In°ation Target Instability and Interest Rates

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Abstract

The implementation of explicit quantitative in°ation targets elucidates the assessment of credibility of future monetary policy. Here the explicit in°ation target is time-varying and stochastic with asymmetric information. It is shown that central bank independence promotes lower in°ation but not at the cost of increased output variability. Marked political instability and instrument dependence are detrimental to credibility. The marginal e®ect from less instrument independence on interest rate volatility is increasing in political instability. Strategic delegation of an optimal in°ation target with a monetary reform eliminates the in°ation bias. Empirical evidence substantiates the predictions when confronted with cross-country OECD data.

Keywords: In°ation target, Credibility, Political instability, Independence
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1. Introduction

Many countries have recently designed and implemented explicit in°ation targets as a means to attain price stability and to a®ect in°ation expectations and nominal contracts (cf. Leiderman and Svensson, 1995 and Haldane, 1995). Predicted future monetary policy and forecasted in°ation relative to the path of the in°ation target signal the extent to which the target is expected to be honored. Credibility of monetary policy is thus manifested in potential divergence between the quantitative in°ation target and the public's in°ation expectation embodied in the standard and implied forward nominal yield curves. Whether economic and political institutions may account for the (mis)trust in quantitative in°ation targets is examined in this paper.

It is an equally justi¯able as often marketed argument that domestic institutions must be adjusted to procure credibility of monetary policy and to deter permanently high and volatile long term interest rates. Casual observations give at hand that political turmoil increases nominal interest rates, in°ation expectations, and thus decrease con¯dence in the in°ation target, for example when incumbents prior to elections tend to conduct looser ¯scal policy. At the same time central bank independence seems to work in the opposite direction. Conspicuous nominal interest rate variation indicates that the target is not fully credible. The conjecture is that lack of independence is a necessary but not su±cient condition for high interest rate variability. Some case studies indicate that institutional factors indeed may explain interest rate performance. Long term interest rates seem to be higher and more volatile in United Kingdom, Italy, Canada and France, and lower in Switzerland, Japan, United States and Germany (cf. Bernanke and Mishkin, 1992 and in Hardouvelis, 1994). Furthermore, high expected in°ation as manifested in the forward yield curve (except left end-points) is observed in United Kingdom and Sweden, whilst the United States, France and Germany display considerably lower interest rates (cf. Svensson, 1994). The interpretation is that the former su®er from limited credibility due to their in°ation record and their institutional status.

While the monetary policymaker generally has a prime concern about stable prices and keeping in°ation down, he tries not to accomplish the price stability goal at all costs but cares also about employment. The government assigns an objective function to the rational monetary policymaker who dislikes in°ation and output deviations from their respective explicit or implicit targets, and whose interaction with the public generates the economic outcome (cf. Kydland and Prescott (1977), Barro and Gordon (1983) and, for theoretical overviews, Persson and Tabellini, 1990 and Cukierman, 1995). The subsequent positive and normative literature has, however, implicitly regarded the in°ation target as a constant with accompanied symmetric information. This is not an obvious or warranted assumption since the targets can be revised from time to time. The postulation of a constant target with non-biased information may be even less appropriate if the target represents an intermediate money growth or exchange rate targeting regime.[1]

In practical policy the in°ation target is sometimes set by the central bank alone and sometimes jointly with the government. The current paper allows the implemented in°ation target to be partly determined by governmental interference. The government's in°ation target follows a time-varying and stochastic process, which effectively relinquishes the typical but less realistic assumption of a time-invariant and commonly known policy target. The stochastic in°ation target imposes extra information asymmetries between agents. In particular, while being secret to the public as it forms expectations the contemporaneous target is observed by the monetary policymaker when setting in°ation. Because information about policy targets tends to be biased toward the policymaker away from the public this makes sense.

In°ation aversion is identi¯ed through the in°ation target level. An in°ation target-conservative (-liberal) government is characterized by a low (high) 'political' in°ation target level. Hence, a higher (lower) target is associated with lower (higher) in°ation aversion in the political sphere. Many governmental turnovers due to altered political majorities within the parliamentary session or in terms of a replacement of the Prime Minister or party in o±ce after a general election indicate a politically unstable situation. Variations in the in°ation target thus gauges time-varying political preferences concerning in°ation. Alesina and Roubini (1992), in accordance with the partisan theory, let the in°ation target be higher for left wing parties relative to right wing parties. Even though such an interpretation applies also to the present model its primary purpose is to model political variation per se.

The implemented in°ation target will be some combination of the explicit political target and the explicit, constant target of the central bank. To what extent the central bank's claimed target will prevail is determined by the susceptibility to continuous external instructions of the central bank, its instrument independence.[2] The preferences of the in°ation target-conservative (-liberal) government is mapped onto the central bank in accordance with the latter's instrument independence. A perfectly instrument independent central bank is isolated from political in°ation target directives, implements its own preferred target, and chooses autonomously the best way to achieve the ultimate objective. A less than fully instrument independent central bank, however, takes political directives. The identi¯cation of (instrument) independence, 'conservatism', and political instability via the assigned but stochastic explicit in°ation target is non-conventional, since these variables typically (inspired by Rogo®

[1] Despite that price stability may be a far cry from stable in°ation, the paper interprets the price stability goal as one of low and stable in°ation (cf. Svensson, 1996).

[2] Fischer (1995) decomposes central bank independence into goal and instrument independence. In the present paper the ultimate goal is decided by the government for a longer term with the eligible democratic in°uence making the bank fully goal dependent.

(1985)) have been identified through the relative weight on inflation stabilization.

The emphasis on the inflation target is relevant for at least three reasons. First, the approach is in consonance with observed implementations of quantitative inflation targets. Secondly, empirical cross-country evidence establishes that more independence and decreased political instability promote lower inflation and lower inflation variability (cf. Alesina and Summers, 1993, Cukierman, Edwards and Tabellini, 1992 and, for a survey, Cukierman, 1996). However, lower inflation (due to independence) is not associated with increased output variability. If anything, the opposite is observed (cf. Grilli et al., 1991 - 'almost like having a free lunch', Eijffinger and Schaling, 1993, Havrileski and Granato, 1993 and, in particular, Debelle and Fischer, 1995 and Fischer, 1995). The findings seem to refute the implication that lower inflation must come at the cost of increased output variability. By the identification of independence via the explicit inflation target instead of the relative weight put on inflation stabilization the inconsistency is eliminated.[3]

A third reason for modeling inflation targets is that it elucidates the evaluation of credibility of future monetary policy. With an explicit target a direct comparison with expected future inflation embodies the extent to which it is believed. Expected future inflation is embodied in the term structure of interest rates. Potential divergence between the endogenously generated nominal yield curve and the central bank's own claimed inflation target indicates future mistrust in the target. The paper examines how long run interest rate volatility relates to independence and political instability. Because of the generic inflation bias under discretion, a normative solution is considered with strategic delegation from the government to the central bank of an optimal inflation target, given a time-varying governmental inflation target with asymmetric information.

Existing empirical work on institutions and economic outcome shows a weak relation between independence and nominal interest rate volatility. Cukierman et al. (1993) find a negative relation between legal central bank independence and variance of real deposit interest rates, whereas the effect on the variability of nominal rates is insignificant. Cukierman and Webb (1995) show a positive relation between political vulnerability of the central bank and the variance of real interest rates. Taking into account the possibility that political instability also matters the paper contributes with new empirical evidence on nominal interest rates and institutions. The rest of the paper proceeds as follows: The model is presented in section 2 and equilibrium outcomes derived in section 3. Section 4 introduces the standard and forward yield curves, while section 5 tests some predictions on cross-country OECD data. Section 6 concludes. The appendix contains some algebra and recapitulates variable definitions and data sources.

[3] Alesina and Gatti (1995) model politically induced output variability satisfying the evidence.

2. The Model

2.1. A Time-Varying Inflation Target and Instrument Independence

The economy evolves over an infinite number of periods. The positive analysis assumes that in each period t the central bank is given mandate by society (the government) to conduct monetary policy according to an assigned loss function. The intertemporal, forward-looking objective function of the policymaker is

$$Z = E_0 \left[\sum_{t=1}^{\infty} \delta^{t-1} Z_t \right]; \qquad (2.1)$$

where δ is the subjective discount factor, and E_0 denotes conditional expectation at the beginning of the infinite game. In each period t; Z_t denotes the assigned and time-varying concave objective function defined over inflation and output according to

$$Z_t = \frac{1}{2} \left((\pi_t - \hat{\pi}_t)^2 + \lambda (y_t - \hat{y}_t)^2 \right); \qquad (2.2)$$

where $\pi_t \equiv \log[P_t / P_{t-1}]$, y_t is log output, and λ measures the relative weight placed on output versus inflation stabilization. It is conceivable to use output instead of employment in the utility function as long as output is a linear function of employment. The implemented explicit inflation target is denoted $\hat{\pi}_t$ and the implicit output target is denoted $\hat{y}_t$: I assume that $\hat{y}_t$ is a constant, $\hat{y}$; which exceeds the positive natural output level (for example due to labor market distortions). First-best equilibrium is thus not attainable. The underlying preferences of society (the government) can be stated as $\tilde{Z}_t = \frac{1}{2}((\pi_t - \tilde{\pi}_t)^2 + \lambda (y_t - \hat{y}_t)^2)$; who has a different inflation target but the same relative weight and output target.

The central bank is responsible for achieving the ultimate goal represented by the assigned objective function (2.2). As a means the central bank has an intermediate time-dependent inflation target which, however, is set by the government in each period and regularly laid upon the central bank which adopts the instruction in accordance with its degree of instrument independence.[4] A negative target innovation is interpreted as interference from an inflation target-conservative government regarding how monetary policy should be conducted to reach the ultimate goal. Thus, the inflation target specification captures an exogenous political business cycle effect on equilibrium policy, given a sufficiently dependent central bank.

To what extent governmental instructions translate into actual revisions of the implemented explicit inflation target is formalized through a linear mapping from the government to the central bank,

[4] In the Rome Treaty (Article 107) it is established that independence of the central bank crucially hinges on the prohibition to take instructions from its principal.

$$\begin{aligned} \hat{\pi}_t &= \psi \bar{\pi}_t + (1 - \psi)\pi^c_t \\ \pi^c_t &= 0 \end{aligned} \qquad \forall \psi \in [0; 1]: \tag{2.3}$$

Hence, the implemented inflation target is the weighted sum of the political target and the central bank's own claimed target, where the latter is constant and normalized to zero. The susceptibility of the central bank to governmental instructions is captured by the time-invariant parameter ψ: As ψ approaches unity the central bank is less instrument independent, whereas a low ψ indicates a high degree of independence.[5]

The government's aversion to inflation varies across time, motivating a time-varying and stochastic specification of the political inflation target. The explicit target of the government follows a mean reverting first-order autoregressive process with a permanent and a transitory term, which imposes asymmetric information between the policymaker and the public,

$$\bar{\pi}_t = \mu + \gamma \bar{\pi}_{t-1} + \eta_t. \tag{2.4}$$

In (2.4) where $\mu > 0$; $\gamma \in [0; 1)$ for stationarity, and η_t is i.i.d. with zero mean and variance σ^2_η. Because $E[\bar{\pi}_t] = E[\bar{\pi}_{t-k}]$ for any t and k; unconditional expectations are strictly positive. An inflation target-conservative (-liberal) government is characterized as more (less) inflation averse, having a lower (higher) average or period inflation target. High volatility in the target identifies marked political instability, and vice versa. The permanent term in (2.4) allows for a governmental inflation target innovation to persist over the political business cycle.

2.2. The Public

The public is characterized by the expectation-augmented Phillips-curve

$$y_{s;t} = \beta(\pi_t - \pi^e_t) + \omega_t; \ \beta > 0; \tag{2.5}$$

where only unanticipated inflation has real effects, and where ω_t denotes an i.i.d. supply shock in period t with zero mean and variance σ^2_ω: The public, while setting nominal wages, internalizes the policymaker's behavior and since it cares about real wages it sets wages according to expected inflation. By the assumption of rational expectations

$$\pi^e_t = E_{t-1}\pi_t; \tag{2.6}$$

where E_{t-1} denotes expectations as of period $t - 1$ conditional on all information available at that time, and π^e_t denotes subjective expectations hold by the public. The

[5] Notice that independence is an exogenous variable. Cukierman, Webb and Neyapti (1992) suggest endogenous central bank laws responding to inflation. However, that applies more likely to actual (not legal) independence such as the turnover rate of the central bank governor.

structural model is extended by an aggregate demand function (cf. Rogoff, 1985), which is decreasing in the one period ex ante real interest rate,

$$y_{d,t} = -\alpha(i_t - E_t\pi_{t+1}) + \epsilon_t; \quad \alpha > 0; \tag{2.7}$$

where ϵ_t is i.i.d. with zero mean and variance σ_ϵ^2. On the right hand side $i_t \equiv i_{t,t+1}$ $\forall t$ defines the one period (short term) nominal interest rate and $E_t\pi_{t+1}$ denotes the period t expected inflation rate between t and $t+1$.

Spot nominal interest rates with different times to maturity and forward interest rates with various forecast horizons embody expectations of the public about future monetary policy and future expected inflation. Thus, the introduction of the term structure of interest rates exhibits whether and to what extent the inflation target is expected to be honored. The standard yield curve displays bond yields to maturity contingent on time to maturity and displays time averages of expected future short term interest rates. The forward yield curve expresses expected future short term interest rates at a specific date discarding what has happened up to that point in time. Taking the time averages of the $T-t$ expected one-period spot interest rates constitutes the standard yield curve for zero-coupon bonds which is a representation of the expectations hypothesis,

$$i_{t,T} = \frac{1}{T-t}\sum_{j=t}^{T-1} E_t i_{j,j+1} + \xi_{t,T}; \tag{2.8}$$

where $i_{t,T}$ denotes the $T-t$ term spot interest rate and $\xi_{t,T}$ a term premium for holding a long bond.

The implied forward interest rate on a forward contract can be defined by

$$f_{t,t',T} \equiv \left[\frac{(1+i_{t,T})^{T-t}}{(1+i_{t,t'})^{t'-t}}\right]^{\frac{1}{T-t'}} - 1 \quad \forall t < t' < T; \tag{2.9}$$

where t; t'; and T denote trade date, settlement date, and maturity date, respectively.[6] On the right hand side, $i_{t,T}$ denotes the spot rate that carries interest between period t and T; and $i_{t,t'}$ the spot rate that carries interest between t and t'. Hence, to sell (in blanco) at time t a bond that carries interest $i_{t,t'}$ until t' and buy immediately at time t a bond with interest $i_{t,T}$ which matures in $T > t'$; is on an arbitrage-free market identically equal to a period t purchase of a forward contract which is payed for in t' and carries interest between t' and T: The forward interest rate can thus be viewed as the public's predicted future spot interest rate.

[6] Schiller (1990) describes in detail the term structure of interest rates and various term premia, while Svensson (1994) shows how forward and standard yield curves can be used for monetary policy purposes.

The non-arbitrage condition (2.9) implies that any forward contract can be financed by a spot contract at the settlement date. The difference between the certain forward interest rate and the uncertain spot rate at time t' is the expected excess return on such a transaction, which constitutes the nominal forward term premium $\xi_{t;t';T} \equiv f_{t;t';T} - E_t i_{t';T}$ with forecast horizon $t' - t$. In particular, for any forecast horizon τ; it follows that the forward term premium is defined by

$$\xi_{t;t+\tau;t+\tau+1} \equiv f_{t;t+\tau;t+\tau+1} - E_t i_{t+\tau;t+\tau+1} \;\forall \tau \geq 0; \tag{2.10}$$

where $f_{t;t+\tau;t+\tau+1}$ denotes the forward interest rate traded in period t; settled in period $t+\tau$; and maturing one period after settlement. Henceforth it is assumed that investors are risk neutral. With zero expected excess return on a forward contract, the forward rate exactly gauges the period t expected future spot rate. The $T - t$ term spot interest rate in (2.8) can accordingly be computed directly from observed forward interest rates.

3. Equilibrium

3.1. Commitment

Precommitment to a state-contingent optimal rule is hard to enforce and probably infeasible in real life. Still the solution is considered here as a benchmark, serving as an informative reference point. The economy evolves over an infinite number of periods and within each period the timing under commitment is displayed in Figure 3.1. Assume that the policymaker first credibly announces a state contingent strategy for inflation. The public sets nominal wages contingent on the strategy and on period $t - 1$ information but ignorant of the innovations $\nu'_t = (\eta_t \; \omega_t \; \varepsilon_t)$. Finally, the policymaker sets inflation. The inflation target is thus subject to asymmetric information.

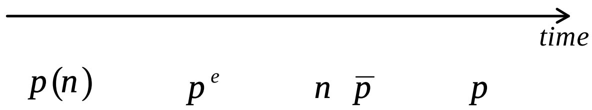

Figure 3.1. Timing of events under commitment.

The ex ante commitment implies that the central bank internalizes into its optimization problem the effects of the decision rule on the public's expectations. Following Persson and Tabellini (1994), the policymaker optimizes directly over inflation and expected inflation, where inflation may depend on current innovations but expected inflation depends only on lagged innovations (lagged state variable). In the subgame perfect equilibrium the policymaker moves first and can control the public's expectations subject to the constraint that these expectations are rational.

The dynamic inflation target level implies potential intertemporal links between inflation and the target. The optimal rule under commitment is thus obtained by considering the forward-looking objective function (2.1), given the inherited inflation target. The infinite sum of expected loss functions is equivalently stated as a Bellman equation with the discounted value function $Z(\bar{\pi}_t)$ entering the decision problem, which means that potential effects from the contemporaneous target on future optimal inflation is internalized (cf. Lockwood et al., 1995).

The optimal rule is then the solution to the problem

$$Z(\bar{\pi}_{t-1}) = \min_{\{\pi_t, \pi_t^e\}} E_{t-1}\left\{\frac{1}{2}\left[(\pi_t - \psi\bar{\pi}_t)^2 + \lambda(y_t - y^*)^2\right] + \delta Z(\bar{\pi}_t)\right\} \tag{3.1}$$

subject to (2.4)-(2.5), and rational expectations in (2.6). The Lagrangean is

$$E_{t-1}\left\{\frac{1}{2}\left[(\pi_t - \psi\bar{\pi}_t)^2 + \lambda(y_t - y^*)^2\right] + \delta Z(\bar{\pi}_t) - \mu_{t-1}(\pi_t^e - \pi_t)\right\}. \tag{3.2}$$

The first-order conditions with respect to π_t, when expectations are taken as fixed, and π_t^e become

$$(\pi_t - \psi\bar{\pi}_t) + \beta\lambda(\beta(\pi_t - \pi_t^e) + \omega_t - y^*) + \mu_{t-1} = 0 \tag{3.3}$$

$$-E_{t-1}[\beta\lambda(\beta(\pi_t - \pi_t^e) + \omega_t - y^*) + \mu_{t-1}] = 0 \tag{3.4}$$

where μ_{t-1} is the Lagrange multiplier associated with the rational expectations constraint. In (3.3) the marginal current cost of increase in inflation plus the marginal current cost from increase in output must be equal to the marginal cost of expected inflation in (3.4). Eliminating μ_{t-1} and taking conditional expectations at $t-1$ with (2.6) yields

$$E_{t-1}\pi_t = \psi(\bar{\mu} + \gamma\bar{\pi}_{t-1}). \tag{3.5}$$

Inserting (3.5) into the first-order conditions yields the ex ante optimal decision rule for inflation where nominal wages are optimal for the public given the policy rule, and the rule is optimal for the policymaker given the behavior of the public,

$$\pi_t = \psi(\bar{\mu} + \gamma\bar{\pi}_{t-1}) + \frac{1}{1+\beta^2\lambda}(\psi\eta_t - \beta\lambda\omega_t). \tag{3.6}$$

An inflation target-conservative government generates lower inflation in the current and the subsequent period, given imperfect instrument independence. Because the public is ignorant about the contemporaneous inflation target, a persistent effect on optimal inflation emerges. Output obeys

$$y_t = \frac{1}{1+\beta^2\lambda}(\beta\psi\eta_t + \omega_t); \tag{3.7}$$

where (2.5), (3.5), and (3.6) are used. If, in contrast, the current target would be common knowledge any persistence is ruled out. Optimal inflation is then fully affected by the period t target.

(3.6) encompasses both predetermined and unexpected inflation. The former depends on lagged innovations and may not stabilize shocks to the economy whereas the latter may. A negative (positive) realization of the supply shock lowers (raises) output and is optimally stabilized by the policymaker through unanticipated inflation (deflation). It is always best for the bank to fully offset the effects on inflation and output from a demand shock. The intuition is that a demand shock (unlike a supply ditto) proportionally affects both inflation and output. Long run average inflation becomes

$$E[\pi_t] = \psi\gamma\frac{1}{1-\gamma}\bar{\pi}; \tag{3.8}$$

which is decreasing in independence ψ, increasing in 'conservatism' $\bar{\pi}$; and increasing in persistence γ: Average output, though, does not depend on independence, whereas inflation and output variability decrease in independence. Hence, the implication is that lower inflation (and inflation variability) has no real adverse effects.

The short term nominal interest rate becomes $i_t = E_t\pi_{t+1} - \frac{\beta}{\alpha}(\pi_t - E_{t-1}\pi_t) + \frac{1}{\alpha}(\epsilon_t + \omega_t)$; via (2.6), (2.5) and (2.7). Rational expectations imply that the optimal decision rule in (3.6) is indeed expected by the public, and that the rule is the same for all periods. Substituting for the expectation terms by using (3.5) and its one period lead yields a solution in terms of predetermined variables. The implied equilibrium short term interest rate consistent with the optimal decision rule for inflation is

$$i_t = (1+\gamma)\psi\bar{\pi} + \psi\gamma^2\hat{\pi}_{t-1} + k o_t; \tag{3.9}$$

where $o_t' = [\,\eta_t \;\; \omega_t \;\; \epsilon_t\,]$; $k = [\,k_1 \;\; k_2 \;\; k_3\,] = [\,\psi(\gamma - \frac{\beta}{\alpha(1+\beta^2\lambda)}) \;\; \frac{1+2\beta^2\lambda}{\alpha(1+\beta^2\lambda)} \;\; \frac{1}{\alpha}\,]$ denote the composite shock and the associated policy vector. A negative supply shock lowers output and is therefore stabilized through an unanticipated decrease in the endogenous short term interest rate. The coefficient $\frac{1}{\alpha}$ fully offsets demand shock effects on output. Supply and demand shocks are just transitory, whereas a governmental change of the inflation target may have a permanent effect on the interest rate.

Because the optimization problem is linear-quadratic the indirect utility function $Z(\hat{\pi}_{t-1})$ must be quadratic and consequently we can write the discounted present value of expected future losses conditioned on the state variable $\bar{\pi}_{t-1}$ as

$$Z(\bar{\pi}_{t-1}) = \theta_0 + \theta_1\bar{\pi}_{t-1} + \frac{1}{2}\theta_2\bar{\pi}_{t-1}^2; \qquad (3.10)$$

where θ_i, $i = 0; 1; 2$ are unknown coefficients to be determined. The optimal discounted value of the central bank will be decreasing in independence and increasing in political instability. With perfect instrument independence political instability is fully removed and the optimal loss minimized. The optimal value of (2.1) of society will depend on independence such that the intertemporal discounted loss is minimized when $\chi = 1$; that is, with no independence (cf. Appendix A.1).

3.2. Discretion

It is a general view that discretion with an 'unconstrained' policymaker prevails in reality. I therefore consider a more realistic, yet highly stylized context without precommitment technology. The timing is given in Figure 3.2 where the public sets nominal wages without knowing the inflation target or any other innovation.

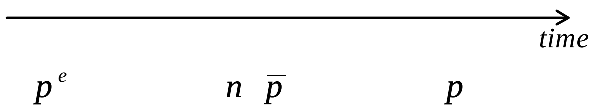

Figure 3.2. Timing of events under discretion.

The central bank solves the problem

$$Z(\bar{\pi}_{t-1}) = E_{t-1}\left\{\min_{\{\pi_t\}} \frac{1}{2}\left[(\pi_t - \chi\bar{\pi}_t)^2 + \lambda(y_t - y^*)^2\right] + \delta Z(\bar{\pi}_t)\right\}; \qquad (3.11)$$

subject to (2.5), (2.4) and (2.3), given expected inflation π_t^e: That is, inflation is set after the innovations have been realized and observed. Taking the first-order condition yields

$$(\pi_t - \chi\gamma\bar{\pi}_{t-1} - \chi\eta_t) + \beta\lambda(\beta(\pi_t - \pi_t^e) + \omega_t - y^*) = 0; \qquad (3.12)$$

where the cost of increased inflation expectations does not enter. The expectation at $t - 1$ of equation (3.12) is

$$E_{t-1}\pi_t - \beta\lambda y^* - \chi\gamma\bar{\pi}_{t-1} = 0 \qquad (3.13)$$

where equation (2.6) is used. Substituting equation (3.13) into (3.12) when expectations are formed rationally yields the ex post optimal decision rule for inflation according to

$$\pi_t = \beta\lambda\hat{y} + \chi(\bar{\imath} + \gamma\pi_{t-1}) + \frac{1}{1+\beta^2\lambda}(\chi\eta_t - \beta\lambda\omega_t)\,; \tag{3.14}$$

whereas equilibrium output is the same as under commitment. In this Nash equilibrium nominal wages are a best reply to the decision rule, and the decision rule is a best reply to nominal wages, irrespective of the realized shocks.

The variance of inflation and output, and average output remain second-best, while average inflation exceeds the commitment outcome with the constant and positive inflation bias. The inflation bias arises because of the binding incentive compatibility constraint, given too diligent an output target. While the policymaker acts ex post to expectations, the policy rule must be such that there exist no incentives to deviate, and the marginal loss of higher inflation is truly balanced in equilibrium by a marginal gain of higher output. The central bank thus aims at first-best optimum, performs worse than under commitment where the policymaker controls expectations via its rule, and is stuck in a third-best equilibrium. The short term interest rate exceeds (3.9) with the inflation bias. A social welfare comparison shows that discretion is Pareto-deficient to commitment where the difference in optimal discounted losses is

$$\frac{1}{2(1-\delta)}(\beta\lambda\hat{y})^2; \tag{3.15}$$

which thus is unaffected by political instability and central bank independence.

3.3. Strategic Delegation of a Time-Invariant Inflation Target

Despite the infeasibility of precommitment to a fully state-contingent rule, the inflation bias under discretion can be mitigated through a proper design of the central bank's objective. This can remove the discrepancy between optimal inflation ex ante (before expected inflation is formed) and optimal inflation ex post.[7] Such a normative result

[7] Cf. Rogoff, 1985 (conservative central bank), Lohmann, 1992 (escape clauses), Persson and Tabellini, 1994 and Walsh, 1995 (linear inflation contract), and Svensson, 1997 (explicit optimal inflation target) for the most influential contributions in this strand of literature. The first two normative suggestions can achieve equilibria better than under discretion but worse than under commitment, whereas the latter two can yield exactly the precommitment solution.

McCallum (1995) considers the inflationary bias to be a fallacy. Even in absence of commitments it is not necessary, he argues, that a central bank behaves in a way that creates an inflation bias. However, without access to a commitment technology this would not be an equilibrium, given the maintained assumption of a distorted labor market. If there is a reputation mechanism at work affecting central bank behavior, it is not clear why the optimal outcome would be the unique equilibrium unless the private sector's trigger strategies are somehow coordinated. A second argument is that instead of removing the inflation bias, strategic delegation relocates the incentive to renege is suggested in this section via a strategic delegation of monetary policy in terms of the explicit time-varying inflation target (λ and $\hat{y}$ remain unaltered) from the government to the, subsequently, fully instrument independent central bank. The delegation is characterized by two constituent bodies and implemented in two steps.

First, the optimal inflation target is determined through a governmental strategic assignment of a modified period loss function to the central bank, where $\bar{\pi}_t$ is replaced by the strategically delegated target $\bar{\pi}_t^*$; which conceivably differs from the one preferred by society. Hence, in the first step the optimization problem is solved subject to the relevant constraints which yields $\pi_t = \beta\lambda\hat{y} + \frac{1}{1+\beta^2\lambda}(\beta^2\lambda\chi\bar{\pi}_{-1} + \chi\bar{\pi}_t^* + \beta^2\lambda\chi\gamma\bar{\pi}_{t-1}^* - \beta\lambda\omega_t)$. By letting the delegation occur in the outset of the game - beginning of period $t = 1$ - it can be shown that the optimal inflation target must fulfill

$$\bar{\pi}^* = \bar{\pi}_0 - \frac{\beta\lambda\hat{y}}{\gamma} \quad \forall\gamma \in (0;1) \tag{3.16}$$

under the assumption that the expected target innovation in period 1 is zero when the delegation is made, and where $\bar{\pi}_0$ is the exogenously fixed inflation target in period 0: By strategically selecting a sufficiently low, constant inflation target the second-best equilibrium is achieved and the inflation bias made void.

Secondly, a monetary reform is carried out so as to warrant the appropriate legislative support. This reform should be associated with a constitutional arrangement which makes it too costly for the government to renege. The monetary constitutional reform, sanctioned in the parliament, essentially makes the central bank fully instrument independent from external instructions for all future periods,

$$\chi = 0; \tag{3.17}$$

which consequently disqualifies the 'automatic' generation of the implemented inflation target in (2.3). The governmental inflation target still evolves according to (2.4), though.[8] A per-period renegotiation on the optimal inflation target is prevented since the target turns out to be time-invariant. Accordingly the strategic delegation does not reoccur in subsequent periods of the infinite game.[9] Because of the monetary reform the delegation is supposed to have sufficient legislative support eliminating ex post incentives to renege.

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from the central bank to the government. In the present model this objection is explicitly taken into account.

[8] In the context of strategic delegation of optimal inflation targets it would be interesting to examine the optimal term of office of the central bank governor, given a time-varying inflation target.

[9] A time-dependent counterpart to (3.16) is given by $\bar{\pi}_t^* = \bar{\pi}_t - \frac{\beta\lambda\hat{y}}{\gamma}$; which thus takes the form of a yearly assignment to the central bank to follow a 'simple' rule, which is not fully state-contingent but merely a function of the actual time-varying target and the constant inflation bias. Such a delegation rule is not immune to renegotiations as the 'once and for all-delegation' in (3.16), though, but optimal in each period.

4. Institutions and Expected Future Monetary Policy

4.1. The Forward Yield Curve

The endogenous forward yield curve embodies the public's expected future inflation. Because it reveals to what extent the claimed constant target of the central bank is believed (given no strategic delegation) it indicates how credible future monetary policy is. The state-dependent forward interest rate under discretion is obtained by substituting the short term interest rate into definition (2.10) for some arbitrary forecast horizon τ,

$$f_{t,t+\tau} = \beta\lambda\hat{y} + \sum_{j=0}^{\tau} \gamma^j \psi\bar{\pi} + \psi\gamma^{\tau+1}\pi_t;\ \ \forall\tau > 0; \quad (4.1)$$

where the instantaneous forward rate $f_{t,t}$ is suppressed and $f_{t,t+\tau} \equiv f_{t,t+\tau,t+\tau+1}$. Changes in the actual central bank inflation target is interpreted as exogenous instructions to conduct a more or less expansionary monetary policy.[10] The time path of the forward yield curve can according to (4.1) be delineated as in Figure 4.1.

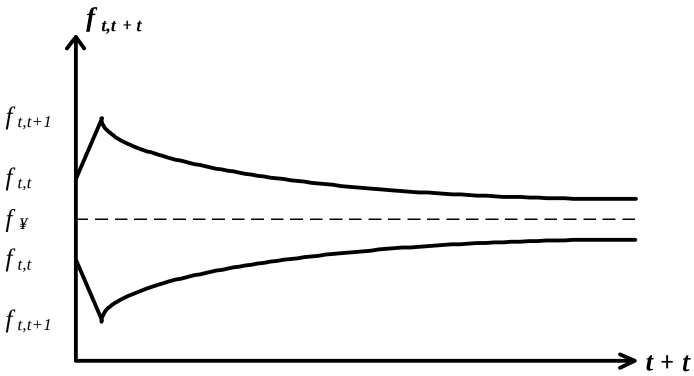

Figure 4.1. The forward yield curve in period t.

The upper curve constitutes the implied forward yield curve with trade date t plotted against $t + \tau$; given $\pi_t > \frac{1}{1-\gamma}\bar{\pi}$. The instantaneous forward rate is hit by a positive composite shock $k\nu_t$. The curve declines geometrically from $f_{t,t+1} = \beta\lambda\hat{y} + (1+\gamma)\psi\bar{\pi} + \psi\gamma^2\pi_t$ toward its long run asymptote $\lim_{\tau\to\infty} f_{t,t+\tau} \equiv f_\infty = \beta\lambda\hat{y} + \frac{1}{1-\gamma}\psi\bar{\pi}$: The vertical distance between the displayed period t forward yield curve and some

[10] Discretion imposes a binding 'credibility constraint' on the policymaker. The inflation bias emerges under discretion because optimal inflation ex ante is not credible ex post. The credibility problem also gives rise to excessively high inflation expectations and therefore a wedge between the explicit inflation target and the yield curve, that is, the announced inflation target is not expected to be honored.

imaginary (not displayed) period $t+s$ curve would for any forecast horizon $\tau > s$ measure the change in inflation expectations between period t and $t+s$.[11]

Proposition 4.1. [i] An inflation target-conservative (-liberal) government implies, for any forecast horizon, lower (higher) forward interest rates, given an imperfectly independent central bank. [ii] The long run value of the forward rate is decreasing in independence and conservatism of the government. [iii] The forward yield curve, geometrically and monotonically approaching its asymptote, slopes down(up)wards when the target is positive (negative). [iv] Past target innovations persist infinitely at a continuously declining rate. [v] Less instrument independence and increased political instability promote mistrust in the central bank's claimed zero inflation target. [vi] Forward rate volatility is increasing in inflation target persistence.

Proof. [i] The result follows from (4.1) if and only if $\psi > 0$. With ψ equal to zero, the term structure is represented by a trivial horizontal forward yield curve since $f_{t,t+\tau+1} = f_{t,t+\tau}\ \forall\tau$. [ii] The statements are proved by taking the partial derivatives of $\lim_{\tau\to\infty} f_{t,t+\tau}$ w.r.t. ψ and Π. [iii] The slope of the forward yield curve in period t becomes

$$f_{t,t+\tau+1} - f_{t,t+\tau} = \gamma^{\tau+1}\psi\Pi + \psi\gamma^{\tau+1}(\gamma-1)\bar{\pi}_t \lessgtr 0 \text{ if } \bar{\pi}_t \gtrless 0, \quad \tau \geq 1.$$

[iv] The forward interest rate can be rewritten as $f_{t,t+\tau} = \bar{\lambda}\hat{y} + \sum_{s=0}^{\infty}\psi\gamma^{s+\tau+1}\eta_{t-s}$ for each $\tau \geq 1$, where the second term conveys that all past realizations decreasingly matter. [v] The unconditional variance of the forward yield curve becomes

$$\mathrm{Var}[f_{t,t+\tau}] = \gamma^{2(\tau+1)}\psi^2\frac{1}{1-\gamma^2}\sigma_\eta^2$$

where the partial derivatives verify the statement. [vi] $\frac{\partial \mathrm{Var}[f_{t,t+\tau}]}{\partial\gamma} > 0$ if $\psi > 0$. ∎

4.2. The Standard Yield Curve

Whereas the forward interest rate conveys information for some variable at a specific future point in time, the spot interest rate measures the time average of a variable between the trade date and the maturity date. The long, $T-t$ term spot interest rate is obtained by substituting (4.1) into (2.10) and (2.8) for $\tau = 0, 1, \ldots, T-t-1$, assuming zero expected excess return on a forward contract. Its one period lead is

$$i_{t+1,T} = \bar{\lambda}\hat{y} + \frac{1}{T-t-1}\left(K\psi\Pi + \frac{1}{1-\gamma}\gamma^2(1-\gamma^{T-t-2})\psi\bar{\pi}_t + h\nu_{t+1}\right), \qquad (4.2)$$

[11] If the forward yield curve with trade date $t+4$, say, lies above the period t curve in future period $t+6$, the vertical distance $f_{t+4,t+6} - f_{t,t+6} = \psi\gamma^3\sum_{s=0}^{3}\gamma^s\eta_{t+4-s} > 0$ expresses the increase between t and $t+4$ in expected $t+6$ inflation. However, as γ approaches zero this difference becomes negligible. If $\bar{\pi}_t < \frac{1}{1-\gamma}\Pi$ the lower curve applies.

with $h = [\, h_1 \;\; h_2 \;\; h_3 \,] = [\, \psi(\frac{1}{1-\gamma}\gamma(1-\gamma^{T-t-2}) - \frac{\beta}{\alpha(1+\beta^2\lambda)}) \;\; \frac{1+2\beta^2\lambda}{\alpha(1+\beta^2\lambda)} \;\; \frac{1}{\alpha} \,]$ and $K > 0$ (intermediate steps in Appendix A.2). The endogenous standard yield curve intuitively responds to changes in the political inflation target, whose impact is decreasing in the forecast horizon. Moreover, interest rates can be permanently lowered when switching from an inflation target-liberal to an inflation target-conservative regime if the central bank is sufficiently dependent and γ is not too small.

The standard yield curve geometrically decreases in time to maturity, given that the target does not follow a random walk. In Figure 4.1 the yield curve would run parallel with and lie outside the forward yield curve, approaching their common horizontal asymptote over the forecast horizon. By repeated substitution it is clear that the $T-t$ term interest rate is increasing in past inflation target innovations although at a continuously declining magnitude. The declining effect follows because when T grows, inverted time to maturity in (4.2) decreases faster than the second term within parenthesis increases.

Long run (average) credibility of the central bank inflation target is consequently embodied in the wedge between average long term nominal interest rate and the zero target. The unconditional expectation of the wedge is

$$E[i_{t+1;T}] = \beta\lambda\hat{y} + \frac{1}{T-t-1}\left(K + \psi\gamma^2\frac{1-\gamma^{T-t-2}}{(1-\gamma)^2}\psi^{-1}\right) > 0 \qquad (4.3)$$

which is decreasing in independence and increasing in conservatism of the government. Moreover, volatility in the yield curve indicates lack of credibility with respect to future monetary policy. Any inconsistency between future nominal interest rates and the central bank target genuinely constitutes lack of credibility. The conditional variance in the long term interest rate (expected future variability) and its unconditional counterpart are given by

$$Var_t[i_{t+1;T}] = \frac{1}{(T-t-1)^2}\left(h_1^2\sigma_\eta^2 + h_2^2\sigma_\omega^2 + h_3^2\sigma_\varepsilon^2\right); \text{ and} \qquad (4.4)$$

$$Var[i_{t+1;T}] = \frac{1}{(T-t-1)^2}\left(\left(\hbar + h_1^2\right)\sigma_\eta^2 + h_2^2\sigma_\omega^2 + h_3^2\sigma_\varepsilon^2\right): \qquad (4.5)$$

with $\hbar = \frac{1}{1-\gamma^2}\left(\frac{\psi\gamma^2}{1-\gamma}(1-\gamma^{T-t-2})\right)^2$: I use the identifying assumption that the innovations are orthogonal to each other, $E[\eta_t\eta_s] = E[\eta_t\omega_t] = E[\eta_t\varepsilon_t] = E[\varepsilon_t\omega_t] = 0 \; \forall t \neq s$ (details in Appendix A.3). While depending on time to maturity, the variance is indeed time-invariant such that no 'volatility bias' arises. Moreover, an appropriate institutional structure facilitates monetary policy without affecting inflation expectations. Low long versus short term interest rate volatility characterizes high credibility with respect to monetary policy. Conversely, low short rate volatility combined with a persistently high long rate volatility indicates lack of credibility. Relative volatility in nominal interest rates, defined in the model as the (A.9) to (4.5) ratio, is clearly influenced by institutional factors.

Proposition 4.2. [i] Interest rate variability is non-decreasing in political instability, given less than full central bank independence. [ii] Interest rate variability is non-increasing in independence. [iii] The marginal effect from less independence on interest rate volatility is higher with more political instability. Imperfect independence is a necessary but not sufficient condition for conspicuous interest rate variability. With a fully firm inflation target independence becomes irrelevant. [iv] Interest rate volatility is, at least for some parameter values, intuitively increasing in persistence of the inflation target. In contrast, with symmetric information about the target, volatility would be unambiguously increasing in persistence. [v] Relative volatility in interest rates is increasing in central bank independence. That is, less independence intuitively raises long rates more than short rates. [vi] Relative volatility in interest rates is decreasing in political instability. That is, increased political instability raises long rates more than short rates.

Proof. [i] The statement applies since the partial derivative of (4.5) w.r.t. σ_η^2 is positive for all $\psi \geq 0$ and $\gamma \in [0, 1)$: [ii] The derivative w.r.t. ψ is non-negative for all $\gamma \in [0, 1)$. [iii] The cross-derivative w.r.t. ψ and σ_η^2 is positive. [iv] For large (small) values on γ (4.5) increases (decreases) from more persistence. Specifically,

$$\lim_{\substack{T-t-1 \gg 0 \\ \gamma \to 1}} \frac{\partial h_1^2}{\partial \gamma} > 0; \lim_{\substack{T-t-1 > 0 \\ \gamma \in (0,1)}} \frac{\partial h_1^2}{\partial \gamma} < 0.$$

[v] Relative volatility is

$$\frac{V[i_{t+1}]}{V[i_{t+1,T}]} = \frac{1}{(T-t-1)^{-2}} \frac{(\breve{k} + k_1^2)\sigma_\eta^2 + k_2^2\sigma_\omega^2 + k_3^2\sigma_\varepsilon^2}{(\breve{h} + h_1^2)\sigma_\eta^2 + k_2^2\sigma_\omega^2 + k_3^2\sigma_\varepsilon^2}$$

where

$$\frac{\partial}{\partial \psi} = \frac{\left[(\breve{k} + k_1^2) - (\breve{h} + h_1^2)\right] 2\sigma_\eta^2(k_2^2\sigma_\omega^2 + k_3^2\sigma_\varepsilon^2)}{(T-t-1)^{-2}\psi\left((\breve{h} + h_1^2)\sigma_\eta^2 + k_2^2\sigma_\omega^2 + k_3^2\sigma_\varepsilon^2\right)^2}$$

where $\operatorname{sgn}\left[\frac{\partial}{\partial \psi}\right] = \operatorname{sgn}\left[(\breve{k} + k_1^2) - (\breve{h} + h_1^2)\right] < 0$ since $\frac{1}{1-\gamma}(1 - \gamma^{T-t-2}) > 1$ when $T > t$ and $\gamma < 1$: [vi] Similar to proof of [v]. ∎

5. Empirical Evidence

In this section the predictions in Proposition 4.2 are confronted with data for a subset of OECD countries over a period ranging from the early 1960s to 1989. The empirical association between interest rate variability and economic-political institutions in terms of political instability and central bank independence is examined. Taking the model literally the time-invariant key regression equation becomes

$$Y_j = \rho_0 + \rho_1 X_j + e_j \tag{5.1}$$

where $Y_j = \mathrm{Var}[i_{t+1;T}]_j$ is long term interest rate volatility for country j, and $X_j = (\psi^2 \sigma_\varepsilon^2)_j$ is the interaction between squared independence and political instability for country j. The country specific residual is defined by unobservable variables, $e_j \equiv \left(\frac{k_2^2\sigma_\omega^2 + k_3^2\sigma_{\varepsilon 2}^2}{(T-t-1)^2}\right)_j$. The residual is inherently orthogonal to the regressors, since the disturbance terms within the model are independently distributed. The coefficient ρ_1 represents the coefficient associated with the interaction term, whilst the constant ρ_0 expresses the mean of the unobservable terms across countries and is given by $\frac{1}{N}\sum_{j=1}^{N}\left(\frac{k_2^2\sigma_\omega^2 + k_3^2\sigma_{\varepsilon 2}^2}{(T-t-1)^2}\right)_j$. Consequently, the model implies that the constant is non-negative as well as decreasing in time to maturity. Some supplementary specifications are tested since they meet the basic idea of the paper, coincide with minor modifications of the model (cf. Mellin, 1997), and relate to similar empirical work neglecting potential impact from political instability.[12]

5.1. The Data and The Assessments of Regressors

The country sample and the period examined are restricted by the availability of monthly data on short and long term interest rate data (cf. Appendix A.5). The empirical analysis encompasses only industrial countries, since interest rate data in developing countries is poorer and less trustworthy. Furthermore (but non-binding), only democracies within the industrial countries are examined, such that the political instability proxy makes sense. The variance of the long and short term interest rates is based on monthly observations on nominal interest rate series with three months to maturity (treasury bills) and five years to maturity and beyond (bonds), respectively. While the frequency is months (not quarters or years) the variance presumably contains more relevant information. The main source for bond yields and treasury bills are the Bank of International Settlements (cf. Appendix A.4).

The countries considered are ranked with respect to their legal central bank independence index CBI, provided in Cukierman, Webb and Neyapti (1992). The independence proxy is coded using information about (i) the appointment, the term of office, and the dismissal of the governor, (ii) the policy formulation procedure: who formulates monetary policy and the extent to which the central bank takes governmental instructions, (iii) the implementation of the price stability goal, and (iv) limitations

[12] During the sample period many countries have merely had implicit inflation targets and instead explicit exchange rate targets. Therefore variability in nominal interest rates may at times partly account for devaluation expectations rather than doubts concerning the achievement of an explicit inflation target.

on lending. Their actual CBI-index based on the turnover rate of the central bank governor TOR is also considered.

In the model the degree of political instability too drives the results. Three admittedly rough assessments of political instability based on raw data in Lane et al. (1991) are constructed. The ¯rst proxy PPCH gauges transitions in the political process where a governmental turnover results in a new party and Prime Minister entering o±ce. Secondly, PCH counts the number of governmental shifts where the incumbent Prime Minister is replaced although the same party may remain in power. Thirdly, the number of governmental shifts regardless the election outcome GCH is used, which thus captures changes in the cabinet irrespective of whether the Prime minister leaves o±ce or not. Each measure of governmental change constitutes a ratio de¯ned by the relevant number of transitions to the number of years in the sample period. The interaction term is captured by a product-dummy variable.

Cukierman and Webb (1995) create an index for political vulnerability of the central bank PVU, which represents an extension of the actual turnover rate and is de¯ned as the fraction of political transitions followed within six months by a replacement of the central bank governor. PVU assesses a very speci¯c type of instability, namely governmental turnovers together with turnover of the central bank governor. However, the subservience of the central bank may be in°uenced by political turbulence in other ways. For example, via the price stability goal or the policy formulation procedure, without the drastic dismissal of the governor. To be precise, the content of the model is rather that political instability per se together with a broader measure of independence a®ect economic outcome. In the regressions the main focus is therefore on legal independence and the political instability proxy.

The institutional variables are considered as exogenous variables because of the long term characterization of independence and political instability. For example, changes in legal independence manifestly occurs quite seldom (cf. Cukierman, Webb and Neyapti). Consequently the sample periods are fairly long being determined by the indexation of legal independence. Pooled regressions group the cross-country data in sub-periods which possibly better seizes the information of institutional changes that have occurred over time, as well as it entails additional degrees of freedom in the cross-country regressions. To control for potentially country speci¯c variables which are not explicitly taken into account in the regression equations, I complement by allowing for country speci¯c ¯xed e®ects. Unreported yearly pooled cross-section and time-series regressions use up to three binary proxies for each measure of political instability.

5.2. The Results

By testing the predicted association between nominal interest rate volatility and central bank independence together with political instability in a cross-country perspective the paper contributes with new results for the industrial countries. In the empirical literature on institutions and economic outcome there is (to my knowledge) only one attempt to uncover institutional e®ects on nominal interest rates. Using CBI and TOR as regressors (separately and simultaneously), Cukierman et al. (1993) run cross-section regressions over the period 1978 to 1989 for industrial and developing countries. CBI is insigni¯cant whilst TOR signi¯cantly a®ects bond yield volatility in the expected way.[13] The present model, however, suggests that the natural regression equation comprises the interaction between squared legal independence and the assessment for political instability. The Lagrange multiplier test (LM test) introduced by Breuch and Pagan (1980) frequently rejects the null hypothesis of no contemporaneous cross-country correlation (a diagonal covariance matrix) in the regressions. The LM test furthermore rejects the homoscedasticity hypothesis across countries. To avoid ine±ciency of point estimates and biasedness of the estimated covariance matrix, the results are based on an asymptotically appropriate estimator of the covariance matrix adjusted for both heteroscedasticity and cross-sectional correlation (cf. White, 1980 and Greene, 1993).

In Tables A.1-A.3 the regression results of bond yield variability on the relevant variables between 1966-89 including 17 countries are displayed. In each table, column [1] corresponds to the key regression equation (5.1) whereas [3] and [4] by steps add GCH and CBI^2. Column [2] reports the separate e®ects from GCH and CBI^2, respectively. The interacting e®ect between independence and political instability enters signi¯cantly with the predicted negative sign in speci¯cation [1], Table A.1. The interpretation is that bond yield volatility increases more from less independence in countries with more political instability than in countries with less political instability (here seized by governmental shifts regardless of electorate outcome). The null hypothesis of no association is clearly rejected. In accordance with the model the constant too enters signi¯cantly with the correct positive sign. Column [3] adds GCH which enters signi¯cantly with the predicted positive sign. At the same time the interaction proxy remains signi¯cant. When CBI^2 is added too it enters signi¯cantly, whilst the e®ects from the former two variables dissipate. Discarding the interacting variable, CBI^2 and GCH come in signi¯cantly with the right signs. The overall ¯t is 17 percent in the main regression and in the alternative speci¯cations it lies in the interval between 40 and 44 percent.

Tables A.2 and A.3 report pooled regressions. The encouraging results prevail. The impact from the interaction term is even more tangible, being signi¯cant at the 1 percent level. The alternative speci¯cations show about the same results as previously. However, the overall ¯t is generally lower. One explanation is that with shorter sub-

[13] The association between independence and real interest rate variability is tested in Alesina and Summers (1993), Cukierman et al. (1993) and Cukierman and Webb (1995), who all ¯nd a negative but not always signi¯cant relationship.

periods the di®erence in long term interest rate volatility across countries probably dilutes somewhat. Country speci¯c dummy variables intend to capture non-modelled within country variations like, for example, an asymmetric mean reversion parameter of the in°ation target. The ¯xed e®ect model enhances the overall ¯t at the same time as many of the variables come in insigni¯cantly (yet with the predicted signs). This may indicate that some of the parameters in the model are indeed country speci¯c.

To examine the robustness of the results with respect to the sample period I proceed by excluding the 1960s. In Table A.4 the interaction proxy still enters correctly and signi¯cantly at the 5 percent level in column [1]. Adding GCH in [3] implies that both political instability and its interaction with CBI^2 enter signi¯cantly with their predicted positive and negative signs. Apparently, the interaction term explains only 12 percent of the variation in bond yield volatility, but in speci¯cations [2]-[4] R^2 lies in the neighborhood of 35 percent. As for the period 1960-89 (not reported) the interaction term becomes insigni¯cant while the separate terms have stark signi¯cant e®ects. During 1980s the interaction term is again insigni¯cant, although with the right sign. Political instability has a pronounced (1 percent level) predicted impact on bond yield volatility while independence enters insigni¯cantly. Points on the left-end of the yield curve are represented by treasury bills with three months to maturity. Table A.5 displays a signi¯cant negative interacting impact on the average treasury bill volatility, political instability is always insigni¯cant, whereas independence always enters signi¯cantly with the right sign. By means of pooled regressions the number of observations increases to thirty-six. The unreported regressions give an insigni¯cant interaction term (always with a negative sign though), whereas GCH becomes markedly signi¯cant in all speci¯cations. For the (unreported) semi-long period 1972-89 (¯fteen countries) the interacting e®ect is signi¯cant at 5 percent.

The conclusions are fairly robust with respect to the political instability assessment. When running the corresponding regressions with PCH and PPCH as proxies the qualitative results do by and large prevail. Whether political instability is captured by elections resulting in a new Prime minister or party seems to be immaterial for the empirical performance. In the regressions PPCH shows lower overall ¯t, though. However, using PVU instead of CBI and governmental change, or replacing CBI by TOR yield insigni¯cant point estimates for these variables. The paper also states that relative volatility between short and long rate is increasing in independence and decreasing in political instability. Preliminary regressions give weak empirical support for these conclusions, though.

In conclusion, a comparison of the present results with the results in Cukierman et al. (1993) reveals that a combination of political instability and central bank independence has a more tangible impact on bond yield and treasury bill rate volatility, respectively, than if the e®ect of political instability is neglected. I consciously deal with a longer sample period (because institutional variables are rather rigid across time), which as a side-e®ect inevitably limits the number of countries. In general, the variables in the present paper have higher signi¯cance and higher overall ¯t. However, the explanatory power diminishes remarkably as the period length shrinks in the pooled regressions, which is compatible with the results in Cukierman et al. Moreover, contrary to their results I ¯nd that legal but not actual independence has a signi¯cant e®ect on interest rate volatility, which probably hinges on the exclusion of developing countries in my sample.

6. Conclusions

In the aftermath of recent implementations of quantitative in°ation targets, the paper contributes to the recent literature on in°ation targeting and central banking by formalizing in a model the relation between economic-political institutions and economic outcome. The paper examines the role of political instability and central bank independence for interest rate performance, and thus for credibility of explicit or implicit in°ation targets. New empirical evidence on this matter is provided.

In the model the implemented explicit in°ation target is allowed to be time-varying and stochastic with asymmetric information. The in°ation target is non-conventionally used as a benchmark for the identi¯cation of central bank instrument independence, conservatism of the policymaker (the government), and political instability. The implemented in°ation target will be a mapping of the time-varying political target onto the objective of the central bank, whose own target is assumed to be constant. To what extent the objective of an in°ation target-conservative or in°ation target-liberal government prevails depends on the susceptibility of the central bank to external instructions, its instrument independence.

The model generates an average in°ation which is decreasing in independence, whereas average output is independent of central bank independence. In°ation variability and output variability decrease in independence. Because lower in°ation can be achieved without increased output variability, independence has no real adverse effects. The prediction is in accordance with empirical evidence, but counter to Rogo® (1985), whose independence measure, however, goes through the relative weight on in°ation stabilization.

It is established that marked political instability and lack of central bank instrument independence promote persistently high volatility in nominal interest rates, and therefore are detrimental to credibility of future monetary policy. In particular, the rational implication is that the marginal e®ect from less (more) instrument independence on interest rate volatility is increasing (decreasing) in political instability. That is, interest rate volatility increases more from less independence in countries with conspicuous political instability. Absence of political turmoil fully subordinates the consequence of independence. Mistrust in future monetary policy in terms of a wedge between the claimed constant central bank in°ation target and the endogenous spot and forward yield curves, over any forecast horizon, decreases with instrument independence. Thus, independence determines how politically tinged is economic outcome. Moreover, lower independence and increased political instability impede the conduct of monetary policy, and imply an unfavorable relative volatility in short and long term nominal interest rates.

A normative result is considered where strategic delegation of the explicit time-varying in°ation target can achieve the second-best equilibrium. The in°ation bias is eliminated if the government selects a su±ciently low in°ation target. It is shown that the optimal target is time-invariant and thus closed to per-period renegotiations. Because the initial delegation is succeeded by a monetary reform which makes the central bank fully instrument independent, the legislative support is guaranteed.

The predictions are confronted with cross-country data in a subset of OECD countries over various sub-periods ranging from the early 1960s to 1989. The empirical contribution of the paper is that it examines whether the interaction between political instability and central bank independence a®ects long and short term nominal interest rate volatility, respectively. The results are supportive to the theoretical predictions. In particular, the interacting proxy has conspicuous impact on bond yield volatility during the periods considered. Bond yield volatility thus increases more from less independence in countries with marked political instability than in politically stable countries. The conclusion is that lack of credibility of future monetary policy, nominal interest rates deviating from a constant (explicit or implicit) central bank in°ation target, can be explained by monetary and political institutions.

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A. Appendix

A.1. Optimal Losses of the Central Bank and Society under Commitment

Combining the discounted indirect loss function of the central bank with (3.10) and $E_{t-1}[\eta_t \omega_t] = \eta_{t-s} E_{t-1}[\omega_t] = \eta_{t-s} E_{t-1}[\eta_t] = 0 \; \forall s \geq 1$ yields $\theta_2 = \theta_2 \delta\gamma^2$ and $\theta_1 = \theta_1 \delta\gamma$; which hold only if

$$\theta_1 = \theta_2 = 0 \text{ for } \delta, \gamma < 1. \tag{A.1}$$

The central bank's optimal value of (2.1) will, with (A.1) be given by

$$\theta_0 = \frac{1}{2}\frac{1}{1-\delta}\left(\frac{\psi^2\beta^2\lambda}{1+\beta^2\lambda}\sigma_\eta^2 + \frac{\lambda}{1+\beta^2\lambda}\sigma_\omega^2 + \lambda y^{*2}\right). \tag{A.2}$$

Examining the optimal value of (2.1) of society yields

$$\tilde{\theta}_2 = \frac{(\psi-1)^2\gamma^2}{1-\delta\gamma^2}; \quad \tilde{\theta}_1 = \frac{(\delta\tilde{\theta}_2 + (\psi-1)^2)\gamma\,{}^{-1}}{1-\delta\gamma} \tag{A.3}$$

and

$$\tilde{\theta}_0 = \frac{\lambda y^{*2} + \frac{\lambda}{1+\beta^2\lambda}\sigma_\omega^2 + \Delta + \left(\delta\tilde{\theta}_2 + (\psi-1)^2 + \frac{(2-\psi)\psi\beta^2\lambda}{1+\beta^2\lambda}\right)\sigma_\eta^2}{2(1-\delta)}, \tag{A.4}$$

with $\Delta \equiv ((\psi-1)^2 + 2\delta\tilde{\theta}_1 + \delta\tilde{\theta}_2{}^{-1})^{-1}$.

Inserting (A.3) into (A.4) when $\psi = 1$ (perfectly dependent) yields

$$\tilde{\theta}_0 = \frac{1}{2(1-\delta)}\left(\lambda y^{*2} + \frac{\lambda}{1+\beta^2\lambda}\sigma_\omega^2 + \frac{\beta^2\lambda}{1+\beta^2\lambda}\sigma_\eta^2\right) \tag{A.5}$$

which minimizes the optimal discounted loss of society.

A.2. The $T-t$ Term Interest Rate

$$\begin{aligned}
i_{t,T} &= \left(\begin{array}{l} \frac{1}{T-t}[(1+(1+\gamma)+(1+\gamma+\gamma^2)+\cdots+(1+\cdots+\gamma^{T-t-1}))\psi^{-1} \\ +(T-t)\beta\lambda y^* + (\gamma+\cdots+\gamma^{T-t})\psi\pi_t - \frac{(\psi\beta\eta_t-(1+\beta^2\lambda)\omega_t)}{\alpha(1+\beta^2\lambda)} + \frac{\varepsilon_t}{\alpha}] \end{array}\right) \\
&= \left(\begin{array}{l} \left(\beta\lambda y^* + \frac{1}{T-t}[K'\psi^{-1} + (\gamma+\gamma^2+\cdots+\gamma^{T-t})\psi\gamma\pi_{t-1} \right. \\ + \quad (\gamma+\gamma^2+\cdots+\gamma^{T-t})\psi - \frac{\beta\psi}{\alpha(1+\beta^2\lambda)}\eta_t + \frac{1+\beta^2\lambda}{\alpha(1+\beta^2\lambda)}\omega_t + \frac{1}{\alpha}\varepsilon_t] \end{array}\right) \\
&= \left(\begin{array}{l} \left(\beta\lambda y^* + \frac{1}{T-t}[K'\psi^{-1} + \sum_{k=0}^{T-t-1}\psi\gamma^{k+2}\pi_{t-1} \right. \\ + \quad \sum_{k=0}^{T-t-1}\gamma^{k+1} - \frac{\beta}{\alpha(1+\beta^2\lambda)}\psi\eta_t + \frac{1+\beta^2\lambda}{\alpha(1+\beta^2\lambda)}\omega_t + \frac{1}{\alpha}\varepsilon_t] \end{array}\right) \\
&= \left(\begin{array}{l} \left(\beta\lambda y^* + \frac{1}{T-t}[K'\psi^{-1} + \frac{1}{1-\gamma}\gamma^2(1-\gamma^{T-t-1})\psi\pi_{t-1} \right. \\ + \quad \frac{1}{1-\gamma}\gamma(1-\gamma^{T-t-1}) - \frac{\beta}{\alpha(1+\beta^2\lambda)}\psi\eta_t + \frac{1+\beta^2\lambda}{\alpha(1+\beta^2\lambda)}\omega_t + \frac{1}{\alpha}\varepsilon_t] \end{array}\right)
\end{aligned} \tag{A.6}$$

where (4.1) has been repeatedly substituted into (2.10) and (2.8) for $\tau = 0, 1, \ldots, T - t - 1$ and the formula for finite geometric series been exploited. The lead of (A.6) is

$$
\begin{aligned}
i_{t+1,T} &= \left(\begin{array}{l} \beta\lambda\hat{y} + \frac{1}{T-t-1}[(1 + (1+\gamma) + \cdots + (1 + \gamma + \cdots + \gamma^{T-t-2}))\psi\bar{\pi} \\ + \frac{\gamma(1-\gamma^{T-t-2})\psi\pi_t(\gamma\pi_t + \eta_{t+1})}{1-\gamma} - \frac{\beta\psi\eta_{t+1}}{\alpha(1+\beta^2\lambda)} + \frac{(1+2\beta^2\lambda)\omega_{t+1}}{\alpha(1+\beta^2\lambda)} + \frac{\varepsilon_{t+1}}{\alpha}] \end{array} \right) \qquad (A.7)\\
&= \beta\lambda\hat{y} + \frac{1}{T-t-1}\left(K\psi\bar{\pi} + \frac{1}{1-\gamma}\gamma^2(1 - \gamma^{T-t-2})\psi\pi_t + h\nu_{t+1}' \right);
\end{aligned}
$$

where $K > 0$; and h and ν_{t+1}' are (3×1) vectors.

A.3. The Unconditional Variance of $T - t$ Term Interest Rate

$$
\begin{aligned}
Var[i_{t+1,T}] &= E\left[(i_{t+1,T} - E[i_{t+1,T}])^2\right] \qquad (A.8)\\
&= \left(\begin{array}{l} E[(\frac{1}{T-t-1}(K\psi\bar{\pi} + \frac{1}{1-\gamma}\gamma^2(1-\gamma^{T-t-2})\psi \sum_{s=0}^{\infty}\gamma^s\eta_{t-s} \\ + h\nu_{t+1} - K\psi\bar{\pi} - \frac{1}{1-\gamma}\gamma^2(1-\gamma^{T-t-2})\psi\bar{\pi}))^2] \end{array} \right)\\
&= \left(\begin{array}{l} \frac{1}{(T-t-1)^2}E[(\frac{1}{(1-\gamma)^2}\gamma^4(1-\gamma^{T-t-2})^2\psi^2(\eta_t^2 + \gamma^2\eta_{t-1}^2 + \gamma^4\eta_{t-2}^2 + \cdots) \\ + h_1^2\eta_{t+1}^2 + h_2^2\omega_{t+1}^2 + h_3^2\varepsilon_{t+1}^2] \end{array} \right)\\
&= \left(\frac{1}{(T-t-1)^2} \left(\frac{(\psi\frac{\gamma^2}{1-\gamma}(1-\gamma^{T-t-2}))^2}{1-\gamma^2} + h_1^2 \right)\sigma_\eta^2 + h_2^2\sigma_\omega^2 + h_3^2\sigma_\varepsilon^2 \right)
\end{aligned}
$$

where I used (A.7) and noted that $E[\eta_t\eta_s] = E[\eta_t\omega_t] = E[\eta_t\varepsilon_t] = E[\varepsilon_t\omega_t] = 0, \forall t \neq s$:

$$
Var[i_{t+1}] = E\left[(i_{t+1} - E[i_{t+1}])^2\right] = \left(\bar{\kappa} + k_1^2\right)\sigma_\eta^2 + k_2^2\sigma_\omega^2 + k_3^2\sigma_\varepsilon^2; \qquad (A.9)
$$

where $\bar{\kappa} = \frac{\gamma^4}{1-\gamma^2}\psi^2$; k_1 is given in (3.9), and i_{t+1} as previously is shorthand for $i_{t+1,t+2}$.

A.4. Data Description and Variable Definition

GCH ≡ Governmental transition in the form of a change of cabinet irrespective of whether the Prime minister leaves office or not. GCH is self-constructed from existing raw data and defined by the number transitions divided by the number of years in the sample period. Source: Lane et al., 1991.

PCH ≡ Governmental transition in the form of Prime minister turnover without implying a switch of party in office. PCH is self-constructed from existing raw data and defined by the number transitions divided by the number of years in the sample period. Source: Lane et al., 1991.

PPCH ≡ Governmental transition in the form of switch of party in office. PPCH is self-constructed from existing raw data and defined by the number transitions divided by the number of years in the sample period. Source: Lane et al., 1991.

Central bank independence (CBI) ´ Legal central bank independence index in the interval between zero and one. It is characterized by four groups of issues: the appointment, the term of o±ce, and the dismissal of the governor, the policy formulation procedure, the implementation of the price stability goal, and limitations on lending. Source: Cukierman, Webb and Neyapti, 1992.
Turnover rate of central bank governor (TOR) ´ Actual central bank independence in the interval between zero and 0.3. Source: Cukierman, Webb and Neyapti, 1992.
Political vulnerability of central banks (PVU) ´ Number of replacements of central bank governor within six months following a political transition divided by the number of political transitions for a given time period. Source: Cukierman and Webb, 1995.
Short term interest rate: Treasury bills with three months to maturity; Frequency: monthly (New Zealand, quarterly); Source: Bank of International Settlements (BIS) (except Denmark (International Financial Statistics (IFS)) and New Zealand (Main Economic Indicators (MEI))).
Long term interest rate: Bonds with 5-10 years to maturity; Frequency: monthly (New Zealand, quarterly); Source: BIS (except Denmark, Ireland (IFS), and New Zealand (MEI)).

A.5. The Sample of Countries

The country sample and the period are restricted by the availability of monthly observations on short and long term interest rate data. Only democratic industrial countries (OECD) are included. The sample period starts for short rate (TB) and long rates (B) as indicated in the table and ends 1989.12.

Country	TB B	Country	TB B	Country	TB B
Australia	68.01 60.01	Germany	60.01 60.01	Norway	77.09 60.01
Austria	60.01 64.01	Greece	84.09 n.a.	Spain	77.01 78.03
Belgium	60.01 60.01	Ireland	60.01 60.01	Sweden	66.01 60.01
Canada	60.01 60.01	Italy	71.01 60.01	Switzerland	60.01 60.01
Denmark	72.01 60.01	Japan	60.01 66.01	United Kingdom	60.01 60.01
Finland	n.a. 80.01	The Netherlands	60.01 60.01	United States	60.01 60.01
France	60.01 60.01	New Zealand	73.01 60.01		

Independent	[1]	[2]	[3]	[4]
Constant	9.975¤¤¤	5.302	3.579	6.003
	(1.851)	(3.166)	(2.522)	(3.975)
CBI^2		-15.32¤¤		{24.70¤
		(5.922)		(13.59)
GCH		9.094¤	11.81¤¤	7.620
		(4.492)	(4.784)	(7.602)
CBI^2 £ GCH	-44.95¤¤		-33.93¤¤	24.97
	(16.30)		(15.14)	(40.77)
R^2	0.170	0.431	0.404	0.436
No. obs.	17	17	17	17

Note: Standard errors based on an asymptotically consistent covariance matrix allowing for heteroscedasticity within parenthesis. ***, **, * denote signi¯cance at 1, 5, 10 % levels.

Table A.1: Cross-country OLS; 1966-1989; Dependent variable: Bond rate volatility.

Independent	[1]	[2]	[3]	[4]
Constant	3.253¤¤¤	1.652¤	1.331¤	1.348
	(0.661)	(0.971)	(0.766)	(0.965)
CBI^2		-3.563¤		-0.152
		(2.067)		(3.962)
GCH		3.371¤	4.027¤¤	3.999¤
		(2.001)	(1.851)	(2.198)
CBI^2 £ GCH	-9.109¤¤¤		-9.219¤	-8.884
	(3.228)		(5.297)	(9.949)
R^2	0.024	0.134	0.138	0.138
No. obs.	51	51	51	51

Note: See Table A.1. The covariance matrix is asymptotically consistent allowing for heteroscedasticity and contemporaneous cross-country correlation.

Table A.2: Pooled cross-country OLS; 1966-1971, 1972-1979, 1980-1989; Dependent variable: Bond rate volatility.

Independent	[1]	[2]	[3]	[4]
Constant	-	-	-	-
CBI^2		-19.93¤		-19.88
		(11.43)		(16.21)
GCH		0.930	0.084	0.912
		(3.938)	(3.562)	(4.323)
CBI^2 £ GCH	-13.05		-13.41¤¤	-0.138
	(21.31)		(6.605)	(24.35)
R^2	0.386	0.402	0.386	0.402
No. obs.	51	51	51	51

Note: See Table A.2. Includes 17 (unreported) country speci¯c dummy variables.

Table A.3: Pooled cross-country OLS; Fixed e®ect model; 1966-1971, 1972-1979, 1980-1989; Dependent variable: Bond rate volatility.

Independent	[1]	[2]	[3]	[4]
Constant	7.178¤¤¤	4.212	2.756	4.925
	(1.427)	(2.668)	(2.024)	(3.199)
CBI^2		-9.781¤¤		-19.14¤
		(4.784)		(10.94)
GCH		5.749	7.685¤¤	4.294
		(4.468)	(3.841)	(5.725)
CBI^2 £ GCH	-27.60¤¤		-18.22¤	25.22
	(12.20)		(10.07)	(24.95)
R^2	0.117	0.355	0.319	0.370
No. obs.	17	17	17	17

Note: See Table A.1.

Table A.4: Cross-country OLS; 1972-1989; Dependent variable: Bond rate volatility.

Independent	[1]	[2]	[3]	[4]
Constant	10.05¤¤¤	11.677¤¤¤	10.08¤¤¤	13.84¤¤¤
	(1.094)	(1.966)	(1.751)	(2.654)
CBI^2		-12.09¤¤		{37.53¤¤
		(4.338)		(15.26)
GCH		-2.625	-0.050	-6.831
		(3.520)	(3.402)	(5.071)
CBI^2 £ GCH	-27.99¤¤		-28.07¤¤	69.41
	(12.18)		(11.74)	(39.96)
R^2	0.223	0.281	0.223	0.336
No. obs.	12	12	12	12

Note: See Table A.1.

Table A.5: Cross-country OLS; 1966-1989; Dependent variable: Treasury bill volatility.