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ABSTRACT

Theories of rules and discretion suggest that monetary policy rules are first best in terms of social welfare. However, if commitment is not feasible, delegating monetary policy to an independent and conservative central bank can be second best. Monetary policy in Germany during the past one hundred years provides an excellent case to assess the empirical evidence on the use of rules and central bank independence in monetary policy making. Since the creation of a central monetary authority in 1876, Germany has participated in four monetary regimes: the pre-war gold standard, the inter-war gold standard, the Bretton-Woods system, and the floating exchange rate regime.

The bottom line of our analysis is that monetary policy in Germany was always geared toward maintaining price stability with the exception of the two world war periods. Germany relied both on rules and discretion with central bank independence to achieve the goal of price stability. A comparison of the Classical Gold Standard regime with the floating exchange rate regime suggests that society under the floating exchange rate regime with central bank independence was better off. However, this comparison ignores the historical difference in output shocks and the possibility that society became more inflation averse over time.

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Introduction

Theories of rules and discretion have become a corner stone in the formulation of macroeconomic policy. They suggest that monetary policy rules are first best in terms of social welfare. However, if commitment is not feasible, delegating monetary policy to an independent and conservative central bank can be second best. Monetary policy in Germany during the past one hundred years provides an excellent case to assess the empirical evidence on the use of rules and central bank independence in monetary policy making. Since the creation of a central monetary authority in 1876, Germany has participated in four monetary regimes: the pre-war gold standard, the inter-war gold standard, the Bretton Woods system, and the floating exchange rate regime. With the exception of the two world war periods German monetary policy was geared primarily towards maintaining price stability and characterized by a high degree of formal and practical central bank independence.[1]

The period under investigation begins with the first German unification (1871) and ends just before the second German unification (1989). This time period can be divided into three parts: The pre-war period from 1871 to 1913 which coincides with the Classical Gold Standard; the inter-war period between 1924 and 1933, which is also the period of the second gold standard; and the post-war period from 1949 to 1989, which can be divided into two subperiods, the Bretton Woods period (1949 to 1973) and the floating exchange rate period (1974 to 1989).

Policy rules are only feasible when a commitment environment exists. Bordo and Kydland (1992) argued that the Classical Gold Standard established such a commitment environment, and the regression results in section 2 confirm that the Reichsbank, Germany's central bank at the time, adhered to the gold standard rule, although it violated the so-called 'rules of the game'. The Reichsbank's commitment to the gold standard reduced the risk of public debt repudiation through inflation to a minimum and allowed the government to borrow funds in the private capital market. This, according to Bordo and Kydland, was the main motivation for the gold standard rule.

The departure from the gold standard during World War I and hyperinflation after the war

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[1] See Holtfrerich 1988a.

diminished the government's credibility. The Reichsbank was made independent to limit the government's access to central bank credit. Germany joined the reestablished gold standard and the Reichsbank, as the regression results in section 3 show, was fully committed to the new monetary policy rule. Nevertheless, the government faced severe problems in raising funds in the capital markets despite the Reichsbank's new independence and commitment to the gold standard. The simple monetary policy rule was no longer sufficient to appease the public's suspicion that the government could default on its debt again. The government's failure to restore its credibility following hyperinflation deprived it of an important funding resource at a time when fiscal flexibility was needed the most.

Following World War II the monetary authority in West Germany, first the Bank Deutscher Länder and later the Deutsche Bundesbank, was made independent once again. In addition, the Allies forced the new government to balance its budget. West Germany joined the Bretton Woods system which perhaps may be viewed as a new commitment regime. However, over time the Bundesbank was not willing to accommodate the inflationary bias of the Bretton Woods system. The regression results in section 4 show that the Bundesbank shifted its emphasis from pegging the dollar to domestic price stability, and thus contributed to the collapse of Bretton Woods.

Bretton Woods was the last commitment regime in Germany if it was one at all. After its collapse the policy environment was pure discretion. At this point the long tradition of central bank independence became most important. The second part of section 4 examines whether the Bundesbank actually behaved as an independent and conservative central bank. The regression results, which are used to compare the reaction function of the Bundesbank with the reaction function of the government, suggest that the Bundesbank was independent and conservative in the sense of Rogoff's 1985 model.

The bottom line of our analysis is that monetary policy in Germany was always geared towards maintaining price stability with the exception of the two world war periods. Germany relied both on rules and discretion with central bank independence to achieve the goal of price stability. Which regime was more efficient remains unclear. Theory predicts that rules should deliver a better outcome. A

comparison of the Classical Gold Standard regime with the floating exchange rate regime in section 5 suggests that society under the floating exchange rate regime with central bank independence was better off. However, this comparison ignores the historical difference in output shocks and the possibility that society became more inflation averse over time. Adjusting for such differences could mean that rules are first best after all.

In the remainder of this section the theoretical framework of monetary policy rules and central bank independence is explained. Section 2 assesses Reichsbank policy under the Classical Gold Standard. Section 3 analyses the Reichsbank's commitment to the inter-war gold standard and the government's credibility problems following hyperinflation. Section 4 considers the Bundesbank's declining commitment to the Bretton Woods system and investigates whether the Bundesbank was actually independent and conservative. The conclusion in section 6 provides a tentative comparison of the efficiency of the different policy regimes.

1.1 Monetary Policy Rules, Central Bank Independence, and the Phillips Curve

In principle, every equilibrium policy in a model in which the private sector must form expectations about policy decisions must satisfy two requirements. It must be optimal for the policymaker and credible to the public. The latter is called the credibility constraint. Whether credibility constraints are binding for the policymaker depends on the policy environment. Two policy environments are considered, one where credibility constraints are not binding and one where they are.

In the first policy environment credibility constraints are not binding because of a commitment technology that effectively ties the policymaker's hands. Policy is chosen once-and-for-all before the public makes its decisions. Once a policy plan is chosen it becomes too costly to reverse it for economic, political, or other reasons. According to the literature, the policy is chosen under commitment. Monetary systems such as the gold standard contain a commitment technology since it is very costly for the participants to renege.

In the second policy environment, the costs of deviating from a policy plan are very low and

not sufficient to offset the incentives to surprise the private sector. The policymaker can change the policy plan after the public has made its decision. In other words, the policy is chosen under discretion. Yet, since the policymaker's hands cannot be tied, the policy plan must be credible because the private sector does not expect any policy plan to be carried out which leaves an incentive for the policymaker to surprise later on. This means furthermore that policy results under discretion cannot be better than those under commitment since the policymaker faces an additional constraint.

In a simple Phillips curve framework where the government tries to stabilize inflation and output[2]

$$(1.1)\quad y = (\pi - \pi^e) + \epsilon$$

both policy regimes produce the same degree of output stability (variance of output),

$$(1.2)\quad L = E[\pi^2 + \mu(y - k)^2]$$

$$(1.3)\quad y = -\frac{1}{1+\mu}\epsilon$$

but discretion results in a higher rate of inflation (equation 1.4 is the rate of inflation under commitment and equation 1.5 shows the inflation rate under discretion).

$$(1.4)\quad \pi(\epsilon) = \frac{\mu}{1+\mu}\epsilon$$

$$(1.5)\quad \pi(\epsilon) = \mu k + \frac{\mu}{1+\mu}\epsilon$$

The two equilibrium inflation rates differ by the constant μk, which is called the inflation bias under discretion. However, the policy outcome under discretion is identical to the outcome with commitment if k=0. In other words, being able to make a commitment means that the policy maker can commit to

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[2] Equation 1 represents a standard Lucas supply function. The private sector forms inflation expectations not knowing the output shock ϵ. The government, on the other hand , minimizes equation 2 after observing ϵ and using actual inflation as its policy instrument. (Also: μ is the relative weight assigned to output stabilization and k denotes the target level of output which exceeds the natural level of output.)

an output target not different from the natural level of output. This allows us to estimate the policymaker's reaction function in its discretionary form and then test the null hypothesis whether commitments are feasible (H0: k=0).

In reality, policymakers often cannot enter into binding commitments. Thus, the relevant policy regime is more likely to be discretionary. However, it is possible that simple institutional changes improve the discretionary equilibrium. One such institutional change is the appointment of a conservative independent central banker, first proposed by Rogoff (1985).

According to equation 1.5, the inflation bias under discretion increases in proportion to the weight parameter μ. Yet, a higher μ also reduces the variance of output. Rogoff (1985) showed that the government could exploit this trade-off by appointing a central banker who puts a smaller but non-zero weight on output stabilization[3] Compared to pure discretion, where inflation is too high, it is optimal to accept some additional output variation in exchange for a lower inflation rate. Nonetheless, the equilibrium under the independent conservative central banker is still second best to the commitment regime since the credibility constraint remains binding leaving the outcome under discretion with central bank independence inferior to the one with commitment where the credibility constraint is not binding. Moreover, if commitments are feasible (k=0), appointing an independent conservative central banker is not optimal since the inflation bias is zero anyway but a lower μ reduces output stability.

The Reichsbank and the Classical Gold Standard

This section analyzes the policy of the Reichsbank during the 'Classical Gold Standard' (1880-1913). The gold standard is seen as a contingent monetary policy rule and the question is raised whether the Reichsbank adhered to this rule or departed from it by following other domestic policy targets. It

[3] It should be noted that this regime is not purely discretionary although it is still characterized by the Nash equilibrium conditions and the credibility constraint. In this regime it is assumed that the government can effectively commit to an independent central banker implying that the cost of reneging must be infinite. This suggests two possibilities. First, central bank independence requires an economic policy environment in which the costs of breaking the commitment to the independence of the central bank are infinite. Such costs could be that the independence of the central bank is guaranteed in the constitution, is commonly accepted by society, and has enjoyed a long tradition. Second, switching from pure discretion to central bank independence is not feasible unless the previous requirements have been met before.

is shown that the Reichsbank never suspended or endangered convertibility although it violated the so-called 'rules of the game'.

2.1 The Gold Standard As A Contingent Rule

Bordo and Kydland (1992)[4] argue that the gold standard besides functioning as an international exchange rate arrangement and providing macro stability worked as a contingent rule to constrain government policy action. In their model the government uses debt to smooth distortionary taxes over time. In addition to choosing optimal taxes the government can also choose an optimal default rate on its outstanding debt (here the inflation tax). In a commitment regime the government can force itself to honor its outstanding debt and not default via inflation or suspension of payments. If the government cannot engage into a binding commitment - in other words, if it follows a discretionary regime - rational bond holders expect the government to have an incentive to completely default on its outstanding debt. Hence, in a discretionary equilibrium bond holders will not buy any government debt.

Bordo and Kydland argue that the gold standard functioned exactly as such a commitment mechanism. Once a country went on the gold standard it became extremely costly to leave it because of economic and political pressures from both within the country and abroad. Bordo and Kydland also maintain that the gold standard was not a fixed but a contingent rule. The cost of adhering to a fixed rule in the face of large shocks (wars, natural catastrophes, financial crises, or other contingencies) is not optimal. Under a contingent gold standard rule the government maintains the gold standard under all circumstances except when a contingency appears. The gold standard (convertibility) is suspended or relaxed for the duration of the contingency plus an adjustment period (specified in advance) and afterwards resumed under the old conditions.

The success of the gold standard as a contingent rule depends on the reputation of the government or monetary authority's ability to stick to its commitment. Several types of policy action

[4] See also Giovannini (1993) and De Kock and Grilli (1989).

can be seen as a violation of the commitment[5]: repeated devaluation of the currency in terms of gold; outright suspension of convertibility; and delayed resumption or devaluation after a contingency.

Furthermore, certain operating procedures can be considered inappropriate under the gold standard. For example, not playing by the so-called 'rules of the game' is viewed as inconsistent with adhering to the gold standard rule. The 'rules of the game', first used by Keynes, define monetary policy operating procedures for the participants of the gold standard. Unfortunately, there is no unique definition of the 'rules of the game'. Henceforth, it should not be surprising that findings of violations of the 'rules of the game' vary with the definition used.[6] Nevertheless, adherence to the 'rules of the game' can be assumed if monetary policy accelerates the adjustment of the balance of payments or stabilizes the exchange rate around parity to avoid a violation of the gold export points.

Besides violating the 'rules of the game', keeping insufficient reserves and maintaining a small liquidity ratio (ratio between reserves at the central bank and notes issued) was considered inappropriate. Devaluation, suspension, and delayed resumption were not a problem in Germany during the period of the 'Classical Gold Standard'. However, many scholars claim that the Reichsbank violated the 'rules of the game' and did not maintain a stable liquidity ratio.[7]

2.2 The Reichsbank's Discount Rate Policy, Convertibility, and the 'Rules of the Game'

Although the Reichsbank used various other policy instruments, the discount rate was by far its most important policy tool[8]. The Reichsbank, like many other central banks at the time, followed the so-called 'real bills doctrine' and considered it to be its duty to discount all bills of exchange as long

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[5] Bordo and Kydland (1992) call these actions 'discretion under the gold standard'.

[6] See Nurkse (1944), Bloomfield (1959), McGouldrick (1984), Giovannini (1986) and McKinnon (1993).

[7] See Bloomfield (1959), Bopp (1954), McGouldrick (1984), Mosbacher (1974), Plenge (1913), Seeger (1968), and Sommariva and Tullio (1987).

[8] 'The adjustment of the 'discount rate' is the only effective means for regulating the domestic demand for money. For influencing cash movements between home and abroad,'the discount rate', it is true, is not the only means, but, the most important and effective.' See 'The Reichsbank, 1876-1900' p.205.

as they met the legal requirements[9]. Since the Reichsbank tried under all circumstances to avoid rationing of central bank credit, the discount rate was the most effective tool to regulate the demand for Reichsbank credit[10].

Besides regulating domestic money demand, the discount rate was also used to influence the flow of capital and gold between home and abroad. A temporary or permanent increase of the discount rate relative to the discount rates in other countries caused an inflow of short-term and long-term capital respectively. The Reichsbank also used devices to promote gold imports, but with limited success[11]. With the discount rate the most important instrument of the Reichsbank, the question naturally arises whether the Reichsbank's discount rate policy was consistent with its commitment to the gold standard.

According to the traditional story, a central bank adhered to the 'rules of the game' if it used monetary policy to maintain external balance. Two objectives were important to maintain external balance. First, to stabilize the exchange rate around parity. Second, to speed up the adjustment process of the balance of payments. Maintaining exchange rate stability indirectly serves the objective of reducing gold flows since it prevents the exchange rate from depreciating below the gold-export point or appreciating above the gold-import point. This implies that a central bank playing by the 'rules of the game' was supposed to increase its discount rate when faced with a depreciating currency or a balance of payments deficit. Rising interest rates would lower the price level and thus decrease the trade deficit - cause the price specie flow mechanism to operate - and attract capital from abroad. A central bank was supposed to decrease the discount rate when experiencing a balance of payments

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[9] Max Schinkel testifying before the 'German Banking Inquiry of 1908' said: 'if the quality of the bill satisfies the Reichsbank, it takes any amount that is sent to it, at the official rate'; See 'German Banking Inquiry of 1908' vol.I, pp.377/8.

[10] 'As the Bank cannot, without great severity, arbitrarily refuse applications for credit, provided they meet the requirements of the Bank Act, it has no other alternative but to regulate calls for credit indirectly by adjusting the interest rate at which it is ready to grant credit.' See 'The Reichsbank, 1876-1900' pp.204/5.

[11] See 'The Reichsbank, 1876-1900' p.205 and Bopp (1954) pp.186/7. The Reichsbank could only hinder gold exports by refusing to redeem its notes at branch offices, however, it was required at all times to redeem its notes at the headquarters in Berlin.

surplus and appreciating exchange rates. Furthermore, a central bank's credit policy geared primarily to movements in central bank's reserves was supposed ... to have the effect of increasing central bank holdings of income earning assets when holdings of external reserves rose, and of reducing domestic assets when reserves fell'[12].

Bloomfield (1959) analyzed these relations for Germany and ten other countries during the 'Classical Gold Standard' period. He found that while the discount rate rose when the liquidity ratio fell, the Reichsbank's holdings of earning assets in more cases moved in the opposite than in the same direction to reserves. Bloomfield concluded that the Reichsbank tried to stabilize the liquidity ratio but at the same time violated the 'rules of the game'[13].

The short-coming of the traditional 'rules of the game' approach is that it focuses only on the outcome of monetary policy relative to some ad-hoc criteria but does not investigate whether a central bank's monetary policy was consistent with convertibility. In particular, analyzing the correlation of target variables like gold reserves or exchange rates with policy instruments like central bank credit or interest rates, relative to some ad-hoc benchmark, cannot determine whether a central bank's objectives are inconsistent with maintaining convertibility. To test a central bank's commitment to the gold standard it seems important to analyze its reaction function. The reaction function in turn should be derived from an explicit optimization problem that contains a trade-off between maintaining convertibility and some other target.

For this purpose, a simple model of exchange rate determination must be found. The simplest exchange rate model is probably based on the uncovered interest parity assumption. According to uncovered interest parity, the expected change of the exchange rate is identical to the interest rate differential.

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[12] See Bloomfield (1959) p.47.

[13] See Bloomfield p.30 and p.49.

(2.1) $e_t - e_{t+1}^E = -(d_t - d_t^{UK})$.

Equation 2.1 is the uncovered interest parity identity[14], e_t is the log of the current period's exchange rate (M/£), e_{t+1}^E is the log of next period's expected exchange rate, d_t is the domestic discount rate, and d_t^{UK} is the foreign (British) discount rate. Under the commitment regime, it can be assumed that the expected exchange rate and the parity exchange rate are identical ($e_{t+1}^E = \bar{e}$). If the Reichsbank was committed to maintain convertibility it would have stabilized the exchange rate around parity. A prolonged deviation of the exchange rate from parity would have implied a regime shift from commitment to discretion. Thus, the Reichsbank's objective function can be formulated as a quadratic loss function.[15]

(2.2) $\min \; (d_t - \bar{d}_t)^2 + \mu(e_t - \bar{e})^2$

Equation 2.2 specifies the Reichsbank's objective function with a trade-off between stabilizing the exchange rate around parity and smoothing the discount rate around some target $\bar{d}_t$. The parameter μ measures the weight of the exchange rate target in the objective function. A zero weight would indicate that the Reichsbank did not stabilize the exchange rate and therefore violated its commitment to convertibility.

Choosing discount rate smoothing as an alternative objective of the Reichsbank is not arbitrary. The heads of the Reichsbank and leading German monetary economists at the time thought that it was the main responsibility of the Reichsbank to accommodate the demand for central bank credit in order to stabilize the money market.[16]

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[14] For a derivation of equation 1 see Rivera-Batiz and Rivera-Batiz (1985) pp.70/1.

[15] The quadratic loss function is commonly used as a utility or objective function in micro and macroeconomic applications. Most appealing is its simplicity and certainty equivalence property. However, the use of quadratic loss functions for regression purposes can cause an estimation bias if asymmetries exist.

[16] Helfferich (1899) p.315: 'The adaption of the quantity of money in circulation to the fluctuations of the demand for means of payments is, as is generally recognized, the most important task of central banks.' Von Lumm in 'Die Stellung der Notenbanken in der Volkswirtschaft' said: '... in times of money scarcity, surprisingly large quantities of commercial paper have been thrown into the portfolio of the Reichsbank which the latter could not prevent it.' Cited in Flink (1929) p.26.

The Reichsbank adapted its money supply to the fluctuations of money demand by keeping its discount rate as low and stable as possible[17]. The Reichsbank's discount rate reaction function is found by solving its minimization problem subject to equation 2.1.

$$(2.3)\quad d_t = \frac{1}{1+\mu}(\bar{d}_t + \mu d_t^{UK})$$

Equation 2.3 has been estimated using a non-linear least squares method. The regression is based on a monthly sample from 1880 to 1913. The discount rate target ($\bar{d}_t$) is specified as a 12 month moving average of the discount rate. Table 1 contains the regression results of equation 2.3.[18]

Table 1

Reichsbank reaction function (equation 2.3), 1881:1 - 1913:12, sa

μ	R^2	Q(19)*
0.144*	91	15.5
0.021		

Standard deviations are in the second row ,below the parameter estimates
a) Ljung Box Q-statistic for autocorrelation
* significant at the 1% level

The weight parameter for the exchange rate target in table 1 is significantly different from zero. On average, to justify a deviation of the discount rate from target by 1 percentage point the expected depreciation of the exchange rate from parity must be at least 2.6%. This basically means that the Reichsbank did not use the discount rate to correct temporary violations of the gold points and, thus,

[17] Von Lumm (1912) p.135: 'In the general interest of stimulating national economic activity, the central bank must constantly take into consideration maintenance of as low and stable a discount rate as conditions permit.' Von Lumm's statement must be taken with a bit of caution. By 'stimulating national economic activity' he did not mean that the central bank should pursue an activist monetary policy in the modern sense but merely accommodate credit demand.

[18] The data sources are discussed in the appendix. All the variables used are stationary and seasonally adjusted.

did not play by the 'rules of the game'.[19] The fact that the M/£ exchange rate violated the gold points only on a few occasions[20] must be attributed to factors other than the Reichsbank's direct efforts to stabilize the exchange rate. Most stabilizing were probably exchange rate expectations by market participants who were convinced that the government was committed to maintaining convertibility. Indeed, temporary violations of the gold points are not inconsistent with convertibility as long as the average exchange rate does not deviate from parity over time. The fact, that the Reichsbank was willing to increase its discount rate permanently by two percentage points to avoid a 5% depreciation suggests that it was committed to keeping the exchange rate close to parity. This result becomes even more evident when using annual rather than monthly data. Table 2 presents the estimation results of equation 2.3 using annual instead of monthly data.

Table 2

Reichsbank reaction function (equation 2.3, annual data), 1983 - 1913

μ	R^2	Q(6)
0.41*	47	7.67
0.22		

* significant at the 5 % level

According to table 2, maintaining convertibility at parity has a positive and significant weight. To justify an increase in the discount rate by a full percentage point over the year, the Reichsbank had to expect the exchange rate to deviate by 1.5% from parity. In other words, the Reichsbank would increase the discount rate by 3.3% to avoid a permanent devaluation of the Mark by 5%, which means

[19] Gold export points were usually 0.5 % above parity, see Giovannini (1993) figure 4. In other words, the Reichsbank would increase the discount rate by only 0.19 percent points in response to a violation of the gold export point.

[20] See Giovannini (1993) pp.31/2.
During the period from 1880 to 1913 the M/£ exchange rate was on average 0.006 M/£ below parity (20.43 M/£), the variance of the deviation from parity was just 0.002.

effectively doubling the average level of the discount rate. This indicates clearly that the Reichsbank's discount rate policy was consistent with maintaining gold convertibility and the gold standard rule.

Summarizing, these findings give rise to the following conclusion. Judged by its discount rate policy, the Reichsbank did not really play by the 'rules of the game' since it did not pay much attention to temporary violations of the gold points. However, violating the 'rules of the game' does not necessarily mean that the Reichsbank was not committed to the gold standard rule. The 'rules of the game' are merely an operating procedure and are not a necessary precondition for the gold standard rule. By temporarily departing from the 'rules of the game' flexibility can be obtained to accommodate fluctuations in the credit market. As long as this practice does not threaten convertibility, it is not inconsistent with the gold standard rule. The regression results, on the other hand have clearly demonstrated that the Reichsbank was fully committed to convertibility.

The Reichsbank in the Inter-war Period

The Reichsbank's involvement in economic policy making changed after 1923 compared to the period before currency stabilization and even the pre-war period. The Reichsbank was made completely independent from the government and became actively involved in economic policy. Under the leadership of its president, Schacht, the influence and power of the Reichsbank increased to such an extent that it has been labeled the 'Extra Government'[21]. During the inter-war gold standard the Reichsbank became the symbol for currency stability in Germany. Despite increasing internal and external pressures the Reichsbank defended its commitment to the gold standard successfully. However, critics of the Reichsbank point out that the price for this uncompromising policy was too high, namely depression and the loss of democracy in Germany.

The Reichsbank's commitment to currency and price stability, can be tested using the macroeconomic model described in section 1.

Equation 3.1 is the aggregate supply function which incorporates a trend term (z_t, which

[21] See Müller (1973) pp.38/43.

(3.1) $y_t = z_t + \alpha(p_t - w_t) + u_t$

(3.2) $m_t - p_t = y_t + v_t$

captures technical progress and other supply conditions), a real wage term ($p_t - w_t$), and a random shock term (u_t). Equation 3.2 is the aggregate demand function which is based on the quantity theory of money.[22] Wage setters are supposed to stabilize the expected real wage around some target (ω_t). Thus, each period they set the nominal wage equal to the expected price level (p_t^e) plus their real wage target.

(3.3) $w_t = p_t^e + \omega_t$

Inserting equation 3.3 into equation 3.1 yields a standard Lucas supply function.

(3.4) $y_t = z_t + \alpha(p_t - p_t^e) - \alpha\omega_t + u_t$

In equilibrium output and prices are determined as follows:

(3.5) $y_t = z_t + \frac{\alpha}{1+\alpha}(m_t - m_t^e) - \alpha\omega_t + \frac{1}{1+\alpha}u_t$

(3.6) $p_t = -z_t - v_t + \alpha\omega_t + \frac{1}{1+\alpha}(m_t + \alpha m_t^e - u_t)$

Supposing the monetary authority can actually observe the output shocks (u_t) after wages have been set implies that it can stabilize output. Whether the monetary authority would do so depends on its preferences between, say, price stability and output stability.

(3.7) $\min\ (p_t - p_{t-1})^2 + \mu(y_t - g_t)^2$

(3.8) $g_t = y_{nt} + \beta = z_t - \alpha\omega_t + \beta$

Equation 3.7 specifies the monetary authorities objective function. The output target (g_t) is defined as the natural rate of output (y_{nt}), derived by taking the mathematical expectation of equation 3.5, plus some scale factor (β). The solution to the optimization problem in equation 3.7 depends on the

[22] v_t is the reciprocal of the log of money velocity. To simplify the model, v_t is assumed to be non-stochastic.

policy environment. As demonstrated in section 1, if the output target is identical with the natural output the outcome under discretion is identical to the outcome with commitment. Thus, assuming that setting the output target equal to natural output is only feasible under commitment provides a powerful test method for distinguishing the commitment policy environment from the discretionary policy environment. In other words, by first deriving the reaction function under the assumption that the policy environment is discretionary and then testing whether β is zero, it is possible to determine the policy environment. Equation 3.9 is the monetary authority's reaction function that minimizes the quadratic loss function under discretion and subject to equations 3.5 and 3.6 using money supply (m_t).[23]

$$(3.9)\quad m_t = p_{t-1} + v_t + z_t - \alpha\omega_t + \alpha\mu\beta + \frac{1-\alpha\mu}{1+\alpha^2\mu}u_t$$

Equation 3.9 has been estimated in a two step procedure. In the first step, equation 3.1 has been estimated to obtain estimates for z_t, α, and u_t.[24] In addition, the real wage target (ω_t) has been approximated by a lag function of the actual real wage plus a constant and a trend. In other words, ω_t is equal to the real wage minus the regression residual of the following regression:

$$(3.9a)\quad w_t - p_t = \rho_0 + \rho_1 t + \sum_{i=1}^{4} \sigma_i(w_{t-i} - p_{t-i}) + \epsilon_t$$

[23] The Reichsbank controlled its money supply primarily using the discount rate and credit restrictions. See Northrop (1938) pp265-9.

[24] z_t in equation 1 has been approximated by a constant, trend, and four quarterly lags of y_t. Further lags of y_t were not included since the inclusion did not improve the regression results but limited the sample size unnecessarily.

Table 3

Aggregate supply function (equation 3.1), 1926:1 - 1932:4

constant	trend	y_{t-1}	y_{t-2}	y_{t-3}	y_{t-4}	α	R^2	LM[a]	Q(5)[b]
0.161****	0.0095***	0.94*	-0.33	0.09	0.13	1.05**	84	2.07	3.46
1.04	0.0052	0.19	0.28	0.28	0.22	0.46			

a) Breusch - Godfrey LM first order autocorrelation statistic; b) Box - Pierce Q - statistic for serial autocorrelation
*, **, ***, **** significant at the 1, 2.5, 5, 10 % level

Table 4

Real wage target (equation 3.9a), 1926:1 - 1932:4

ρ_0	ρ_1	σ_1	σ_2	σ_3	σ_4	R^2	LM
-0.013	0.0067*	0.47*	-0.20	0.14	0.01	95	2.32
0.018	0.0031	0.20	0.21	0.21	0.20		

* significant at the 5 % level

According to table 3, the real wage elasticity of supply (α) is close to minus one. The trend of the aggregate supply function is positive, consistent with the fact that productivity actually increased throughout the period. The results in table 4 suggest that labor unions set the growth rate of the real wage target equal to one half the growth rate of the real wage in the previous period plus 0.7 percentage points.

In the second step the results of tables 3 and 4 have been used to estimate equation 3.9. Given the estimates for z_t, α, u_t, and ω_t, the only parameters to be estimated are β and μ.[25] Table 5 contains the regression results of equation 3.9.

Table 5

Reichsbank reaction function (equation 3.9), 1926:1 - 1932:4

β	μ	R^2	DW
-0.6	0.08	70	1.27
0.11	0.09		

[25] v_t has been computed using the equation of exchange.

Both parameters are not statistically different from zero. Commitment was feasible and the Reichsbank adhered to the gold standard (β=0). However, if this was the case the Reichsbank should not have put a zero weight on its output stabilization objective (μ=0). In section 1 it had been shown that under commitment an independent central bank should be as inflation averse as the public and not more. An independent and conservative central bank under commitment is inefficient. In other words, if monetary policy bears any responsibility for the economic instability in the inter-war period the main reason seems to be that the Reichsbank was overly concerned about price stability and failed to concentrate appropriately on output stabilization.

The fact that the Reichsbank overemphasized its commitment to price stability and the gold standard likely reflects a lack of commitment on the part of the government. In contrast to the Reichsbank, the government did not seem much concerned with reestablishing its credibility and demonstrating its commitment to price stability. Such a lack of commitment implies that the government should have had difficulty in borrowing funds. In fact, the inter-war government had tremendous difficulties in raising funds from the capital market.

Borchardt (1978) challenged the traditional view that Brüning, chancellor from 1930 to 1932, was primarily responsible for the collapse of the Weimar Republic because of his deflationary budget policy. Borchardt claims that Brüning's manoeuvrability was too restricted to adopt a Keynesian policy solution.[26] Holtfrerich (1982) criticized Borchardt's thesis, claiming that Brüning had a policy option but deliberately chose the route of fiscal deflation.[27]

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[26] Borchardt argued that Brüning had no alternatives to his policy of fiscal deflation because the government was forced to balance the budget since it could not get any credit from either the capital market or the Reichsbank. Domestic and foreign creditors, according to Borchardt, stopped lending to the government because the latter made itself uncreditworthy through excessive borrowing during the boom of 1927 ; See Borchardt (1990) pp.112/7. Secondly, financial support through the Reichsbank was not feasible, according to Borchardt, because the autonomous Reichsbank was committed to currency stability and changing the Bank Act was not at Germany's discretion since the Bank Act was part of a system of international treaties: See Borchardt (1979) pp.168/74.

[27] According to Holtfrerich, Brüning could have pursued an alternative policy. Holtfrerich bases his hypothesis on three arguments. First, he argues that Borchardt's 'inevitability' hypothesis is bound to overlook the 'factor of freedom of action in history - that is the possibility to do otherwise than was done.' Second, he points out that alternative policy plans were discussed among cabinet members and could not have been unknown to Brüning. Third, he maintains that Brüning choose his policy of fiscal deflation deliberately since he wanted to discipline wage demands, lower social expenditures, and force the Allies to drop their reparation demands. See Holtfrerich (1982) pp.613/31.

Our purpose is not to participate in this discussion in any detail but to link the events in Germany during the depression with the predictions of economic theories that emphasize the role of rules in economic policy-making. In section 2 it had been shown that fiscal policy faces a credibility constraint unless the government possesses a commitment technology that prevents it from defaulting on its outstanding debt. The German government broke its gold standard commitment when it decided to continue its inflationary policy after the war. As a result, the government lost its credit rating. A successful return to the capital market was only possible if the government restored its credibility. Redemption of the old debt and commitment to a new and credible rule seem necessary conditions for a successful comeback.

a) **Redemption of Old Government Debt:**

The redemption of old government debt following hyperinflation was regulated under the Loan Redemption Act of 1925. At that time, the total government debt was approximately 82 billion RM.[28] Existing loans were converted into new loans at a rate of 40:1. With the exception of 'old holders' (those who bought bonds before July 1, 1920 and held them continuously since then), annuities were not prescribed and interest payments were postponed until the extinction of the reparations liability. 'Old holders' (about 60% of the total debt) participated in a lottery each year. The lottery each year selected the holders of 3.5% of the debt held by 'old holders'. Selected holders were paid five times the value of the revalued debt (i.e. 12.5% of the original debt) plus 4.5% annual interest on the revalued debt.[29]

b) **New Commitment Technology:**

Germany under the pressure of the Allies joined the new international gold standard. To enforce the gold standard commitment and protect the central bank from the credit demands of the government,

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[28] See Wunderlich (1929) p.32.

[29] See Holtfrerich (1986) pp.327/30.

the Reichsbank was made independent from the Reich but remained subject to foreign control. In addition, credit to the government was limited to a small amount. Compared with the pre-war gold standard, this new commitment technology seemed much stronger in the sense that it limited the government's access to central bank credit. Moreover, the regression results demonstrate clearly that the Reichsbank was fully committed.

Nevertheless, despite partial redemption and a new monetary policy rule the government had severe problems in raising funds in the domestic capital market. The budget surpluses of the stabilization years (1924-1925) began to erode as early as 1926. In fiscal year 1926-1927 the public sector deficit amounted to 1.7 billion RM (2.3% of GNP). The surge of the public deficit was largely the result of increased spending by local and regional authorities which were given more fiscal autonomy by the fiscal law of February 1924. Foreign capital played an important role in the funding of the rising public deficit.[30] However, when the Reich floated a loan of 500 million RM at 5% interest in 1927 the market value of the new bonds fell from 92.0RM to 86.9RM within five months and the loan had to be converted to 6% interest to maintain the price.[31] Yet, the government's low credit rating did not become fully visible until 1929 when the supply of foreign funds began to dry up. Against warnings by the Reichsbank, the Reich floated a 500 million RM loan in 1929 (the so-called Hilferding Loan) of which only 177 million RM could be placed despite huge tax incentives (no wealth, inheritance, and income tax on the loan).[32] The Hilferding Loan was the last loan the Reich attempted to float domestically and after the Young Loan in 1930 the Reich issued no further bonds abroad.

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[30] Capital inflows from abroad were basically triggered by the large interest rate differential between Germany and the United States, as well as by regained international confidence in the RM following the stabilization years. The Reichsbank welcomed the use of foreign funds to rebuild Germany's industrial base but was very critical of the use of foreign funds by public authorities.

[31] German bond prices began to slip abroad at the same time. During the fiscal year of 1927/8 German first class bond prices began to fall in New York while Moody's AAA U.S. bond prices rose; See balderston (1983) p.407. Part of the decline of German bond prices in New York was the result of Parker Gilbert's (the Agent General for Reparations) public criticism in October 1927 of the conduct of German public finances.

[32] See James (1985) p.53.

Table 6

Increase in German government debt, million RM

Fiscal year*	1926/7	1927/8	1928/9	1929/30	1930/1	1931/2	1932/3
Increase in public debt	1742	1075	3561	3159	2704	155	170
as % of GNP	2.3	1.3	4.0	3.6	3.4	0.2	0.3

Source: James (1986) p.52
* April 1 to March 31

The strength of Borchardt's hypothesis that the government was forced to balance its budget is its consistency with the theoretical prediction. The experience of hyperinflation had taught the German public that exploding public deficits increase the temptation for the government to monetize the debt. The Reichsbank's independence and commitment to the gold standard reduced the risk that the government could use monetary policy to finance its expenditures. Nonetheless, the Reichsbank's commitment to the gold standard did not guarantee that the government would exercise fiscal discipline.

The public probably remained suspicious that rising deficits could eventually cause the government to break the Reichsbank's independence and use monetary policy to finance its expenditures. In fact, one could argue that 'through the light-minded borrowing during the boom Germany has made itself uncreditworthy during the recession.'[33] A fiscal policy rule that would have ensured that deficits remained limited would probably have improved the government's credit rating, which would also have increased the Reichsbank room to target output and inflation. Furthermore, the partial redemption of old debt was probably insufficient to restore the government's credibility.

Holtfrerich (1986) considered the settlement of the debt redemption as reasonable since it left German bond holders not much worse off than bond holders in other countries. However, what really matters is probably not how fair the redemption was but whether it was sufficient to restore the

[33] Letter from Prof. M. J. Bonn to State Secretary Schäffer, September 10, 1931; cited in Borchardt (1990) p.116.

government's credit rating.[34] In fact, one could argue that 'through the light-minded borrowing during the boom Germany has made itself uncreditworthy during the recession.'[35] A fiscal policy rule that would have ensured that deficits remained limited would probably have improved the government's credit rating, which would also have increased the Reichsbank room to target output and inflation. Furthermore, the partial redemption of old debt was probably insufficient to restore the government's credibility.

In summary, the pre-war government was able to borrow funds without difficulties by simply committing itself to the gold standard. The same, so it seems, was not true for the inter-war government. Although the Reichsbank was made independent and was clearly committed to the gold standard, the government had severe problems in raising funds in the capital market. This suggests that by breaking the gold standard commitment through hyperinflation the government lost all its credibility. It could not be restored through the Reichsbank's independence and commitment to the gold standard. This aggravated the problems of the inter-war period. The Reichsbank saw itself isolated in its attempt to secure currency and price stability. As a result, it ignored output stabilization completely. The government, on the other hand, deprived itself of an important resource of funding, constraining its flexibility at a time when fiscal spending was needed the most.

The Deutsche Bundesbank During the Post-War Period

After more than thirty years of political and economic instability post-war Germany enjoyed high and stable growth and one of the lowest inflation rates world wide. These developments have in

[34] Balderston (1982) argued that '... by repudiating its own debt at the revaluation of 1925, the post-stabilization Reich destroyed its own credit, on a market that was weak anyway, and dug a hole for itself that it could not climb out of when the depression came.'

[35] Letter from Prof. M. J. Bonn to State Secretary Schäffer, September 10, 1931; cited in Borchardt (1990) p.116.

part been attributed to the stability of Bundesbank policy. This section shows that the Bundesbank was primarily focused on controlling inflation. The first part assess the growing conflict between the Bundesbank's inflation objective and the Bretton Woods system. The main conclusion is that the Bundesbank by adhering to its inflation target probably contributed to the collapse of the Bretton Woods system. The second part tests the properties of central bank independence in the case of the Bundesbank. The results suggest that the Bundesbank is independent in the sense that it is more inflation averse than the government and has not been influenced by electoral or partisan politics.

4.1 The Deutsche Bundesbank and the Bretton Woods System

Germany's experience with the Bretton Woods system was marked by a persistent balance of payments surplus, constant fear of imported inflation, and the struggle over revaluation. During the Bretton Woods period, inflation in Germany was lower and productivity growth and real interest rates were higher than in most industrialized countries.[36] As a result, Germany's balance of payments tended to be in surplus most of the time. The balance of payments surplus, in turn, had an expansionary impact on Germany's money supply, threatening price stability.

The Bundesbank attempted to solve this dilemma by sterilizing foreign reserve inflows and isolating the capital account from the effects of higher real interest rates. The latter was accomplished through capital controls, especially high reserve requirements on foreign deposits. This strategy was quite successful until the return to convertibility in 1958.[37] Convertibility and increasing capital mobility made it more difficult to sterilize foreign reserve inflows. In response, Germany resorted to tighter capital controls.[38] However, by the late 1960s and early 1970s it became nearly impossible to prevent large inflows of speculative capital attracted by high real interest rates and expectations of

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[36] See Bordo (1993) Table 1 and Obstfeld (1993) Table 1.

[37] See Obstfeld (1993).

[38] The controls included measures such as prohibiting interest payments to foreigners, higher reserve requirements on foreign deposits, restrictions on borrowing abroad, and restrictions on the purchase of domestic bonds by non-residents. See Marston (1993).

currency revaluation.[39] As a result, the Bundesbank was left with two alternatives: either to support the Bretton Woods system and to adjust its money supply to the balance of payments disequilibrium or follow a purely domestic policy and risk the break-up of the exchange rate system.

The hypothesis that the Bundesbank was not willing to adjust its monetary policy to external disequilibria can be tested using a simple reaction function model. In a fixed exchange rate regime, external disequilibria occur whenever the fixed value of the currency and its fundamental value depart (here assumed to be determined by purchasing power parity). Thus maintaining an external equilibrium without adjusting the parities requires adjusting the fundamental value of the currency to its fixed value. Using the purchasing power parity concept, the fundamental value of the currency is simply the difference between the domestic and the foreign price level. If the Bundesbank was primarily interested in maintaining an external equilibrium then stabilizing the exchange rate at parity should have been of much higher priority than, say, controlling inflation. Thus, the Bundesbank's optimization problem could be characterized as follows.

$$\text{(4.1)} \quad \min \pi_t^2 + \mu(e_t - \bar{e})^2$$

$$\text{(4.2)} \quad e_t = p_t - p_t^*$$

$$\text{(4.3)} \quad m_t - p_t = \gamma + \phi y_t - \lambda i_t$$

Equations 4.1 to 4.3 specify the Bundesbank's optimization problem.[40] The Bundesbank minimizes a quadratic loss function by controlling the money supply (m_t) subject to the purchasing power parity condition and the money demand function.[41] The resulting reaction function is given in equation 4.4.

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[39] See Obstfeld (1993) and Kindelberger (1976) pp.142/6.

[40] $\pi_t = p_t - p_{t-1}$ (quarterly inflation rate).

[41] All variables are in logs except for the interest rate (i_t). The exchange rate (e_t) is the DM/$ rate and the foreign price level (p_t^*) is the U.S. price level.

$$(4.4)\quad m_t = \gamma + \phi y_t - \lambda i_t + \frac{p_{t-1} + \mu(p_t^* + \tilde{e}_t)}{1 + \mu}$$

Any estimation of equation 4.4 requires the assumption that the Bundesbank in fact used money supply as its control variable. In practice, however, the Bundesbank did not use any monetary aggregate as control or intermediate target variable before 1975. Instead, it targeted banks' liquidity positions.[42] Nonetheless, the use of central bank money[43] as the Bundesbank's control variable can be justified for two reasons. First, although the Bundesbank did not officially target central bank money before 1975 it controlled it indirectly to determine the supply of money. Second, compared to other monetary aggregates central bank money had a stable relation with the price level, output, and interest rates making it an ideal control variable.[44]

Unit root tests of all variables in equation 4.4 indicate that they are non-stationary but integrated of first order.[45] Engle and Granger (1987) have shown that variables which are non-stationary might have a linear combination which is stationary. Engle and Granger call variables with this property co-integrated and develop several test methods to test for co-integration. Interpreting the relation of co-integrated variables as a long-run equilibrium implies that deviations from equilibrium are stationary. Engle and Granger also show that if a number of variables are co-integrated there exists a specific error correction model that describes the short-run behavior of these variables.

The application in this case is as follows. Although all variables in equation 4.4 are non-stationary there could be a linear combination which is stationary. This relationship would describe the Bundesbank's long-run behavior. The question is whether the inflation target, the exchange rate target,

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[42] See Schlesinger and Bocklemann (1973) pp.171/81.

[43] Currency plus minimum reserves which commercial banks must hold at the central bank. This is identical to a weighted average of the components of M3 with weights 1 for currency, 0.166 for demand deposits, 0.124 for savings deposits, and 0.081 for time deposits.

[44] See Deutsche Bundesbank (1989) and Trehan (1988).

[45] Unit root hypotheses were not rejected at the 10% level for all variables using the standard Dickey-Fuller unit root test. However, after taking first differences the unit root hypotheses were rejected at the 1% level for all variables.

or both targets are included in this long-run relationship. This can be tested by imposing certain restrictions on the co-integration vector.

$$(4.4a)\quad m_t = \gamma + \phi y_t - \lambda i_t + \alpha p_{t-1} + (1-\alpha)(p_t^e + \bar{e}_p)\ ;\quad \alpha = \frac{1}{1+\mu}$$

Equation 4.4a is the linearized form of equation 4.4. Three different combinations can be tested for co-integration: first, no restriction on α; second $\alpha=1$; third $\alpha=0$. According to Engle and Granger co-integration can be detected in a two step procedure. In the first step the co-integrating vector is estimated using standard OLS or NLS. In the second step the regression residuals are tested for stationarity using the Dickey-Fuller regression. Table 7 contains the estimation and test results for the three versions of equation 4.4a which have been estimated using quarterly data for the time period from 1962:1 to 1971:1 .[46]

Table 7

Long-run reaction functions of the Bundesbank (equation 4.4a), 1962:1 - 1971:1

α	γ	ϕ	λ	R^2	DW	DF[a]
0.84	-9.05	1.21	0.002	99	1.70	-5.27**
0.21	0.58	0.05	0.003			
1.00	-9.15	1.21	0.003	99	1.75	-5.21*
	0.56	0.04	0.003			
0.00	-8.53	1.17	-0.004	98	1.01	-3.55
	0.67	0.05	0.003			

a) Dickey-Fuller test statistic for no co-integration
* significant at the 1% level, ** significant at the 5% level

[46] The test statistics for the Dickey-Fuller regressions for co-integration are from Engle and Yoo (1987).

Table 7 suggests that focusing exclusively on the exchange rate target (α=0) was not a long-run equilibrium for the Bundesbank. Instead, the long-run behavior with the highest probability is the one where the Bundesbank focuses entirely on the inflation target (α=1). Yet, the test results show also that the Bundesbank, though with a smaller probability, possibly focused on both targets but assigning a relatively larger weight to the inflation target (α=0.84). All in all, the Bundesbank seemed not willing to adjust its monetary policy to stabilize the Bretton Woods system, which comes as no surprise since the Bundesbank continuously complained that the Bretton Woods system suffered from an inflationary bias.[47]

However, the question still remains how to square these findings with the Bundesbank's complaints that it had to react on many occasions to external pressures.[48] Most likely the Bundesbank adjusted its money supply only partly to changes in the desired money supply and otherwise reacted to short-term shocks. This can be assessed using the error correction representation of the Bundesbank's money supply function.

$$(4.5)\quad \Delta m_t = a + \sum_{i=0}^{n} (b_i \Delta y_{t-i} + c_i \Delta i_{t-i} + d_i \Delta p_{t-1-i} + f_i \Delta p^*_{t-i} + g_i \Delta \bar{e}_{t-i} + h_i \Delta m_{t-1-i}) - k\, EC_{t-1}$$

Equation 4.5 is the error correction form of the Bundesbank's money supply function based on the co-integration model. All terms but the last in equation 5 capture the Bundesbank's short-run reaction to internal and external shocks. The last term (error correction term) captures the adjustment from the deviation from the long-run money supply in the previous period.[49]

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[47] 'It may, from all the experiences in the post-war period, be safely said that our present international system has a clear inflationary bias and a clear bias to the disadvantage of surplus countries.' See Emminger (1967) p.518.

[48] See Emminger (1976) pp.514/17 and Schlesinger and Bockelmann (1973) pp.181/202.

[49] The error correction term (EC_{t-1}) is the difference between the actual money supply and the desired money supply (equation 4.4a) in the last period.

Table 8

Error correction representation of the Bundesbank's money supply function (equation 4.5), 1962:4 - 1971:1

k	a	c_7	d_3	f_6	h_5	R^2	LM[a]
0.22*	0.029*	- 0.004**	-0.33..	0.43***	-0.54*	62	0.13
0.05	0.003	0.002	0.15	0.21	0.15		
k	a	c_7	d_6		h_5	R^2	LM
0.14*	0.029	- 0.006*	-0.22		-0.42*	53	0.38
0.05	0.003	0.002	0.14		0.16		

a) Breusch-Godfrey first order autocorrelation statistic
*, **, *** significant at the 1, 5, and 10% levels

Table 8 contains the regression results for two error correction models. The first corresponds to the co-integration relation where the Bundesbank focuses on inflation and the exchange rate ($\alpha = 0.84$). The second corresponds to the co-integration relation where the Bundesbank focuses only on inflation ($\alpha = 1$). In both cases equation 4.5 was first estimated with eight lags for all first differences. Lags that were insignificant were then eliminated, taking care that this did not induce residual autocorrelation.

In the first case the coefficient on the error correction term (k) reveals that 22% of the previous quarter's discrepancy between the actual and the desired money supply was corrected each quarter. In other words, the Bundesbank reacted to other factors in the short-run and adjusted only a portion of its money supply towards the desired level. The reaction to interest rate changes is

consistent with the prediction of the money demand function although the lag seems very long. The Bundesbank apparently did not react to output shocks, indicating that it did not attempt to fine-tune the economy. The negative reaction to domestic price changes three quarters earlier as well as the positive reaction to foreign price changes six quarters earlier are consistent with the predictions of the long-run model. The Bundesbank also reacted quite significantly to money supply shocks five quarters lagged. These money supply shocks could possibly have been caused by external factors such as balance of payments disequilibria.

In the second case most reactions are similar to the first case. The adjustment to errors in the previous period is somewhat smaller. Moreover, the reaction to changes in the domestic price level, though consistent, is not very significant and much more delayed. All in all, the results in both configurations seems to be consistent with the Bundesbank's complaints that it had on occasion to adjust to external disequilibria.

4.2 Monetary Policy and Central Bank Independence in the Post Bretton Woods Period

During the Bretton Woods period, the Bundesbank already possessed statutory independence[50], after the breakdown of the Bretton Woods system the Bundesbank became completely independent. The first formal argument that central bank independence can actually improve economic policy making was given by Rogoff (1985). Based on the articles by Kydland and Prescott (1979) and Barro and Gordon (1983a,b), he showed that appointing an independent conservative central banker is actually in the interest of both the public and the government.[51]

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[50] Here, statutory independence is defined as formal independence from the executive branch of the government. A central bank is independent from the government if the latter cannot (1) determine the formation and execution of monetary policy, (2) elect and recall officials of the central bank at will, and (3) require the central bank to finance the budget deficit or exercise financial control over the central bank in any other way. Along these criteria, the Bundesbank has been ranked the most independent central bank besides the Swiss central bank by all studies in this area; See Bade & Parkin (1985), Alesina (1988), Grilli, Masciandaro, & Tabellini (1991), Cukierman, Webb, & Neyapti (1991).

[51] See section 1.

The concept of central bank independence contains several testable implications. The argument made by Rogoff would predict that compared to fiscal policy, monetary policy would react more strongly to inflationary pressures and less to output shocks. Furthermore, average inflation should be lower in countries with independent central banks.[52] In addition, an independent central bank should be less inclined to accommodate fiscal deficits and its policy should not be correlated with the electoral cycle or partisan changes in government.

Demopoulos et.al. (1987) and Burdekin and Laney (1988) analyzed the relation between fiscal deficits and monetary constitutions in a cross-country comparison. Both studies concluded that only the independent central banks did not accommodate government budget deficits.[53] Alesina et.al. (1991) and Johnson and Siklos (1992) studied the effects of electoral and partisan variables on monetary policy in OECD countries. All find relatively little evidence for electoral or partisan influence on monetary policy for independent as well as dependent central banks. Nevertheless, they detect that monetary policy in Germany eased before elections in the post Bretton Woods period.

The relation between average inflation and central bank constitutions has been studied by several authors.[54] All find that lower average inflation is associated with higher central bank independence. They also find that the Bundesbank, which is usually ranked as the most independent central bank, does best on this score. Finally, many monetary reaction functions have been estimated to study whether different monetary constitutions have an effect on how central banks react to

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[52] Simple cross-country comparisons of inflation and output growth performances can be misleading if one cannot distinguish differences in inflation and output growth that were caused by different policies from those caused by different economic conditions. In the Rogoff framework, only the mean of inflation is a function of policy variables alone. The variance of inflation as well as of output growth are functions of policy as well as country specific structural variables while the mean of output growth is only a function of country specific structural variables (natural rate). For example, the variance of output growth can be smaller in the country with the more independent central bank because the variance of its output shocks is smaller.

[53] Demopoulos et.al. (1987) actually show that the Bundesbank did accommodate the seasonal increases in the budget deficit. However, using seasonally adjusted data they find that the Bundesbank did not accommodate the budget deficit.

[54] See for example Banaian, Laney, & Willet (1986), Bade & Parkin (1985), and Alesina & Summers (1991).

inflation, unemployment, or fiscal deficits.[55] The results confirmed that the more independent central banks reacted more strongly to inflationary pressures, however, they also tended to ease money supply whenever unemployment rose and accommodated fiscal deficits to some degree. This pattern was particularly strong in the case of Germany.[56]

These findings raise the question whether the so-called independent central banks are actually so independent. Simple cross-country comparisons might be misleading since they only reveal how central banks of varying degrees of statutory independence behave. Yet, their behavior could be a pure reflection of structural differences between countries. Following Rogoff, the degree of independence can best be tested by comparing the reaction of the monetary authority to inflation and unemployment with that of the government in each country separately. The testable implication would be that an independent central bank should react more strongly than the government to inflationary pressures but more weakly to rising unemployment.[57]

Fiscal policy in the form of the budget deficit is certainly a good representative of the government's economic policy. Then, assuming that fiscal and monetary policy both have inflation and output control as policy targets, monetary policy is independent and conservative if it has a higher preference for inflation control. The model for deriving the reaction functions for the Bundesbank (BB) and the fiscal authority (FA) is given by:[58]

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[55] These studies all differ in their choice of dependent and independent variables. However, most of them use either money growth or the interest rate as the dependent variable and a combination of inflation, real growth, unemployment, and fiscal deficit as the independent variables. A summary of most estimation results is given in Bade and Parkin (1985). A more recent attempt to estimate cross country monetary reaction functions has been made by Johnson and Siklos (1992).

[56] See Bade and Parkin (1985) p.27.

[57] To be sure, the idea is not that fiscal policy could actually have a long-run impact on inflation, output, or employment independent from monetary policy. Instead, the purpose of this test is to test whether the government has a different attitude towards inflation and unemployment.

[58] This model is a modification of the model used by Bradley and Potter (1986) who analyzed the reaction functions of the Federal Reserve Bank and the U.S. Treasury. The structure of the theoretical framework is the same for both authorities, however, preferences and views on the economy may differ. Thus, those parameters that may be different are indexed (i = BB,FA).

$$(4.6)\quad \min L_i = (\Delta p_t - \Delta \bar{p})^2 + \mu_i(\Delta y_t - \Delta \bar{y})^2 + \lambda_i(\Delta e_t - \Delta \bar{e})^2$$

$$(4.7)\quad \Delta p_t = \alpha_i \Delta m_t + \beta_i D_t + \Delta p_t^f$$

$$(4.8)\quad \Delta y_t = \gamma_i \Delta m_t + \delta_i D_t + \Delta y_t^f$$

$$(4.9)\quad \Delta e_t = \rho_i \Delta m_t + \sigma_i D_t + \Delta e_t^f$$

When i=BB, equation 4.6 is the Bundesbank's loss function which it minimizes subject to equations 4.7, 4.8, and 4.9 using the growth rate of money supply (Δm_t). The loss function consists of three components; an inflation target (Δp_t,) a growth target (Δy_t), and the DM/$ exchange rate (Δe_t).[59] The exchange rate target has been included since DM/$ exchange rate developments at times had significant impacts on the Bundesbank's monetary policy.[60] When i=FA, equation 4.6 is the fiscal authority's loss function which it minimizes subject to the same constraints using the budget deficit (D_t). Equations 4.7, 4.8, and 4.9 reflect the Bundesbank's and the fiscal authority's view of the structure of the economy. In this case, both use the same model but different parameter values; the rate of inflation, output growth, and the exchange rate changes are each determined by their forecasted values (Δp_t^f, Δy_t^f, Δe_t^f) and the two policy variables.[61] The two reaction functions for the Bundesbank and the fiscal authority are the following:

The constraints (equations 4.7, 4.8, and 4.9) represent only each's authorities view on the economy and not necessarily the true structure of the economy. Furthermore, the model implies that fiscal policy makers think that they could have a permanent effect on inflation and output independent from monetary policy. This certainly neglects the budget constraint of fiscal policy. In reality, this would only be possible if the budget deficit was monetized by the central bank.

[59] The variables in equations 4.6 to 4.9 are the following: p_t is the log of the price level, y_t is the log of real GNP, e_t is the log of the DM/$ exchange rate, Δ is the first difference operator, m_t is the log of central bank money, and D_t is the public sector deficit.

[60] See Bundesbank annual reports 1986-88.

[61] For technical reasons it is assumed that both authorities make identical forecasts.

$$(4.10)\quad \Delta m_t = g_{10} + g_{11}\Delta p_t^f + g_{12}\Delta y_t^f + g_{13}\Delta e_t^f + g_{14}D_t$$

$$(4.11)\quad D_t = g_{20} + g_{21}\Delta p_t^f + g_{22}\Delta p_t^f + g_{23}\Delta e_t^f + g_{24}\Delta m_t$$

$$\begin{aligned}
\textit{Where: } g_{10} &= M^{-1}(\alpha_{BB}\Delta\bar{p}_t + \mu_{BB}\gamma_{BB}\Delta\bar{y}_t + lamda_{BB}\rho_{BB}\Delta\bar{e}_t)\\
g_{11} &= -M^{-1}\alpha_{BB}\\
g_{12} &= -M^{-1}\mu_{BB}\gamma_{BB}\\
g_{13} &= -M^{-1}\lambda_{BB}\rho_{BB}\\
g_{14} &= -M^{-1}(\alpha_{BB}\beta_{BB}+\mu_{BB}\gamma_{BB}\delta_{BB}+\lambda_{BB}\rho_{BB}\sigma_{BB})\\
M &= \alpha_{BB}^2 + \mu_{BB}\gamma_{BB}^2 + \lambda_{BB}\rho_{BB}^2\\
g_{20} &= L^{-1}(\beta_{FA}\Delta\bar{p}_t + \mu_{FA}\delta_{FA}\Delta\bar{y}_t + \lambda_{FA}\sigma_{FA}\Delta\bar{e}_t)\\
g_{21} &= -L^{-1}\beta_{FA}\\
g_{22} &= -L^{-1}\mu_{FA}\delta_{FA}\\
g_{23} &= -L^{-1}\lambda_{FA}\sigma_{FA}\\
g_{24} &= -L^{-1}(\alpha_{FA}\beta_{FA}+\mu_{FA}\gamma_{FA}\delta_{FA}-\lambda_{FA}\rho_{FA}\sigma_{FA})\\
L &= \beta_{FA}^2 + \mu_{FA}\delta_{FA}^2 + \lambda_{FA}\sigma_{FA}^2
\end{aligned}$$

Equations 4.10 and 4.11 are actually nonlinear but are presented as simple linear functions, since each function is underdetermined. The signs of the g coefficients depend upon the signs for the parameters of the constraints. In this case, it is simply assumed that expansionary monetary policy and fiscal deficits increase inflation and output and cause a depreciation of the currency ($\alpha,\gamma,\rho>0$; $\beta,\delta,\sigma<0$), thus money supply growth should react contractionary to predicted increases in inflation, output growth, and currency depreciation ($g_{11},g_{12},g_{13}<0$), the budget deficit should react expansionary to predicted decreases in inflation, output growth, and currency depreciation ($g_{21},g_{22},g_{23}>0$).

Before the reaction functions can be estimated, values for predicted inflation, output growth, and currency depreciation must be constructed. Following Bradley and Potter (1986), forecasts are constructed using a rolling ARMA model for each variable. This is done in a two step procedure. First, an ARMA specification is identified for each variable.[62] Second, each ARMA is estimated for

[62] The inflation rate has been identified as an ARMA(1,8) with Q(8) = 5.2, GNP growth as an ARMA(1,6) with Q(8) = 3.5, and DM/$ rate changes as an ARMA(1,4) with Q(8) = 2.8.

a certain sample and the one-period forecast is stored. Step two is repeated until each forecast series is complete moving the sample one period forward at a time.

Three modification of equations 4.10 and 4.11 have been made before estimation. First, the lagged fiscal deficit has been included into the Bundesbank's reaction function to control for the possibility that the Bundesbank monetizes the budget deficit.[63] This is important since fiscal policy cannot have an effect on inflation and output in the long-run without accommodation by monetary policy. Second, lagged values of the dependent variables have been included in each reaction function to allow for partial adjustment. Third, two dummy variables have been added to test the impact of elections and regime shifts on monetary and fiscal policy.[64] Given these modifications, equations 4.10 and 4.11 are rewritten as:

$$(4.12)\quad \Delta m_t = g_{10} + g_{11}\Delta p_t^f + g_{12}\Delta y_t^f + g_{13}\Delta e_t^f + g_{14}D_t + g_{15}D_{t-1} + g_{16}\Delta m_{t-1} + g_{1e}d_e + g_{1p}d_p$$

$$(4.13)\quad D_t = g_{20} + g_{21}\Delta p_t^f + g_{22}\Delta y_t^f + g_{23}\Delta e_t^f + g_{24}\Delta m_t + g_{25}D_{t-1} + g_{2e}d_e + g_{2p}d_p$$

Equations 4.12 and 4.13 have been estimated by two stage least squares using seasonally adjusted quarterly data for the 1975:1 - 1989:4 period.[65]

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[63] The inclusion of past fiscal deficits has been limited to the one period lagged fiscal deficit since others were statistically not significant.

[64] The election dummy (d_e) takes the value one for the election quarter and the three quarters preceding the election and zero otherwise. For the 1983 election only the first quarter preceding the election takes the value one since a change in government occurred in the second quarter. The regime shift dummy (d_p) is zero for the SPD/FDP coalition government (1975:1-1982:3) and one for the CDU/FDP coalition government (1982:4-1989:4).

[65] The sample begins in 1975 for two reasons. First, the Bundesbank began to control central bank money in 1975. Second, no quarterly data for the total public sector deficit is available before 1974. The sample ends in 1989 to avoid the distortions in money supply caused by German monetary unification in 1990.

Table 9

Bundesbank reaction function with election and partisan dummies (equation 4.12), 1975:1 - 1989:4

g_{10}	g_{11}	g_{12}	g_{13}	g_{14}	g_{15}	g_{16}	g_{1e}	g_{1p}	R^2	LM[a]
0.013*	-0.56*	-0.08	-	-0.10	-	0.31*	-	-	40	0.16
			0.07***		0.28***		0.0009	0.005*		
0.004	0.18	0.11	0.04	0.17	0.18	0.12		0.002		
							0.0018			

FA reaction function with election and partisan dummies (equation 4.13), 1975:1 - 1989:4

g_{20}	g_{21}	g_{22}	g_{23}	g_{24}	g_{25}	g_{2e}	g_{2e}	ρ^b	R^2	LM[a]
-0.002	-	0.09	0.03	0.005	0.70*	-	-	-0.50**	29	0.005
	0.21***					0.0005	0.0005			
0.003	0.14	0.09	0.03	0.095	0.13			0.26		
						0.0011	0.0013			

a) Breusch-Godfrey test for first order autocorrelation; b) autocorrelation coefficient
*,**,*** significant at the 1, 5, 10 % levels.

The results in table 9 show that the Bundesbank primarily focused on price stabilization. The second most important objective seems to be the DM/$ exchange rate. The sign for the output growth target is positive but not significant. These results confirm that the Bundesbank primarily tried to safeguard the value of the currency as is required by the Bundesbank Act. Yet, not consistent with

this objective is the fact that the Bundesbank seems to have been accommodating the government's budget deficit (g_{14} and g_{15} are negative). The estimates also suggest that contrary to earlier findings by Alesina et.al.. (1991) and Johnson and Siklos (1992) the Bundesbank did not ease its money supply before elections.[66] On the other hand, the change in government in 1982 had a significant effect on monetary policy.

The fiscal authority reacted to changes in forecasted output growth in the predicted manner, though the sign is not very significant. It is surprising that the fiscal authority increased its budget deficit when the inflation forecasts rose. The most obvious explanation seems to be that rising inflation reduces the real deficit leaving room for increases in the nominal deficit. Furthermore, the fiscal authority did not react to changes in money supply, suggesting that the fiscal authority determined its policy without direct consideration of monetary policy. Finally, the two political dummy variables have no significant effect on fiscal policy.

All in all, the results confirm that the Bundesbank is independent according to Rogoff's definition. Nonetheless, the Bundesbank seems to have been monetizing the budget deficit somewhat. However, monetizing the budget deficit does not necessarily make the Bundesbank dependent. Alesina and Tabellini (1987) showed that if the social welfare function includes stabilizing the budget deficit then an independent conservative central banker in Rogoff's sense would monetize the budget deficit to some degree but less than the government would. Finally, a structural change (Chow) test applied to separate estimations of the two time periods before and after the change in government in 1982 does not detect a structural change in the Bundesbank's reaction function. The null-hypothesis of no structural change can only be rejected for the fiscal reaction function.[67] In other words, only

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[66] Alesina et.al.. used the growth rate of M1 which the Bundesbank never controlled. Compared to central bank money, M1 behaves quite differently and has no stable demand function. See also Trehan (1988). Their finding that the Bundesbank supported the electoral cycle could be distorted by the selection of an inappropriate policy instrument.

[67] The F-statistic for no structural change for the monetary reaction function is $F(7,46) = 1.26$ and for the fiscal reaction function $F(6,46) = 2.14$.

the fiscal authority but not the Bundesbank was really affected by the change in government.

Conclusion: A Comparison

The aim of the conclusion is to compare the performance of the target variables of monetary policy under the different policy regimes. Theory predicts that if the policymaker is capable of making a commitment the policy outcome will be first best. On the other hand, if the policymaker is not able to make a commitment a second best outcome can still be achieved through central bank independence.

Table 10

Monetary policy regimes

Period	Degree of central bank independence	Policy regime	Commit -ment
1880-1913	Officially dependent Practically independent	Classical Gold Standard	Yes
1925-1932	Officially and practically independent (foreign control until 1930)	Gold exchange standard	Mixed
1950-1973	Officially and practically independent	Bretton Woods system	Mixed
1974-1989	Officially and practically independent	Floating exchange rates	No

Table 10 describes the degree of central bank independence and the monetary policy regime in operation for each time period. The pre-war period was dominated by the gold standard rule. In the inter-war period, monetary policy was independent from the government committed to the reestablished gold standard. Nevertheless, the inter-war period can at the most be characterized as a mixed commitment regime since the Reichsbank's commitment was partly offset by the government's inability to restore its credibility and commit itself to the gold standard.

In the Bretton Woods period, central bank independence characterized the legal and practical status of the monetary authority. However, as seen in section 4, the commitment of monetary policy to the Bretton Woods regime was mixed. The floating exchange rate period, on the other hand, is a clear example of independent and conservative central banking.

Given the mixed nature of the policy regimes in the inter-war and Bretton Woods period as well as other external factors influencing those periods (depression, reconstruction boom) it seems best to limit the comparison to the Classical Gold Standard period and the floating exchange rate period.

Table 11

Comparison of target and policy variables[68]

Period	Target variables			Monetary policy variable		Fiscal policy variable
	Inflation	Output growth	Per capita output growth	Money growth	Velocity growth	Debt-GNP ratio
1880-1913	0.9 (5.7) up	2.9 (8.1) flat	1.7 (8.1) flat	5.7 (23.4) flat	-1.9 (37.8) flat	53.0 (32.8) up
1925-1932	-0.8 (36.9) up	1.2 (92.6) down	0.6 (89.4) down	1.4 (102.3) down	-1.0 (83.3) flat	28.4 (113.4) up
1950-1973	2.4 (7.7) up	6.8 (19.6) down	5.1 (10.8) down	14.7 (39.4) down	-5.5 (47.0) up	18.5 (4.2) flat
1974-1989	3.5 (4.1) down	2.1 (3.6) down	2.2 (3.7) flat	6.2 (19.1) down	-0.5 (30.2) up	34.0 (55.2) up

For a data description see the appendix. Variances are in parentheses underneath each average. The direction of the trend in each period is indicated below the variances. See also figures 1 to 6.

Table 11 exhibits the figures for inflation, output growth, per capita output growth, money growth, money velocity growth, and the debt-GNP ratio for the four periods described in table 10. Inflation and output growth embody the target variables of both monetary and fiscal policy. Money growth and to some extent money velocity are the policy variables of monetary policy. The debt/GNP ratio characterizes the fiscal policy variable. A first examination seems to suggest that the Bretton Woods period did best combining the highest output growth with moderate inflation. By contrast, the

[68] Annual averages

inter-war period appears to be the worst, having the lowest and most unstable output growth as well as a massive deflation. However, as pointed out before, the performances in these two periods were distorted by other factors and are not ideal measures to compare the different policy regimes. A first examination of the inflation and output growth performance during the Classical Gold Standard and the floating exchange rate periods does not provide clear results. In terms of average inflation and output growth the Classical Gold Standard period was clearly the better of the two. Yet, per capita output growth was stronger in the floating exchange rate regime. Moreover, in terms of inflation and output growth stability the floating exchange rate period outperformed the Classical Gold Standard period.

In section 1 it had been shown that in terms of a specific social welfare function (quadratic loss function of inflation and output growth) the commitment regime is first best. This social welfare function can be used to compare the performances of the Classical Gold Standard regime and the floating exchange rate regime.

$$(5.1)\quad y_i = \bar{y}_i + (\pi_i - \pi_i^*) - \epsilon_i,\ i = CGS, FER$$

$$(5.2)\quad L_i = E[(\pi_i - \pi_i^*)^2 + \lambda_i (y_i - k_i)^2]$$

According to equation 5.1, the natural rate of output growth in the two periods[69] can be set equal to the average rates of output growth in table 11. Minimizing equation 5.2for both regimes subject to equation 5.1 gives the following inflation and output growth functions.

$$(5.3)\quad \pi_{CGS} = \pi^*_{CGS} + \frac{\lambda_{CGS}}{1+\lambda_{CGS}}\epsilon_{CGS}$$

Using equations 5.3 to 5.6 equation 5.2 can be rewritten for both periods as follows:

[69] CGS stands for Classical Gold Standard period and FER for floating exchange rate period.

$$(5.4)\quad \pi_{FER} = \pi^{*}_{FER} + \mu_{FER}k_{FER} + \frac{\mu_{FER}}{1+\mu_{FER}}\epsilon_{FER}$$

$$(5.5)\quad y_{CGS} = \bar{y}_{CGS} - \frac{1}{1+\lambda_{CGS}}\epsilon_{CGS}$$

$$(5.6)\quad y_{FER} = \bar{y}_{FER} - \frac{1}{1+\mu_{FER}}\epsilon_{FER}$$

$$(5.7)\quad L_{CGS} = var(\pi_{CGS}) + \lambda_{CGS}(\bar{y}_{CGS}-k_{CGS})^2 + \lambda_{CGS}var(y_{CGS})$$

$$(5.8)\quad L_{FER} = var(\pi_{FER}) + \mu^2_{FER}k^2_{FER} + \lambda_{FER}(\bar{y}_{FER}-k_{FER})^2 + \lambda_{FER}var(y_{FER})$$

Assuming that the weight parameters in the social welfare functions were identical in both periods and furthermore assuming that the difference between natural and desired output growth were equal in both periods, the difference between equations 5.7 and 5.8 is as follows:

$$(5.9)\quad L_{CGS} - L_{FER} = var(\pi_{CGS}) - var(\pi_{FER}) - \mu^2_{FER}k^2_{FER} + \lambda(var(y_{CGS})-var(y_{FER}))$$

Equation 5.9 still contains two unknown parameters, the second power of the inflation bias ($\mu_{FER}^2 k_{FER}^2$) and the weight parameter λ. The value of the second power of the inflation bias can be determined assuming that the Bundesbank allowed for approximately 2% inflation.[70] Then, given that the average inflation was 3.5%, the inflation bias would be 1.5%. It is probably impossible to quantify the weight parameter, but the theoretical model implies that under otherwise identical circumstances the loss under commitment should always be smaller than the loss under discretion with central bank independence as long as λ is bigger than zero. Yet, inserting the variances of inflation and output growth from table 2 into equation 5.9 shows that for any λ bigger than 0.16 the loss under floating exchange rates with central bank independence was smaller than under the Classical Gold

[70] The Bundesbank indicated in its annual reports when setting the annual monetary growth target that it considered approximately 2% annual inflation unavoidable. See Bundesbank annual reports since 1975.

Standard.[71] Since a λ larger than 0.16 seems not unreasonable for Germany[72] in either period, equation 5.9 implies that social welfare under the floating exchange rate regime with central bank independence was higher than under the Classical Gold Standard.

However, the procedure has not controlled for different output shocks (ϵ). Yet, different variances of ϵ can distort the analysis significantly. Deriving the variances for output growth from equations 5.5 and 5.6 and assuming that variances of the output shocks are identical implies that the variance of output growth under discretion with central bank independence must be greater than the variance of output growth under commitment.[73] However, table 11 shows that the output growth variance under the Classical Gold Standard was twice as large as under the floating exchange rate regime. In other words, it must be concluded that the variance of the output shock under the Classical Gold Standard was much greater, distorting the results of the comparative analysis. Bordo (1992) finds that the variance of supply shocks (ϵ) was 1.7 times larger in the Classical Gold Standard period compared to the floating exchange rate period.[74]

A second distortion could come from the initial assumption that the public was equally inflation averse in both periods. One could easily argue that because of two dramatic inflation periods the German public was more inflation averse in the post-war period. As a result, the previous comparison would be biased in favor of the post-war period.

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[71] $L_{CGS} - L_{FER} = 5.7 - 4.1 - 2.3 + \lambda(8.1 - 3.7)$.

[72] $\lambda = 0$ implies that society would tolerate 0.4 percentage inflation above target in exchange for a 1 percentage point increase in output growth above the natural rate of output growth.

[73] $\frac{1}{(1+\lambda)^2}\sigma^2 < \frac{1}{(1+\mu)^2}\sigma^2, \ \lambda > \mu > 0$

[74] See Bordo (1992), table 4.

Appendix

Data Sources

Table 1: d_t: Reichsbank discount rate (monthly average, sa), NBER 13, 15.

d_t^{UK}: U.K. discount rate (monthly average, sa), Bank of England, NBER 13, 13.

Table 2: Same as table 1 but annual averages.

Table 3: p_t: Log of cost of living index (quarterly average, sa), Institut für Konjunkturforschung, Konjunkturstatistisches Handbuch 1936, Berlin, 1935, p.107.

y_t: Log of real net national product (quarterly average, sa), the annual real NNP (Walther Hoffmann, Das Wachstum der deutschen Wirtschaft seit Mitte des 19. Jahrhunderts, 1965, pp.827/8) was benchmarked using the quarterly index of production in manufacturing (Institut für Konjunkturforschung, Konjunkturstatistisches Handbuch 1936, Berlin, 1935, p.52).

w_t: Log of hourly wage index (quarterly average, sa), the index has been constructed by dividing the total wage sums by total hours worked. The total wage sum was obtained from Konjunkturstatistisches Handbuch 1936, Institut für Konjunkturforschung, Berlin, 1935, p.95. Total Hours worked are the product of total employment and average hours per employee. Total employment is an update of the employment data of the Konjunkturstatistisches Handbuch 1936, p.12, and has kindly been provided by Albrecht Ritschl. Average hours per employee is an update from average hours per employee in industry from 'Beschäftigung, Arbeitszeit und Arbeitereinkommen in der deutschen Industrie', Statistisches Reichsamt, Sonderbeilage zu 'Wirtschaft und Statistik', 1935, Nr.13.

Table 4: Same data as table 3 excluding y_t

Table 5: Same data as table 3 plus m_t: Log of currency in circulation (quarterly average, sa), Institut für Konjunkturforschung, Konjunkturstatistisches Handbuch 1936, Berlin, 1935, p.130.

Table 7: m_t: Log of central bank money (quarterly average, sa), Deutsche Bundesbank, Statistische Beihefte zu den Monatsberichten der Deutschen Bundesbank, Reihe 4, table 35.

y_t: Log of real GNP (quarterly, sa), ibid, table 1

i_t: Nominal short run interest rate (quarterly average, sa), day-to-day rate, Deutsche Bundesbank monthly report, table V.6

p_t: Log of cost of living index (quarterly average, sa), ibid, table VIII.7

$\bar{e}_t$: Log of DM/$ fixed exchange rate (quarterly average), ibid, table IX.9

p_t^*: Log of US consumer price index (quarterly average, sa), Citibase

bp_t: Real balance of payments (quarterly, sa), Deutsche Bundesbank monthly report, table IX.1

Table 8: Same as table 7.

Table 9: Same data sources as table 7 plus

D_t: Total government (Federal, States, and Local) budget deficit (quarterly, sa), Deutsche Bundesbank monthly report, table VII.2

Table 11 and figures 1 to 6:

Consumer price index: 1880-1979, Sommariva and Tullio (1987) pp.231-234. 1980-1989, Deutsche Bundesbank, Monthly Reports.

Real GNP: 1880-1979, Sommariva and Tullio (1987) pp.226-229. 1980-1989, Deutsche Bundesbank, Monthly Reports.

Population: 1880-1979, Sommariva and Tullio (1987) pp.234-238. 1980-1989, International Financial Statistics Yearbook 1990.

M2: 1880-1913, Bordo (1986), "Financial Crises, Banking Crises, Stockmarket Crashes and the Money Supply: Some International Evidence" in F. Capie and G. Wood eds., Financial Crisis and the World Banking System, 1924-1933, Bordo and Jonung (1987), 1950-1989, Deutsche Bundesbank Monthly Reports.

Public Debt (Federal, Regional, and Local): Deutsche Bundesbank (1976): Deutsches Geld und Bankwesen in Zahlen 1876-1975, Tables 1.01 and 1.02.

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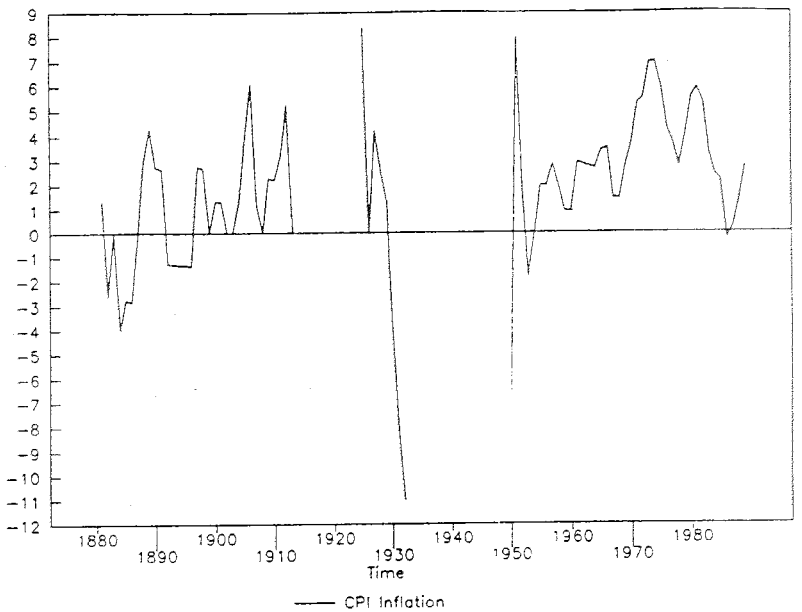

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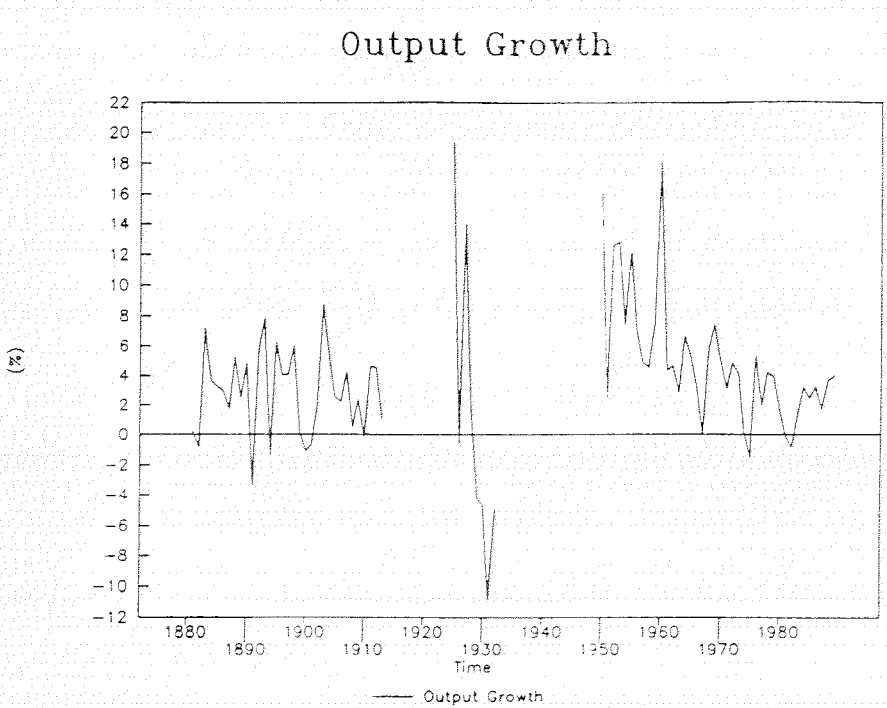
Chapter 11
Figure 1



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Chapter 11
Figure 2

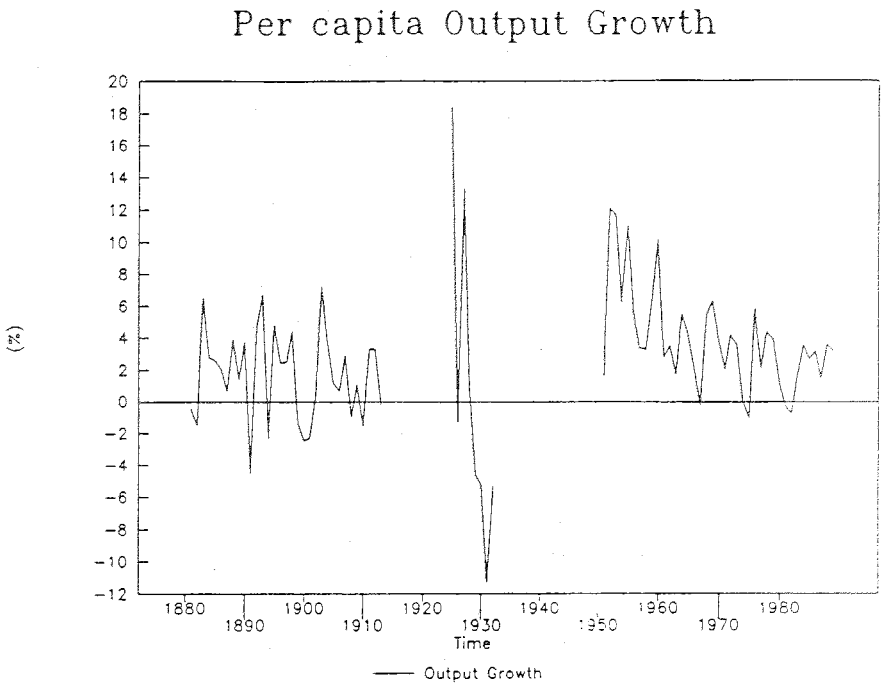

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Figure 3

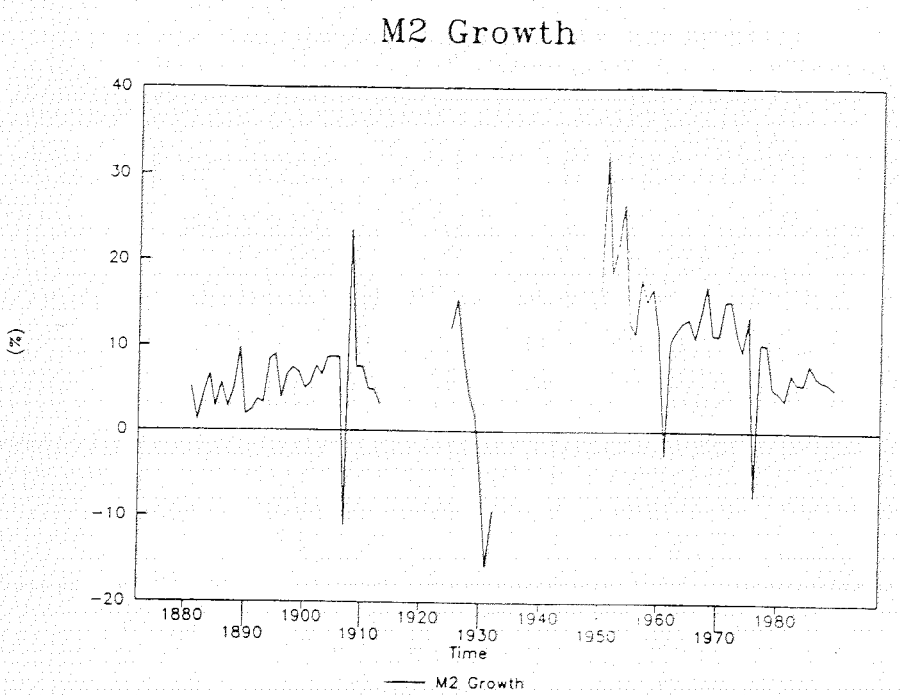

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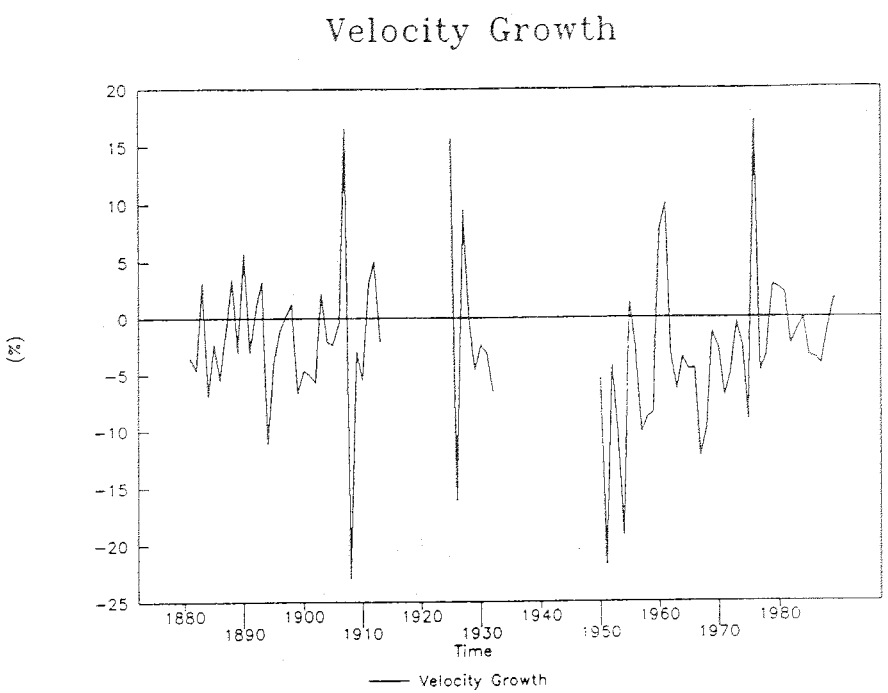
Figure 4



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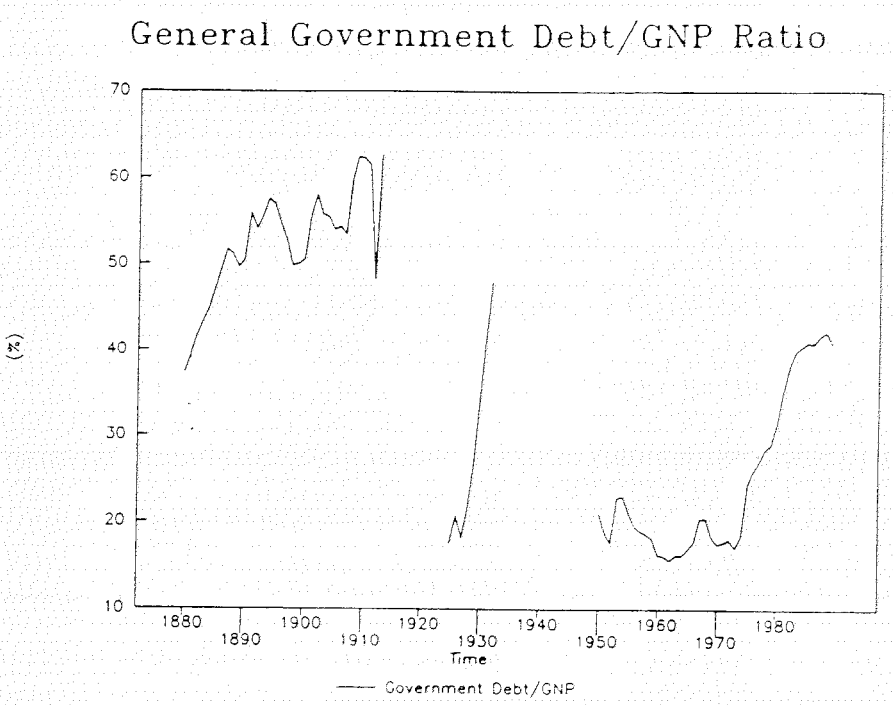
Chapter 11
Figure 5



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Chapter 11
Figure 6