}_2 + \mu)$$

and this condition implies that:

$$\pi^p_i \geq \bar{\pi} + \lambda - (2\delta \rho (\mu - \lambda))^\frac{1}{2} \quad (4)$$

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:

$$v(\pi^p_i, \bar{\pi}, \rho \pi^p_i + (1 - \rho)(\bar{\pi} + \mu)) + \delta v(\bar{\pi} + \mu, \bar{\pi}, \rho(\bar{\pi}_2 + \lambda) + (1 - \rho)(\bar{\pi} + \mu)) \geq v(\pi_i + \mu, \bar{\pi}, \rho \pi^p_i + (1 - \rho)(\bar{\pi} + \mu)) + \delta v(\bar{\pi}_2 + \mu, \bar{\pi}, \bar{\pi}_2 + \mu)$$

and this implies that the following condition should be fulfilled:

$$\pi^p_i \geq \bar{\pi} + \mu - (2\delta \mu (\mu - \lambda))^\frac{1}{2} \quad (5)$$

It follows that $\bar{\pi} + \lambda - (2\delta \rho (\mu - \lambda))^\frac{1}{2} \leq \bar{\pi} + \mu - (2\delta \mu (\mu - \lambda))^\frac{1}{2}$. Therefore, both conditions (4) and (5) will be satisfied if and only if $\pi^p_i \geq \bar{\pi} + \mu - (2\delta \mu (\mu - \lambda))^\frac{1}{2}$. Furthermore, one must have $\pi^p_i \leq \bar{\pi} + \lambda$. But $\bar{\pi} + \lambda \geq \bar{\pi} + \mu - (2\delta \mu (\mu - \lambda))^\frac{1}{2}$ 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 $\pi_1^p \in \left[\pi + \mu - \left(2\delta\mu\rho(\mu - \lambda)\right)^{\frac{1}{2}}, \pi + \lambda\right]$ 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 ($\mu$ close to $\lambda$), which would correspond to a more homogeneous society; 2) the weak type significantly values the future ($\delta$ very high, close to 1); and 3) credibility is high (society expects the central banker is of type $\lambda$ with high probability, i.e., $\rho$ is high).

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

We employ the intuitive criterion to try 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.

*Proof:*

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:
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:

$$v_N^w = v(\pi^p, \pi, \pi^p) + \delta v(\pi^w, \pi, \rho \pi^s + (1-\rho)\pi^w)$$

$$= v(\pi^p, \pi, \pi^p) + \delta v(\pi + \mu, \pi, \rho \lambda + (1-\rho)\pi^w)$$

$$= -\frac{1}{2} (\pi^p - \pi)^2 - \frac{1}{2} \delta \mu^2 + \delta \lambda (\mu - \lambda)$$

Thus, the weak type does not deviate from pooling if and only if $v_D^w < v_N^w$, which implies:

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

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

$$v_N^s = v(\pi^p, \pi, \pi^p) + \delta v(\pi^s, \pi, \rho \pi^s + (1-\rho)\pi^w)$$

$$= -\frac{1}{2} (\pi^p - \pi)^2 - \frac{1}{2} \delta \lambda^2 - \delta (1-\rho)(\mu - \lambda)$$

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

$$v_D^s = v(\pi^D, \pi, \pi^p) + \delta v(\pi^s, \pi, \pi^s)$$

$$= -\frac{1}{2} (\pi^D - \pi)^2 + \lambda (\pi^p - \pi^D) - \frac{1}{2} \delta \lambda^2$$

Thus, the strong type deviates to convincingly signal his type iff $v_D^s > v_N^s$, or yet

$$\lambda [\delta (1-\rho)(\mu - \lambda)] > \left(\pi - \frac{\pi^D + \pi^p}{2}\right) (\pi^p - \pi^D)$$  \hspace{1cm} (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.

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”\textsuperscript{16}. As detailed in the Appendix, Vickers’ method fails to consider equilibrium regions that could not be ruled out in a sequential equilibrium approach.

Although eliminating the pooling equilibria by alternative refinements might be desirable from a theoretical standpoint, it may not be a desirable result from a social perspective. If society’s utility is quadratic in the inflationary surprise, which is analogous to assuming that people do their best to produce their economic forecasts, pooling may be more desirable given that the inflationary surprise, if there is one, is deferred into the future.

\textsuperscript{16} Italicized comments are ours.
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 week 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 takes office, the central banker is in the middle of its term. Finally, to make the model reflect the Brazilian and the American realities, 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 environments.

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

Suppose, as previously discussed, that both the head of government and the central banker can be of the strong-type or of the 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.

\[
v(\pi_t, \pi_t^e, \gamma, \theta_{CB}, \theta_p) = -\frac{1}{2} (\pi_t - \pi_t^e)^2 + \gamma \theta_p (\pi_t - \pi_t^e) + (1 - \gamma) \theta_{CB} (\pi_t - \pi_t^e)
\]

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 we have the previous model where only the central banker preferences affect his utility. However, as \( \gamma \) 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 \( \gamma \) corresponds to each one of the institutional frameworks we wish to analyze.

5.2. Institutional framework I: The simultaneous terms case
Suppose that the head of government has the prerogative of nominating a new the 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 trade-off inflation-output trade-off. Therefore, we assume that, in this case\(^\text{17}\), \(\gamma = 1\) or, equivalently, that \(\theta_p = \theta_{CB}\).

Note that, in that case, we return to the situation that has been analyzed in the first part of the paper, in which the political uncertainty generates an uncertainty in monetary policy of the same intensity. In particular, the higher cost of signaling for the strong-type central banker when ex-ante heterogeneity of central bankers (now seen as ex-ante heterogeneity of head of government) is higher.

### 5.3. Institutional framework II: The staggered terms case

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 his third term. Then, the head of government does not have the prerogative of nominating a new the central banker. Therefore, we might expect that either \(\gamma = 0\), or it is very small. For the sake of simplicity, we assume the value zero for that parameter.

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.

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

\(^{17}\) The present modeling 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.
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 brief extension presented here allows us to disentangle the role of uncertainty about the type of the president and uncertainty about the type of the central banker, and understand role of simultaneous terms for the head of government and the central bank on signaling. 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.

Figure 4 below illustrates the findings using data from the 2000-2001 electoral process in the USA, which institutions are of type II, and the 2002-2003 electoral process in Brazil, that has a type I institutional framework. Whereas the FED’s interest rate did increase from 5.5% in January to 6.5% in May 2000, it remained stable along the year and on January 2001 it started a reduction
path of 0.5 percentage point per month until May 2001. On the other hand, Brazilian Central Bank’s interest rate increased from 18.75% in January to 25% in December 2002, increased further to 26.5% in January 2002, with the new central banker, and remained at that very high figure until June 2002, when it was first reduced to 26%.

Figure 4. Central bank interest rates during the 2000-2001 electoral process in the USA and the 2002-2003 electoral process in Brazil

7. Conclusion

This paper applied Cho and Kreps (1987)’s intuitive criterion on an extended version of Vickers (1986)’s signaling model of monetary policy to 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. 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 on 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, the article allows a comparison of two distinct institutional environment
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

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

1. In our model, we allow for an explicit inflation target $\pi$ in central bank’s utility function; in Vickers the implied target is zero.
2. In the intertemporal utility, we add a time discount factor $\delta$ 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.

Separating equilibria in Vickers

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 $\pi_1 = K_i$ 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:

   \[ v(K_i, \rho K_i + (1 - \rho)c_i) + v(c_i, \lambda) = v(c_i, \rho K_i + (1 - \rho)c_i) + v(c_i, \mu) \]

   A.1
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 $K_i = c_i \left[ 1 + \frac{1}{2} \left( \frac{\mu - \lambda}{c_i} \right) \right]$

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

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, $\pi_i^s = \lambda$, as a possible choice for a separating equilibrium.

**Pooling equilibrium in Vickers**

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

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:

\[
\frac{1}{2}L_i^2 + c_i(L_i - L_i) + \frac{1}{2}c_i^2 + c_i(\bar{c} - c_i) = \frac{1}{2}c_i^2 + c_i(L_i - c_i) + \frac{1}{2}c_i^2 + c_i(\mu - c_i)
\]

\[
\Rightarrow (L_i - c_i)^2 = 2\rho c_i(\mu - \lambda)
\]

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

\[
L = [L_{\mu}^-, L_{\mu}^+] \cap [L_{\mu}^-, L_{\mu}^+]
\]

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 \(L_S > c_S\), as, in this case, the strong type will prefer his optimal discretionary choice, \(c_S\).