A Non-normative Theory of Inflation and Central Bank Independence*

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August 1998

Abstract

We study monetary policy under different central bank constitutions when the labor-market insiders set the nominal wage so that the outsiders are involuntarily unemployed. If the insiders are in the majority, the representative insider will be the median voter. We show that an independent central bank, if controlled by the median voter, does not produce a systematic inflation bias, albeit equilibrium employment is too low from a social welfare point of view. A dependent central bank, in contrast, is forced by the government to collect seigniorage and to take the government's re-election prospects into account. The predictions of our theory are consistent with the evidence that central bank independence decreases average inflation and inflation variability, but does not affect employment variability.

Keywords: central bank independence; inflation bias; median voter; political business cycles; seigniorage.

JEL classification: E52; E58.

*The first author acknowledges financial support from the Sonderforschungsbereich 303, which enabled him to work on this paper while visiting the University of Bonn. We have benefitted from suggestions of Michele Fratianni, Paul Levine, Neil Rankin, Ákos Valentinyi, Jürgen von Hagen, Carl Walsh, Jens Weidmann, and, especially, Andrew Oswald. Moreover, the paper has been improved by comments of the audiences at the Bank of England, Bonn, Liverpool, the Konstanz Seminar on Monetary Theory and Policy 1997 and the Royal Economic Society Conference 1997.

1 Introduction

Europe's nations have chosen a status of independence for the European Central Bank on the conviction that independence is a necessary condition for avoiding an inflation bias in monetary policy. This conviction has been nourished by the unmatched stability record of the Deutsche Bundesbank. Measured over the post-war period, German CPI inflation has been 2.8 percent on average, which is significantly less than in the other industrialized countries. Furthermore, as Blinder (1998) notes, post-war averages are shaped by the extraordinary inflation waves of the 1970s and early 1980s that were unleashed by the Vietnam war, the breakdown of the Bretton Woods system, and two large oil price shocks. If the turbulent period 1970–82 is excluded, German inflation has been 2.0 percent on average. This favorable result can be equated with the virtual absence of an inflation bias given that for measurement reasons the true rate of price level change is overestimated by the measured rate and that sufficient nominal interest rate variability requires a positive inflation rate.[1] In fact, the Bundesbank has been led over decades by the notion that a measured rate of price level change of 2 percent represents the desired state of price stability.

Surprisingly, there is no economic theory that can explain why the Bundesbank has resisted the temptation of letting inflation have its way. For example, Rogoff (1985) developed a model of an independent central bank where the bankers, who are more conservative than the government, produce lower inflation than the government, but in that model the inflation bias vanishes only in the extreme case that employment stabilization is disregarded. Estimates of the Bundesbank's reaction function by Clarida and Gertler (1997) confirm that the Bundesbank does stabilize the real economy.[2] Recent alternative suggestions were to eliminate inflation bias through an inflation contract [Walsh (1995)] or an inflation target [Svensson (1997)]. This does not help to explain

[1] For the US, Boskin, Dulberger, Gordon, Griliches and Jorgenson (1998) estimated that measured CPI inflation exceeds true CPI inflation by 0.8-1.6 percentage points and Orphanides and Wieland (1998) showed that an inflation target of 2 percent is required to ensure that the non-negativity constraint for nominal interest rates is not binding in the conduct of stabilization policy.

[2] Taking the short-term interest rate as the policy instrument they find a significant response to monthly observations of industrial production. Note that this significance vanishes when annual data is used and deviations of money growth from target are taken as the policy instrument; see Neumann (1997).

the Bundesbank's record either, because it has never worked under an inflation contract or an inflation target.

The present paper develops a new model of central bank independence that can explain the absence of an inflation bias in Germany. The point of departure from the literature is to call into question the standard assumption that the objective of monetary policy is social welfare. Existing contributions typically assume, implicitly or explicitly, that all individuals are identical. Under this assumption social welfare, defined in an utilitarian way as the weighted sum of all individual utilities, equals the representative agent's utility. Since, trivially, the representative agent is also the median voter, it is then natural to assume that social welfare is the objective of monetary policy. A plausible justification is that the government is elected by the median voter and that the central bank's status of independence can survive only if it is backed by the median voter.[3] Matters are completely different if, as in this paper, it is assumed that individuals are not identical. In particular, the median voter's utility then differs from social welfare and identifying the policy objective with social welfare has no descriptive content.

In order to make our point formally, we develop a simple model in the spirit of Blanchard and Kiyotaki (1987). In each sector of our economy, one trade union has the monopoly power to set the nominal wage that is to be paid to all workers. Given the standard assumption that unions care only about the well-being of their members, the "insiders", they will reduce aggregate employment at the expense of the non-union members, the "outsiders". The presence of monopoly unions is thus distortionary and equilibrium employment is lower than is desirable from a social welfare point of view. This implies that our model is capable of reproducing the familiar inflation bias of the Barro-Gordon analysis, provided that the monetary authority's objective function is taken to be social welfare. However, for the reasons outlined above, we subscribe to the positive view that the median voter's utility, instead of social welfare, counts. In our model the median voter is an insider, because only if the monopoly unions are backed by the majority of the population, they can survive, implying that the majority of the population must be insiders. The key point to notice now is that the insiders are

[3]The latter point can be illustrated by noting that, for example, a simple majority of the German parliament can change the institutional status of the German Bundesbank.

against the creation of surprise inflation other than for the stabilization of unanticipated productivity shocks. The reason is that since they are fully employed, a creation of surprise inflation aimed at increasing employment beyond the natural rate would hurt them, as it drives them off their desired employment, lowers their real wage and leads to costly inflation.

Given that the independent central bank cares about the median voter, we derive results that are in stark contrast to the literature. First, in our model equilibrium inflation no longer depends on the difference between the natural rate level of employment and the higher level that is desirable from a social welfare point of view. Instead, the independent central bank provides zero inflation on average. Second, the independent central bank stabilizes employment optimally from the median voter's point of view as well as from the social welfare point of view.

Though the median voter plays a decisive role in our analysis, she cannot avoid an inflation bias if the central bank is dependent. In this case a political business cycle in inflation arises as in Fratianni, von Hagen and Waller (1997) and Lohmann (1995), stemming from the government's attempt to fool the median voter so as to improve the re-election prospects. Moreover, the government may force the dependent central bank to create more seigniorage than is optimal from the median voter's point of view. This occurs because the government values revenues that can be collected without effort on its part [Persson, Roland and Tabellini (1996)]. As a result, a principal-agent problem emerges and the dependent central bank is found to create higher average inflation and a higher inflation variability than the independent central banker, while employment variability remains unaffected. These predictions of our theory are in line with the stylized facts of the large body of cross-country studies of the correlations between the legal degree of central bank independence and the level and variability of inflation and employment; see e.g. Grilli, Masciandaro and Tabellini (1991), Cukierman (1992), Alesina and Summers (1993) and Eijffinger, Schaling and Hoeberichts (1998).

The paper is organized as follows: in Section 2 we describe the labor market structure and the objective functions of different players; Section 3 provides the equilibrium solutions when the central bank is independent and the policy objective is either social

welfare or the median voter's utility; in Section 4 we introduce rational retrospective voting and show that the standard results obtain when the central bank is dependent; Section 5 concludes.

2 The Model

Our model is similar to that used by Herrendorf and Lockwood (1997). It has the following actors: a government, a central banker and a large number of identical trade unions and firms.[4] In each sector of the economy, there is one firm, which sells its product in a competitive market, and one trade union, which has monopoly power over wage setting – a so-called monopoly union. The number of union members, the insiders, is taken to be the same across sectors and is exogenously given.[5] We also assume that the number of non-union members, the outsiders, is the same in each sector and denote the share of insiders in the total labor force by s. Note that, otherwise, the outsiders would have an incentive to migrate to sectors with relatively fewer outsiders, where job prospects are more favorable for them, providing the number of insiders is the same across sectors. Finally, we suppose that the monopoly unions set the nominal wage and the firm determines employment.

The sequence of events in each period is as follows: (i) each trade union sets the nominal wage, w_t [if not mentioned explicitly, all variables are in logarithms]; (ii) a productivity shock ϵ_t occurs and is observed only by the central bank; (iii) the central banker chooses the price level, p_t, the value of which is not observed by anyone else at the time of action; (iv) a shock, θ_t, to the government's competence occurs, the realization of which is observed only by the government; (v) the average per capita employment, l_t, is determined by firms labor demand and is observed by everybody [l_t equals the log of total employment in hours divided by the number of workers]; (vi) if the period is odd, an election is held; (vii) the realizations of p_t and θ_t are observed. With regards to the elections, we assume that the simple majority of votes decides whether the incumbent is

[4] Technically, we assume continua of measure 1 of identical trade unions and firms.

[5] More general specifications such as that of Blanchard and Summers (1986) determine union membership endogenously. We prefer not to do this, because it would introduce dynamic features into our otherwise repeated game structure.

re-elected or a randomly drawn challenger replaces her.

Given the nature of the nominal wage contracts, employment in each sector is determined by the labor demand of this sector's firm. We assume that the economy-wide average per capita employment depends on the real wage, the productivity shock, ϵ_t, and the competence of the incumbent, Θ_t:[6]

$$
\begin{aligned}
l_t &= (p_t - w_t) + \epsilon_t + \Theta_t, \qquad (1)\\
\Theta_t &\equiv \iota_t \theta_{t-1} + \theta_t,\\
\theta_0 &\equiv 0,\\
\iota_t &\equiv \begin{cases} 1, & \text{if the incumbent holds office for the second period,} \\ 0, & \text{if the incumbent holds office for the first period.} \end{cases}
\end{aligned}
$$

As in Rogoff and Sibert (1988), the innovation θ_t to the incumbent's level of competence has a positive impact on aggregate employment. The two shocks ϵ_t and θ_t are taken to have zero covariance and to be independently, identically, and uniformly distributed with zero means and compact supports $[-x_\epsilon, x_\epsilon]$ and $[-x_\theta, x_\theta]$, $0 < x_\epsilon, x_\theta < \infty$. The definition of ι_t captures the idea that competence shocks are incumbent specific. They therefore carry over to the next period only if the incumbent remains in office.

In order to distinguish the insiders from the outsiders, we make the key assumption that the per capita employment of a representative insider is larger than that of a representative outsider. In particular, we assume that firms find it optimal to hire such that the per capita employment of insiders and outsiders is given by $L_t^k = (1 + h^k)L_t$, where $k \in \{i, o\}$ indicates whether the individual is an insider or an outsider, h^k are constants with $h^o = -sh^i/(1-s)$, and L_t is the average level of per capita employment across all individuals. Assuming that h^i is small, taking logs implies

$$l_t^k = l_t + h^k. \qquad (2)$$

[6]Note that since there is a continuum of measure one of identical sectors, the value of any economic variable must be the same in each sector and on the aggregate. We therefore do not need to distinguish between the two.

Wage-setting is modelled by supposing that each trade union maximizes the expected utility of it's representative member.[7] We assume that insiders and outsiders have the same individual preferences, preferring a higher over a lower real wage and disliking deviations of employment and of inflation from the respective bliss points, $\bar{l}$ and 0. In particular, the present discounted utility as of period t is

$$U^k(t) = \sum_{j=t}^{\infty} \delta^{j-t} U_j^k = \sum_{j=t}^{\infty} \delta^{j-t} \Big[(w_j - p_j) - \frac{a}{2}(l_j^k - \bar{l})^2 - \frac{b}{2}\pi_j^2 \Big], \tag{3}$$

where $\delta \in (0,1)$ is a discount factor and a and b are positive constants. Inflation is defined as the rate of price change, i.e. $\pi_j \equiv p_j - p_{j-1}$. Using (2), it is straightforward to rewrite (3) in terms of (the log of) average per capita employment:

$$U^k(t) = \sum_{j=t}^{\infty} \delta^{j-t} \Big[(w_j - p_j) - \frac{a}{2}(l_j - \bar{l}^k)^2 - \frac{b}{2}\pi_j^2 \Big], \tag{4}$$

where $\bar{l}^k \equiv \bar{l} - h^k$ denote the economy-wide average per capita employment levels [i.e. employment in hours divided by the total number of individuals in the work force] desired by insiders and outsiders, respectively. Our assumptions imply that, ceteris paribus, insiders prefer a lower level of average per capita employment than outsiders, $\bar{l}^i < \bar{l} < \bar{l}^o$.

Given the utility function (4), we can derive semi-reduced forms for the nominal wage and for employment, still depending on the actual and the expected price level. Maximizing the expectation of (4) subject to labor demand (1) while taking inflation expectations as given results in the following first-order condition for a typical trade union's choices of the nominal wage:

$$w_{t+1} = p_{t+1}^e - l^n + \iota_{t+1}\theta_t, \tag{5}$$

where the natural rate of employment is defined as $l^n \equiv \bar{l}^i - 1/a$. Substituting (5) into

[7] Although this assumption is not without problems, it is widely adopted; see Booth (1995) for a discussion.

(1) yields a semi-reduced form for employment:

$$l_{t+1} = l^n + (p_{t+1} - p^e_{t+1}) + \epsilon_{t+1} + \theta_{t+1}. \tag{6}$$

We see that a positive competence shock in the current period implies that in the next period workers can take home a higher real wage if the incumbent is still in charge, without adverse consequences for employment. Thus, if the incumbent continues to be in power, both the insiders' and the outsiders' utility in period $t+1$ increases in the realization of the government's competence shock in t.[8]

3 Monetary Policy Under Central Bank Independence

In this section, we model monetary policy under an independent central bank. Necessary and sufficient conditions for central bank independence are *institutional* and *personal* independence from government [Neumann (1991)]. Institutional independence means that the government cannot directly interfere with the implementation of monetary policy, which requires that government representatives do not have a say on the central bank board and that the central bank cannot be forced to finance government debt. Personal independence from the government can be achieved through long-term appointments and by prohibiting early removal from the office and reappointment. Both institutional and personal independence are granted by the laws of the more independent central banks, such as the Swiss National Bank or the Bundesbank. In particular, the Bundesbank Law explicitly prohibits monetizing government debt and stipulates that the official term length is eight years, which doubles due to the practice of unconditional reappointment.

An independent central banker has no reason to please the government and can therefore maximize its own objective function. To relate our framework to existing work, we first replicate the standard results of the literature, which typically assumes

[8] Substituting (5) and (6) into (4), this can easily be shown formally as well.

that independent central banks are concerned with some form of social welfare function.

3.1 The Standard Theory

The seminal contribution on the delegation of monetary policy to an independent central bank is due to Rogoff (1985), who build on Barro and Gordon (1983). These authors had assumed that the government maximizes social welfare. Applying the standard utilitarian notion that social welfare is the sum of all individual utilities, the government's objective function in our setting becomes:

$$U^g(t) = \sum_{j=t}^{\infty} \delta^{j-t}[sU_j^i + (1-s)U_j^o]. \tag{7}$$

Maximizing the expectation of (7) for given ϵ_t and p_t^e and subject to (4), (5) and (6), the first-order condition of the government's problem is obtained:

$$0 = -a[p_t - p_t^e + \epsilon_t - (\bar{l} - \bar{l}^i)] - b(p_t - p_{t-1}), \tag{8}$$

where we have used the fact that $(1-s)(\bar{l}^o - \bar{l}^i) = (\bar{l} - \bar{l}^i)$. Taking the expectations operator through this expression, a typical trade union's price expectation can be derived: $p_t^e = p_{t-1} + (a/b)(\bar{l} - \bar{l}^i)$. After substituting this back into (8) and using (5) and (1), we find the equilibrium solutions:

$$w_t = \frac{a}{b}(\bar{l} - \bar{l}^i) - l^n + \iota_t\theta_{t-1}, \tag{9a}$$

$$\pi_t = \frac{a}{b}(\bar{l} - \bar{l}^i) - \frac{a}{a+b}\epsilon_t, \tag{9b}$$

$$l_t = l^n + \frac{b}{a+b}\epsilon_t + \theta_t. \tag{9c}$$

As in Barro and Gordon, equilibrium inflation is found to exhibit a systematic inflation bias, $(a/b)(\bar{l} - \bar{l}^i)$, which is is proportional to the difference between the "average" employment target, $\bar{l}$, and the insiders' lower employment target, $\bar{l}^i$. To understand the analytical form of this bias, note that a social planner (if she could set the nominal wage and inflation so as to maximize welfare) would target the weighted average of the

natural rates preferred by the insiders and by the outsiders, i.e. $s\bar{l}^i + (1-s)\bar{l}^o = \bar{l} - 1/a$, instead of $\bar{l}^i - 1/a$. The existence of monopoly trade unions has the consequence that the equilibrium real wage is too high and equilibrium employment is too low from a social welfare point of view. Since the wage setters take into account that a benevolent central banker tries to correct for this, the systematic inflation bias in (9b) is proportional to the discrepancy between the social planner's preferred natural rate and the prevailing natural rate, $\bar{l} - \bar{l}^i$.

Rogoff (1985) pointed out that the inflation bias can be reduced if an independent central banker is appointed who puts a weight on inflation that is higher than society's weight. The cost of reducing inflation bias comes from the fact that the conservative central banker does not stabilize employment optimally. Rogoff showed that there is a finite degree of weight conservatism such that credibility and flexibility are traded off optimally. So, average inflation under a conservative central banker is positive and Rogoff's model does not fit the record of the Deutsche Bundesbank, which has virtually achieved price stability and, at the same time, stabilized the real economy. This observation motivated our paper.

3.2 A New Theory

Here, we drop the assumption that an independent central bank is guided by an objective function of the form (7). The key question then is which objective function an independent central bank adopts. We argue that while independence means independence from government, it does not mean the lack of constraints or outside control. The main point to notice is that simple majorities of parliament can typically change the central bank law, even for the relatively independent central banks, such as the Deutsche Bundesbank or the Federal Reserve. This allows the median voter to threaten a "misbehaving" central bank board with cuts in the bank's operating budget, changes in their term length, and the introduction of more demanding reporting requirements. Since all of these measures affect negatively the office rent of the central bankers, the threat of using them should impose serious constraints on how far the monetary policy stance can deviate from that preferred by the median voter. Alt (1992) makes this point with respect to the US and

provides empirical evidence that one principal of the Federal Reserve is Congress; see also Grier (1991). In Germany, similar forces are likely to be at work, as a simple majority of the parliament can alter the Bundesbank law.

The above argument suggests that the median voter's preferences should play a prominent role in an independent central bank's objective function. However, there has been some discussion on whether the Deutsche Bundesbank nonetheless behaves in partisan fashion. In particular, Vaubel (1997) suggested that the members of the Central Bank Board attempt to support the government in pre-election periods if they share its political affiliation. However, Neumann (1998) and Berger and Woitek (1997) do not find statistically significant evidence. Consequently, we neglect this possibility and assume that the objective function of an independent central bank is given by

$$U^{cb}(t) = \sum_{j=t}^{\infty} \delta^{j-t}(R^{cb} + U_t^i), \tag{10}$$

where R^{cb} denotes the banker's office rent. Since, in OECD countries, the central bankers' salaries are normally indexed to ex post inflation and since the central bank cannot keep the seigniorage it collects, R^{cb} is a constant.[9]

Maximizing the expectation of (10) subject to (4), (5) and (6), and going through the same analytical steps as before now yields the equilibrium outcome under central bank independence:

$$w_t = -l^n + \iota_t \theta_{t-1}, \tag{11a}$$

$$\pi_t = -\frac{a}{a+b}\epsilon_t, \tag{11b}$$

$$l_t = l^n + \frac{b}{a+b}\epsilon_t + \theta_t. \tag{11c}$$

These solutions drive home the key result of our analysis: the independent central bank does not generate an inflation bias. The reason is that the bank does not attempt to systematically increase employment beyond the prevailing natural rate, because the trade

[9] In Germany, for example, the salaries of members of the Central Bank Board are, like all salaries of civil servants, adjusted to compensate for increases in the CPI.

unions have already picked the levels of the real wage and of employment that are optimal from the insiders' point of view. Any surprise inflation, created to raise employment systematically, would reduce the insiders' real wage rate in exchange for an undesired increase in the economy-wide average of per-capita employment that does not benefit the insiders. The only type of surprise inflation desired by insiders is the one directed at dampening the impact of unanticipated productivity shocks. Solutions (11) indicate that this stabilization task is optimally fulfilled from a representative insiders point of view.[10] In sum, the charter of central bank independence provides precommitment. Since this eliminates the inefficient inflation bias, it is of value to insiders as well as outsiders, and therefore to society as a whole.

We conclude this section by pointing out that, in our model, the insiders do inflict involuntary unemployment upon the outsiders. To see this, consider the hypothetical situation in which the latter can set the nominal wage. With central bank independence, this would result in the following equilibrium outcomes:

$$w_t = -\bar{l}^o + \frac{1}{a} + \iota_t \theta_{t-1}, \tag{12a}$$

$$\pi_t = -\frac{a}{a+b}\epsilon_t, \tag{12b}$$

$$l_t = \bar{l}^o - \frac{1}{a} + \frac{b}{a+b}\epsilon_t + \theta_t. \tag{12c}$$

Comparison of the solutions (11) and (12) shows that the outsiders prefer a reduction in the wage in exchange for an increase in average per capita employment. Since the nominal wage (11a) set by the insiders is higher than (12a), this must also mean that they would want to work more than they do in (11c), that is, the outsiders are involuntarily unemployed when the insiders set the nominal wage.

[10] Note that these results are similar to those of Fratianni et al. (1997). The main contribution of our paper is to be seen in the explanation where the policy objective comes from and why an independent central bank does not have an ambitious employment target.

4 Monetary Policy Under Central Bank Dependence

Given that the median voter is crucial for our results, it may seem that a dependent central bank, too, should provide zero average inflation, as the government is elected by the median voter. In this section, we demonstrate that this is not true. We argue that a dependent central bank will be forced by the incumbent to pursue policies that are not in the interest of the median voter.

4.1 The Government's Objective

As most of the literature, we equate the objective of a dependent central bank with that of the government. The usual justification is that a dependent central bank is basically a government agency. So, the question to answer here is what objective function the government will follow. Since the government is elected by the median voter, we make the common assumption that it cares about the median voter's utility. The literature on political business cycles points out that, in addition, the government will be concerned with the office rent it is collecting; see for example Rogoff and Sibert (1988). Since the government has to stand regular elections, this introduces an incentive to pursue opportunistic policies that are suboptimal from the median voter's point of view.[11]

We assume a form of the government's utility function that captures both the government's concern with the median voter's utility and with securing its office rent, R_j^g:

$$U^g(t) = \sum_{j=t}^{\infty} \delta^{j-t}(R_j^g + U_j^i). \tag{13a}$$

The office rent takes the form

$$R_j^g = r^g + c(p_j - p_j^e) + d(p_j^e - p_{j-1}), \tag{13b}$$

[11] Note that Herrendorf and Neumann (1998) show that the multi-dimensionality of the voting decisions in democratic election can be an additional reason why the elected government does not represent the median voter with respect to monetary policy.

where r^g, c and d are positive constants. The constant term r^g captures the part of the incumbent's utility from holding office that is independent of inflation. This may include the incumbent's salary (which in OECD countries is typically indexed to ex post inflation), fringe benefits etc. As in de Kock and Grilli (1993), the other two terms are linear approximations of the seigniorage that results from unexpected and expected inflation. Since the latter is smaller than the former, we have $c > d$; see Herrendorf (1997) for further discussion.

The assumption that the incumbent's office rent depends positively on seigniorage can be motivated by public choice arguments. Niskanen (1971), for example, argued convincingly that politicians tend to overspend, because they derive private benefits from controlling a large budget, directing a large bureaucracy and the like. Recently, Persson et al. (1996) have taken the more cynical view that the incumbent government can divert the more resources for its own use, the more resources it collects. Since seigniorage is the only revenue source in our highly stylized model, these considerations suggest that it ought to affect the incumbent's utility positively. Note that this argument will be valid also in more complete models with alternative revenue sources. The reason is that collecting seigniorage requires practically no effort on part of the government. In contrast, the tax revenue can be increased only if the tax collection process is made more efficient or if the average tax rate is increased. As the experience of various countries suggests, this typically involves long and tedious processes of approval by parliament and subsequent implementation; see Cukierman, Edwards and Tabellini (1992) for further discussion.

4.2 Equilibrium

We first solve for the equilibrium in even periods, in which no election is held. Taking p_t^e as given, the government maximizes with respect to p_t the expectation of (13a) conditional on ϵ_t and subject to (4), (5) and (6). Following the same steps as above, one

finds for the equilibrium in a non-election period:

$$w_t = \frac{c}{b} - l^n + \iota_t \theta_{t-1}, \tag{14a}$$

$$\pi_t = \frac{c}{b} - \frac{a}{a+b}\epsilon_t, \tag{14b}$$

$$l_t = l^n + \frac{b}{a+b}\epsilon_t + \theta_t, \quad t = 2, 4, 6 \ldots \ . \tag{14c}$$

Next, to solve for the equilibrium in an odd period when an election takes place, we need to analyze first the voting decisions of individuals. Since the competence shock θ_t affects the individual utilities in period $t+1$ if and only if the incumbent remains in office, it is optimal for all individuals to have $\iota_{t+1} = 1$ $[\iota_{t+1} = 0]$ if and only if θ_t is larger [smaller] than zero. In other words, both insiders and outsiders wish to re-elect the incumbent if and only if she experiences a positive competence shock in the election period. In contrast, since the potential challengers of the incumbent do not have a draw of θ_t, their expected competence for period $t+1$ is zero and it is optimal to elect the challenger whenever $\theta_t < 0$.

The key assumption of rational retrospective voting models is that in an election period t voters cannot observe θ_t but only $l_t - l^n$, which is the sum of $p_t - p_t^e$, ϵ_t and θ_t. Since they wish to re-elect competent incumbents and replace incompetent ones, they will form an optimal forecast of θ_t based on the observed realization of $l_t - l^n$. The incumbent then has an incentive to fool the voters by creating surprise inflation, because the expansionary effect of surprise inflation on employment cannot be distinguished from that of a positive competence shock. To solve the model, we restrict attention to Markov-perfect strategies. The state variable in period t is the realization of last period's competence shock, θ_{t-1}. We postulate that in an odd period t individuals re-elect the incumbent, if and only if $l_t - l^n > 0$. Together with the uniformity of the distribution of θ_t, this implies the following re-election probability from the incumbent's point of view:

$$\text{Prob}(\text{ re-election} \,|\, p_t^e, \epsilon_t) = \text{Prob}(\, \theta_t > p_t^e - p_t - \epsilon_t \,|\, p_t^e, \epsilon_t) = \max\left\{0, \frac{x_\theta + p_t - p_t^e + \epsilon_t}{2x_\theta}\right\},$$
$$t = 1, 3, 5 \ldots \ . \tag{15}$$

Given these expressions, we can solve for the Markov-perfect equilibrium of the game. It will be shown below that, indeed, it is optimal for individuals to vote for the incumbent if and only if $l_t - l^n > 0$.

The government's optimal inflation choice in an election period can be found by taking the first derivative with respect to p_t of the expectation of (13a) conditional on ϵ_t and subject to (4), (5), (6) and (15). Supposing that $x_\theta + p_t - p_t^e + \epsilon_t \geq 0$, the first-order condition takes the form

$$0 = c - a(p_t - p_t^e + \epsilon_t) - b(p_t - p_{t-1}) + \frac{\delta(r^g + cd/b)}{2x_\theta}. \tag{16a}$$

(16a) implies that the rational price level expectation is:

$$p_t^e = p_{t-1} + \frac{c}{b} + \frac{\delta(r^g + cd/b)}{2bx_\theta}. \tag{16b}$$

Substituting (16b) into (16a) and using (5) and (6), the equilibrium in an election period is obtained:

$$w_t = \frac{c}{b} - l^n + \iota_t\theta_{t-1} + \frac{\delta(r^g + cd/b)}{2bx_\theta}, \tag{16c}$$

$$\pi_t = \frac{c}{b} - \frac{a}{a+b}\epsilon_t + \frac{\delta(r^g + cd/b)}{2bx_\theta}, \tag{16d}$$

$$l_t = l^n + \frac{b}{a+b}\epsilon_t + \theta_t, \quad t = 1, 3, 5 \ldots . \tag{16e}$$

We have made two assumptions to arrive at these solutions. The first one was that individuals vote for the incumbent if and only if $l_t - l^n > 0$. This can now be justified by noting that from (16e)

$$E(\theta_t|l_t) = \frac{\sigma_\theta^2}{\sigma_\epsilon^2 b^2/(a+b)^2 + \sigma_\theta^2}(l_t - l^n),$$

implying that $E(\theta_t|l_t)$ is positive if and only if $l_t - l^n$ is positive. Since voters wish to re-elect the incumbent only if $\theta_t > 0$, the postulated voting rule is indeed optimal. Our second assumption was that $x_\theta + p_t - p_t^e + \epsilon_t \geq 0$. A sufficient condition for this to be the case in equilibrium is $x_\epsilon \leq x_\theta$. Since we are not interested in cases, in which the

Table 1: Predictions of our Theory

	Dependence	Independence
$E(\bar{\pi})$:	$\frac{\delta(r^g + cd/b)}{4bx_\theta}$	0
$\sigma_l^2 = E(\hat{\sigma}_l^2)$:	$\frac{b^2}{(a+b)^2}\sigma_\epsilon^2 + \sigma_\theta^2$	$\frac{b^2}{(a+b)^2}\sigma_\epsilon^2 + \sigma_\theta^2$
σ_π^2 :	$\frac{a^2}{(a+b)^2}\sigma_\epsilon^2$	$\frac{a^2}{(a+b)^2}\sigma_\epsilon^2$
$E(\hat{\sigma}_\pi^2)$:	$\frac{a^2}{(a+b)^2}\sigma_\epsilon^2 + \frac{\delta^2(r^g + cd/b)^2}{16b^2x_\theta^2}$	$\frac{a^2}{(a+b)^2}\sigma_\epsilon^2$

incumbent has no chance on the margin to improve her re-election prospects through the creation of unexpected inflation, we assume that this condition holds.

Comparing (14b) and (16d) shows that a dependent central bank creates an inflation bias c/b in all periods. Furthermore, in election periods, an additional bias $\delta(r^g + cd/b)/(2bx_\theta)$ arises. The biases are due to the principal-agent problem that stems from the incumbent's motive to collect seigniorage and to win elections. The trade unions understand these incentives and set higher nominal wages. Consequently, voters are not fooled in equilibrium and employment remains unaffected. In other words, our model predicts a political business cycle in inflation but not in employment.

Our theory also predicts that the variances of inflation and employment are unrelated to the status of the central bank; see Table 1 for the analytical details. As regards the variance of employment this is consistent with the cumulative empirical evidence; see e.g. Grilli et al. (1991), Cukierman (1992), Alesina and Summers (1993) and Eijffinger et al. (1998). The prediction of an unaffected inflation variance, in contrast, may seem to contradict the facts. However, this must not be the case, as the standard estimate $\hat{\sigma}_\pi^2 = (1/T)\sum_{t=1}^{T}(\pi_t - \bar{\pi})^2$ is biased when the expectation of inflation varies over time, as it does in our model when the central bank is dependent. Indeed, in contrast to the true variance, the *estimated* inflation variability is negatively related to the degree of central bank independence in our model. We may therefore conclude that our non-normative theory does not contradict the evidence. Note that this is not the case for Rogoff's

theory, which predicts that an independent central bank stabilizes less and therefore increases employment variability.

5 Concluding Remarks

This paper has departed from the observation that we lack a theory of central bank independence that can explain the stability record of the Bundesbank. Time-consistent monetary policy yields excessive inflation even in the model of Rogoff (1985) where the government appoints independent central bankers who are more conservative. We have presented a new theory. The key assumption is that the independent central bank maximizes the welfare of the median voter instead of social welfare. As a result, and in contrast to the standard theory, an independent central banker stabilizes the real economy and, nevertheless, provides zero inflation on average. The reason for this is that our central banker is independent from the government but not from the median voter. The dependent central banker, in contrast, cares about the government's desire to collect seigniorage and to improve the re-election chances. Consequently, an inflation bias cannot be avoided.

The assumption that independent central bankers take the median voter's utility as the policy objective is realistic because the median voter can change the central bank law. Note as a further implication of our theory that central bank independence will be the outcome if the government should put up a referendum on the constitution of the central bank. However, the government of our model may not wish to propose such a referendum because with central bank independence it would loose the grip on seigniorage. Finally, it goes without saying that all results depend on which characteristic of the median voter is made the focal point. We have put the focus on the characteristic of being an insider in the labor market who sets an excessively high wage level and forces involuntary unemployment upon the outsiders. Alternatively, the median voter might be a net creditor; see for example Faust (1996). We leave it to future research to explore what different implications that may have for monetary policy under different central bank constitutions.

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