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CENTRAL BANK INDEPENDENCE: THEORY AND EVIDENCE

by

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ABSTRACT

On the basis of a single-stage Phillips-curve monetary policy game with extrinsic uncertainty we derive several propositions concerning the relationship between central bank independence and (the variance of) output and inflation. These propositions are tested for twelve industrial countries for the post-Bretton-Woods period (1972-1991).
In testing the game-theoretic model, we use several central bank independence measures based on the central bank laws of the sample countries.

JEL Classification Numbers: C72, E58

1 INTRODUCTION*

Recently, there has been worldwide interest in examining the scope for greater monetary policy autonomy for the central bank. At the EC-summit in Maastricht in December 1991 a Treaty on European Economic and Monetary Union (EMU) was agreed upon. According to this treaty, in the final stage of EMU - i.e. by 1997 or later - the European Central Bank is supposed to assume unlimited responsibility for monetary policy. Broadly speaking, according to Alesina and Grilli (1991), the accepted Statute guarantees a central bank as independent from national and European political institutions as the Bundesbank. Furthermore, in the Pacific Basin Countries the same tendency can be discerned. Since the end of 1989 governor Mieno strengthened the position of the Bank of Japan with respect to the Ministry of Finance, while New-Zealand enacted legislation in February 1990 that increased the independence of its Reserve Bank. Finally, in Central Europe, the Czech Republic, Poland and Hungary have been considering proposals concerning central bank independence.[1]

The theoretical rationale for central bank independence finds its origin in the ongoing 'Rules versus Discretion' debate. Authors like Barro and Gordon (1983a) and Rogoff (1985) argue that governments and central banks are tempted to impart an inflationary bias to the economy, thereby sacrificing long-term welfare to short-run political gains. The associated time-consistency problem can be overcome by legislative rules and by setting up politically independent central banks. Hence, one would expect countries with independent central banks to have a lower sustainable rate of inflation.

Unlike the well-developed theoretical literature,[2] there are only a few studies that compare actual monetary regimes between a large number of countries. The most comprehensive studies are Bade and Parkin (1988), Alesina (1988, 1989), Alesina and Summers (1991), Grilli, Masciandaro and Tabellini (1991) and Eijffinger and Schaling (1992, 1993). Focusing on more recent studies, it is striking that the conclusions of the latter are less clear-cut than the theoretical literature. For instance, contrary to Alesina and Summers, Bade and Parkin find no correlation between central bank independence and the variability of inflation. Next, unlike the prediction of the Rogoff (1985) model,[3] both Alesina and Summers and Grilli, Masciandaro and Tabellini find no association between central bank independence and (the variability of) real output growth.

In this paper on the basis of a single-stage Phillips-curve monetary policy game with extrinsic uncertainty - i.e. supply shocks - we derive several propositions concerning the

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1 For an interesting survey of central banking in emerging market-oriented economies see Federal Reserve Bank of Kansas City (1990).

2 For a survey of the 'state of the art' see Cukierman (1993).

3 This framework is summarized in Alesina and Grilli (1991).

relationship between central bank independence and (the variance of) inflation and output growth. These propositions are tested for twelve industrial countries (Australia, Belgium, Canada, France, Germany, Italy, Japan, the Netherlands, Sweden, Switzerland, the U.K. and the U.S.) for the post-Bretton-Woods period (1972-1991). In testing the game-theoretic model we use several indices of central bank independence based on the central bank laws of these countries.

The main conclusions of our paper can be summarized as follows. First of all, both our model and estimation results, give further support to the well-known inverse relationship between the degree of central bank independence and the level of inflation found by Alesina (1988, 1989). Secondly, contrary to Alesina and Summers (1991) and Grilli, Masciandaro and Tabellini (1991), we find no empirical evidence that the more independent the central bank is, the lower the variability of inflation. Thirdly, our estimation results reject clearly the proposition - implied by the Rogoff (1985) model - of a positive relation between independence and the variability of real output growth. In other words, inflation-averse central banks do not bear the costs of triggering recessions nor do politically sensitive central banks reap the benefits of avoiding recessions. Finally, no empirical relationship can be found between central bank independence and the level of real output growth in the long run. Hence, our empirical results support the proposition of Grilli, Masciandaro and Tabellini (1991) that having an independent central bank is like having a free lunch. There are benefits (lower inflation) but no apparent costs in terms of real output growth.

The plan of this paper is as follows. In section 2 we combine the Barro and Gordon (1983a) Phillips-curve monetary policy game with the Alogoskoufis (1993) model of wage and employment determination, to allow for persistence in the natural rate of output. In section 3 we use this model to analyse the theoretical relationships of central bank independence with the means and variances of inflation and real output growth. Finally, in section 4 we confront the propositions from the game-theoretic model with empirical evidence using the various indices of central bank independence.

2 A SIMPLE CLOSED ECONOMY MACROMODEL

2.1 The Model

The main purpose of sections 2 and 3 is to combine the Barro and Gordon (1983a) Phillips curve monetary policy game with the Alogoskoufis (1993) model of wage and employment determination, to allow for persistence in the natural rate of output. Next, following Cukierman (1993) chapter XVIII we use this model to analyse the effects of central bank independence on the mean and variance of inflation and real output growth.

We assume that there are two types of agents, wage-setters and the central bank. Wage-setters unilaterally choose the nominal wage every time period, and the central bank controls monetary policy to determine the inflation rate.

The timing of events is as follows. Wage-setters sign annual nominal contracts (Gray (1976), Fischer, (1977a)) at the beginning of each year, before monetary policy is chosen for that year.

Wage-setters know the domestic monetary regime, i.e. they know the weight of inflation stabilization relative to employment stabilization in the preferences of the central bank. They take this information into account in forming their expectations. Finally, employment is determined by competitive firms. We now move on to the supply side of the model.

2.2 Wage and Employment Determination

Consider the following supply block which is a closed-economy version of Alogoskoufis (1993). Capital will be assumed fixed, and output is given by a short-run production function of the following type

$$(2.1)\quad y_t = \beta\ell_t + \mu_t \qquad\qquad 0 < \beta < 1$$

where lower-case letters refer to logarithmic deviations from steady state values[4]. Thus, y is the log of output, ℓ the log of employment, and μ a measure of productivity. β is the exponent of labour and is less than unity.

Having described the level of output, it remains to specify how productivity evolves over time. We use a stochastic trend specification discussed in Stock and Watson (1988). This specification says that over the long run productivity will grow at some average rate, labelled g. However, shocks to productivity, ν_t^{μ}, can cause productivity growth to deviate from its mean. Moreover, these shocks are persistent with respect to the level of productivity: once perturbed by an ν_t^{μ} shock, μ_t will show no tendency to return to its trendline. Hence, the supply shocks are assumed to have permanent effects on the economy's productive capacity.[5] The mathematical expression for the stochastic trend specification is a random walk with drift

$$(2.2)\quad \mu_t = g + \mu_{t-1} + \nu_t^{\mu}$$

where g is the average (or expected) rate of growth of productivity (the drift of the μ-process), and ν^{μ} is a normally distributed productivity shock with zero mean and variance σ^2_{μ}.

Firms determine employment by equalizing the marginal product of labour to the real wage $w_t - p_t$. This yields the following employment function

$$(2.3)\quad \ell_t = \frac{-1}{1-\beta}(w_t - p_t - \mu_t)$$

where w is the log of the nominal wage and p the log of the price level.

The nominal wage is set at the beginning of each period and remains fixed for one period. The objective of wage setters is to stabilize employment around a target employment level $l_i^s \equiv \bar{\ell}$.Denoting the log of the labour force by l^s, we assume $l_s^i < l^s$Thuss we employ the insider-outsider approach to the labour market (Blanchard and Summers (1986), Lindbeck and Snower (1986))[6]. Thus, wages in each period are set to minimize

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4 For a variable $\hat{X}$ say, $x \equiv d\ell n\hat{X}$

5 We discuss the impact of demand shocks in section 3.

6 The advantages of this approach will become clear in section 3.2.

$$(2.4)\quad E_{t-1}\,(\ell_t - \tilde{\ell})^2$$

where E_{t-1} is the operator of rational expectations, conditional on information available at the end of period t - 1. The minimization of (2.4) is subject to the labour demand function (2.3).[7]

From the first-order conditions for a minimum of (2.4) subject to (2.3) the nominal wage is given by

$$(2.5)\quad w = E_{t-1}\,p_t + E_{t-1}\,\mu_t - (1 - \beta)\,\tilde{\ell}$$

Substituting (2.5) in the labour demand function (2.3), and the resulting equation in the production function, we get the following relation between employment, output and unanticipated shocks

$$(2.6)\quad \ell_t = \tilde{\ell} + \frac{1}{1 - \beta}\,(p_t - E_{t-1}\,p_t + \nu_t^{\mu})$$

$$(2.7)\quad y_t = \beta\tilde{\ell} + \mu_t + \frac{\beta}{1 - \beta}\,(p_t - E_{t-1}\,p_t + \nu_t^{\mu})$$

An unanticipated rise in prices $p_t - E_{t-1}\,p_t$ reduces the real wage, and causes firms to employ more labour. Thus, both aggregate employment and output exhibit a transitory deviation from their respective equilibrium or "natural" rates $\tilde{\ell}$ and $\beta\tilde{\ell} + \mu_t$[8].

On the other hand, an unanticipated shock to productivity increases the marginal product of labour, and given the real wage causes firms to employ more labour. Thus employment rises above $\tilde{\ell}$, and output rises on account of both the higher employment (transitory effect) and the higher productivity (permanent effect).

Subtracting (2.6) from the labour force ℓ^s, using the approximation that the rate of unemployment $u \approx \ell^s - \ell$, and adding and subtracting $\frac{p_{t-1}}{1 - \beta}$, we get the following expression for the short-run determination of unemployment.

$$(2.8)\quad u_t = \tilde{u} - \frac{1}{1 - \beta}\,(\Delta p_t - E_{t-1}\Delta p_t + \nu_t^{\mu})$$

where $\tilde{u} = \ell^s - \tilde{\ell}$ and Δ is the first diference operator. $\tilde{u}$ can be thought of as the equilibrium of "natural" rate of unemployment in this model. Thus, (2.8) is the well known expectations augmented "Phillips curve". Unemployment deviates from its equilibrium rate only to the extent that there are unanticipated shocks to inflation or productivity. Anticipated shocks to inflation and productivity are refelected in wages (equation (2.5)) and do not affect unemployment. We

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7 Alternatively, the loss-function could be assumed quadratic in both the deviations of employment and the real wage from certain target levels. For an analysis along these lines see Funke (1992).

8 Actual output and employment will equal their natural rates when all expectations are fulfilled. Hence, the natural rate of employment equals $\bar{l}$ and the natural rate of output is $\beta\tilde{\ell} + \mu_t$.

can now incorporate the Phillips curve in a monetary policy game. This is the subject of the next section.

3 A STATIC GAME BETWEEN WAGE-SETTERS AND THE CENTRAL BANK

3.1 The Social Welfare versus the Political Approach to Central Bank Behaviour

In order to investigate optimal monetary policy - in which the inflation rate is treated as a directly controllable policy instrument[9] - consider a central bank that is concerned with both price stability and low unemployment. We assume a quadratic loss function, that penalizes both inflation and unemployment. More specificly we use

$$(3.1)\quad L_t = \frac{1}{2}(\Delta p_t - \Delta p^*)^2 + \frac{d_2}{2}(u_t - u^*)^2$$

where Δp^* and u^* are the inflation and unemployment targets of the central bank. The parameter d_2 measures the weight of unemployment stabilization relative to inflation stabilization in the preferences of the central bank.

The central bank chooses Δp and wage-setters "choose" $E_{t-1}\Delta p_t$. Normalizing Δp^* and u^* at zero yields

$$(3.2)\quad L_t = \frac{1}{2}(\Delta p_t)^2 + \frac{d_2}{2}(u_t)^2$$

According to Cukierman (1993), chapter III the recent literature on monetary policy games has given two competing interpretations to the loss function of the monetary policymaker in equation (3.1).

One part of the literature regards this function as a social welfare function and the central bank as a benevolent social planner (Kydland and Prescott (1977), Barro and Gordon (1983a, 1983b), Rogoff (1985) and Canzoneri (1985)).

The other part views the central bank as a mediator between different interest groups that try to push monetary policy in various directions. On this view, the loss function (3.1) reflects a distributionally motivated political compromise mediated through the central bank between the advocates of employment stimulation and the advocates of price stability (Weintraub (1978), Burns (1979), Kane (1980, 1982), Beck (1982), Wooley (1984), Hetzel (1985), Havrilesky (1987), Willet (1988) and Mayer (1990)). The coefficient d_2 then measures the relative political clout of the two groups (Cukierman and Meltzer (1986a), Cukierman (1986)).

The social welfare approach seems best suited to describe how a central bank *should* behave. However, (Cukierman (1993), chapter III) points out that it is a relatively weak paradigm for explaining the *actual* policies chosen by central banks. For as shown by Bade and Parkin (1988), Alesina (1988, 1989), Grilli, Masciandaro and Tabellini (1991) and Eijffinger and Schaling (1992) in most countries central banks are highly dependent on the government in general and

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9 Depending on operating procedures the policymaker sets the money stock or the interest rate. However, it is simpler to think of the central bank to choose inflation directly. For a lucid exposition of monetary policy games with the money stock as policy instrument see Canzoneri and Henderson (1991).

the treasury or ministry of finance in particular. As a result, the policies implemented by central bankers are not independent from the general political proces in which distributional considerations are predominant. The impact of these considerations on the choice of policy varies with the degree of central bank independence. The greater the political independence given to the bank by law the smaller the impact of distributional and other political considerations on monetary policy.

More realisticly, we choose the political approach to central bank behaviour as the interpretation of equation (3.1). Hence we view the coefficient d_2 as a measure of the political dependence of the central bank. The lower d_2 the more independent the central bank[10]. That is, the degree of central bank independence equals d_2^{-1}

3.2 Time Consistent Inflation Policy

Following Alogoskoufis ((1993), p. 17) we start with a cooperative game, i.e. we assume that the natural rate of unemployment is efficient. In the context of the model of sub-section 2.1, this can be represented by the assumption that $\tilde{l}$, the target employment level of wage-setters is equal to l^s, the effective labour force. In the latter case the central bank has no incentive to try and reduce unemployment below its equilibrium rate. As there is no conflict between the unemployment targets of wage setters and the central bank, the policy game can be seen as a cooperative one[11]. This state of affairs is summarized in the first column of table 1.

Table 1

Policy Games and Unemployment Targets

Central Bank	Wage-Setters	
	$\tilde{l} = l^s$ $\tilde{u} = 0$	$\tilde{l} < l^s$ $\tilde{u} > 0$
$u^* = 0$	$u^* = \tilde{u}$	$u^* < \tilde{u}$
Natural Rate	Efficient	Inefficient
Policy Game	Cooperative	Non-Cooperative

We now turn to the second column of table 1, i.e. the situation where the equilibrium unemployment rate is inefficiently high. In what follows we show that then the equilibrium inflation rate becomes proportional to the natural rate of unemployment. In this case discretionary monetary policy is no longer a Pareto-equilibrium, due to the time-inconsistency of optimal monetary policy.

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10 An alternative approach is explicit modelling of the interaction of separate monetary and fiscal authorities. See e.g. Alesina and Tabellini (1987) and Cukierman (1993), chapter XVIII.

11 For a review of some important concepts of game theory see Blackburn and Christensen (1989).

Assuming that $\bar{l} < l^s$ i.e. that $\bar{u} > 0$ the central bank has incentives to systematically create inflation in order to reduce unemployment below its natural rate.

Substituting the Phillips curve (2.8) in the loss function (3.2) yields

$$(3.3)\quad L_t = \tfrac{1}{2}\,(\Delta p_t)^2 + \frac{d_2}{2}\,[\bar{u} - \frac{1}{1-\beta}\,\Delta p_t + \frac{1}{1-\beta}E_{t-1}\Delta p_t - \frac{1}{1-\beta}\nu_t^{\mu}]^2$$

From the first order conditions for a minimum of (3.3), i.e. $\frac{\partial L_t}{\partial \Delta p_t} = 0$, we obtain the central bank's reaction function to wage-setter's expectations

$$(3.4)\quad \Delta p_t = \frac{d_2(1-\beta)}{(1-\beta)^2 + d_2}\,\bar{u} + \frac{d_2}{(1-\beta)^2 + d_2}E_{t-1}\Delta p_t - \frac{d_2}{(1-\beta)^2 + d_2}\,\nu_t^{\mu}$$ [12]

Taking expectations conditional on information at t - 1 of (3.4) gives

$$(3.5)\quad E_{t-1}\,\Delta p_t = \frac{d_2}{1-\beta}\,\bar{u}$$

Equation (3.5) is the reaction function of wage-setters. Upon substituting (3.5) in (3.4) we get

$$(3.6)\quad \Delta p_t = \frac{d_2}{1-\beta}\,\bar{u} - \frac{d_2}{(1-\beta)^2 + d_2}\,\nu_t^{\mu}$$

Figure 1 shows the central bank's reaction function if $v_t^{\mu} = 0$, i.e. the average inflation rate as a function of the expected inflation rate.[13]

[INSERT FIGURE 1]

The only point at which expectations are rational is at point N, which represents the non-cooperative Nash equilibrium.

Denoting the average inflation rate by $\Delta\tilde{p}_t$, from (3.6) it follows that

$$(3.7)\quad \Delta\tilde{p}_t = \frac{d_2}{1-\beta}\,\bar{u}$$

Hence, at point N the inflation rate is above zero (the outcome in the cooperative case).

Subtracting (3.5) from (3.6) we obtain the following expression for unanticipated inflation

$$(3.8)\quad \Delta p_t - E_{t-1}\Delta p_t = \frac{-d_2}{(1-\beta)^2 + d_2}\,\nu_t^{\mu}$$

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12 Demand shocks can be included in the analysis by extending the model with an aggregate-demand curve. This would complicate the algebra without affecting our results.

13 This figure is based on a similar one in Blanchard and Fischer (1989), p. 597.

Upon substituting (3.8) in (2.8) we get

$$(3.9)\quad u = \tilde{u} - \frac{1-\beta}{(1-\beta)^2 + d_2}\nu_t^\mu$$

Equations (3.7) and (3.9) highlight the time inconsistency of optimal monetary policy. The monetary policy strategy of the central bank, i.e. equation (3.4) is time-consistent in the sense that at each point in time the inflation rate selected is best, given the current situation. However, as can be seen from equations (3.7) and (3.9), the resulting policy is socially sub-optimal. It is sub-optimal since it results in an excessive level of inflation, i.e. it produces an inflationary bias with no gains in the form of systematic lower unemployment. This completes the description of the non-cooperative Nash equilibrium.

3.3 Results for Inflation and its Variance

Following Cukierman ((1993), chapter XVIII) in this section we investigate the effects of central bank independence on the mean and variance of inflation. Taking the first derivative of (3.7) with respect to d_2, we get

$$(3.10)\quad \frac{\partial \Delta\tilde{p}_t}{\partial d_2} = \frac{\tilde{u}}{1-\beta} > 0$$

From (3.10) we derive proposition (3.1).

PROPOSITION 3.1: The more independent the central bank (the lower d_2) the lower the average inflation rate.

Note that the greater $\frac{1}{1-\beta}$ (i.e., the greater the reduction in unemployment from unanticipated inflation in the expectations augmented Phillips curve (2.8)) and the larger the natural rate of unemployment the greater the inflation benefits of appointing independent central bankers.

We now consider inflation variability. Upon taking variances of (3.6) we get

$$(3.11)\quad \frac{\text{Var }\Delta p_t}{\sigma_\mu^2} = \left[\frac{d_2}{(1-\beta)^2 + d_2}\right]^2$$

From (3.11) it follows that

$$\lim_{d_2\to\infty}\left[\frac{d_2}{(1-\beta)^2 + d_2}\right]^2 = 1$$

That is, if the degree of central bank independence d_2^{-1} equals zero no stabilization of inflation is achieved. In this case, in fact Var $\Delta p_t = \sigma^2_{\mu}$, i.e. the variance of the productivity shock is completely transmitted to inflation.

Taking the first derivative of (3.11) with respect to d_2, we get

$$\text{(3.12)} \qquad \frac{\partial(\text{Var } \Delta p_t/\sigma_\mu^2)}{\partial d_2} = \frac{2d_2(1-\beta)^2}{[(1-\beta)^2 + d_2]^3} > 0$$

From (3.12) we derive propostion 2:

PROPOSITION 3.2: The more independent the central bank (the lower d_2) the lower the variance of the inflation rate.

By again differentiating (3.12) with respect to d_2, we find that

$$\text{(3.13)} \qquad \frac{\partial^2(\text{Var}\Delta p_t/\sigma_\mu^2)}{\partial d_2^2} = \frac{2(1-\beta)^2[(1-\beta)^2 - 2d_2]}{[(1-\beta)^2 + d_2]^4}$$

By setting $[(1-\beta)^2 - 2d_2]$ equal to zero we find a point of inflection at $d_2 = \frac{(1-\beta)^2}{2}$[14]. Using (3.12) and (3.13) we obtain Figure 2.

[INSERT FIGURE 2]

From Figure 2 we derive propostion 3.3.

PROPOSITION 3.3: If a highly independent central bank loses some of its independence at first this will strongly increase inflation variability. In this respect loss of independence matters less for weaker institutions.

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14 Following Blanchard and Fisher (1989, p. 598) $\xi \equiv \frac{[1/(1-\beta)]^2}{1/d_2}$ is, loosely speaking a measure of the utility gain from unexpected inflation: $\frac{1}{1-\beta}$ gives the decrease in unemployment (see equation (2.8)), and $1/d_2$ the utility loss from higher inflation. Hence, at the point of inflection this utility gain equals 1/2.

This completes the description of the results on the mean and variance of inflation.

3.4 Results for Output and its Variance

In this sub section, we examine the effects of central bank independence on the mean and variance of real output (growth).

Adding and subtracting $\frac{\beta}{1-\beta} p_{t-1}$ from (2.7) yields

$$(3.14) \quad y_t = \beta \bar{l} + \mu_t + \frac{\beta}{1-\beta} (\Delta p_t - E_{t-1} \Delta p_t + \nu^{\mu}_t)$$

If we employ $\tilde{y}_t$ as short-hand for $\beta\tilde{\ell} + \mu_t$ we get

$$(3.15) \quad y_t - \tilde{y}_t = \frac{\beta}{1-\beta} (\Delta p_t - E_{t-1}\Delta p_t + \nu^{\mu}_t)$$

Equation (3.15) is the famous Lucas surprise supply function which says that unanticipatied inflation and/or productivity shocks cause transitory deviations of output from its equilibrium (mean) level $\tilde{y}$.

Upon sustituting (3.8) in (3.15) we get

$$(3.16) \quad y_t - \tilde{y} = \frac{\beta(1-\beta)}{(1-\beta)^2 + d_2} \nu^{\mu}_t$$

From (3.16) it follows that the mean level of output is independent from d_2, i.e. independent from the prevailing monetary regime. Of course, this result is just a corrollary of the natural rate property of the Alogoskoufis (1993) supply block[15].

Taking variances of (3.16) yields

$$(3.17) \quad \frac{Var(y_t - \tilde{y})}{\sigma^2_{\mu}} = \left[\frac{\beta(1-\beta)}{(1-\beta)^2 + d_2}\right]^2$$

From (3.17) it follows that

$$(3.18) \quad \lim_{d_2 \to \infty} \left[\frac{\beta(1-\beta)}{(1-\beta)^2 + d_2}\right]^2 = 0$$

That is, if the degree of central bank independence d_2^{-1} equals zero perfect stabilization of output is achieved. In this case, in fact Var $(y_t - \tilde{y}_t) = 0$.

Taking the first derivative of (3.17) with respect to d_2 we get

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15 For instance, introducing multiperiod wage contracts (Fischer (1977b)), would imply policy non-neutrality. In the latter case the degree of central bank independence would show an inverse relation with the level of output.

(3.19) $$\frac{\partial[\mathrm{Var}(y_t - \tilde{y}_t)/\sigma_\mu^2]}{\partial d_2} = \frac{-2\beta^2(1-\beta)^2}{[(1-\beta)^2 + d_2]^3} < 0$$

From (3.19) we derive proposition 3.4.

PROPOSITION 3.4: The more independent the central bank (the lower d_2) the higher the variance of output around its mean or natural level $\tilde{y}$.

Note that if $\tilde{y}_t = 0$ (e.g. Alesina and Grilli (1991)) proposition 3.4 is a statement about the actual variance of output. This is not the case in the present analysis. Actually the persistence of productivity shocks is inherited by the natural rate of output (c.f. Cukierman (1993), chapter XV).

We have

(3.20) $$\tilde{y}_t = \beta\tilde{\ell} + \mu_t$$

Hence

(3.21) $$\tilde{y}_{t-1} = \beta\tilde{\ell} + \mu_{t-1}$$

Upon substituting (2.2) in (3.20) we get

(3.22) $$\tilde{y}_t = \beta\tilde{\ell} + \mu_{t-1} + g + \nu_t^\mu$$

Combining (3.22) with (3.21) yields

(3.23) $$\tilde{y}_t = \tilde{y}_{t-1} + g + \nu_t^\mu$$

Therefore in the present analysis the natural rate of output follows a random walk with drift. It is around this "walking" natural rate that output is being stabilized.

Again differentiating (3.19) with respect to d_2 we find that

(3.24) $$\frac{\partial^2[\mathrm{Var}(y_t - \tilde{y}_t)/\sigma_\mu^2]}{\partial d_2^2} = \frac{6\beta^2(1-\beta)^2}{[(1-\beta)^2 + d_2]^4} > 0$$

Using (3.19) and (3.24) we obtain Figure 3.

[INSERT FIGURE 3]

This completes the description of the results on the mean and variance of output.

Now we move from levels to growth rates, i.e. we now examine the effects of central bank independence on the growth rate of output and its variance. Taking first differences of (3.16) we get

$$\Delta y_t - \Delta \tilde{y}_t = \frac{\beta(1-\beta)}{(1-\beta)^2 + d_2} \Delta \nu_t^{\mu} \qquad (3.25)$$

From (3.23) we derive proposition 3.5.

PROPOSITION 3.5: The mean or average rate of growth of output $(\Delta \tilde{y}_t)$ is independent from the prevailing monetary regime (d_2).

Taking variances of (3.25) we get

$$\frac{Var(\Delta y_t - \Delta \tilde{y}_t)}{\sigma_{\Delta\mu}^2} = \left[\frac{\beta(1-\beta)}{(1-\beta)^2 + d_2}\right]^2 \qquad (3.26)$$

where $\sigma_{\Delta\mu}{}^2 \equiv Var\ \Delta\nu_t{}^{\mu} = \sigma_{\mu}^2 + \sigma_{\mu_{t-1}}^2$. Since (3.26) is simular to (3.17) the same discussion applies. Hence

PROPOSITION 3.6: The more dependent the central bank (the higher d_2) the lower the variance of the growth rate of output around its mean or average rate of growth.

Finally, we summarize the main propositions from this section in table 2

[INSERT TABLE 2]

In order to confront these propositions with some cross-country evidence we can now move on to empirical testing. This the subject of the next section.

4 EMPIRICAL EVIDENCE ON CENTRAL BANK INDEPENDENCE

4.1 Central Bank Independence and the Level of Inflation

According to Alesina (1988, 1989) and Alesina and Summers (1991) countries with an independent central bank will have a lower rate of inflation than countries with a dependent central bank. As stated in section 1, this well-known inverse relationship between central bank independence and the level of inflation is particularly sensitive to the numerical values of the various indices of central bank independence.

Furthermore, the negative correlation between central bank independence and inflation does not necessarily imply a causal relation from central bank independence to inflation or the other way around. The correlation could be explained by a third factor, e.g. the culture and tradition of monetary stability in a country, leading both to an independent central bank and a low rate of inflation.[16] As an example could be taken Germany, for which country one could argue that the hyperinflation in the 1920s caused such a culture and tradition of monetary stability.[17]

However, in our opinion the degree of central bank independence is the ultimate cause of the level of inflation. For central bank independence is the ability and willingness to conduct an autonomous monetary policy directed at price stability as the single policy goal. If not seriously hampered by other elements of economic policy, such as wage increases, budget deficits and government debt, it will eventually lead to low sustainable inflation.

Therefore, our regression analysis (OLS method) assumes the various indices of central bank independence to be the explanatory variables of the average inflation (CPI) on an annual base in the twelve countries considered (Australia, Belgium, Canada, France, Germany, Italy, Japan, the Netherlands, Switserland, the UK, the US and Sweden):

$$(4.1)\quad \text{average inflation} = a_0 + \overset{(-)}{a_{1*}}\ \text{central bank independence} + \epsilon_t$$

We investigated empirically the policy independence index of Bade and Parkin (BP), the index of Alesina (AL)[18], the broad index of political independence of Grilli, Masciandaro and Tabellini (GMT) and a new index of policy independence, which we call the Eijffinger - Schaling (ES) index.[19] The ES-index of central bank independence is compared with previous indices (BP, AL, and GMT) in Eijffinger and Schaling (1993). This cross-section analysis of the empirical relation between these indices of central bank independence and the level of inflation should be interpreted carefully because of the limited degrees of freedom.

The relationship between the varions indices and average annual inflation is analysed for the whole post-Bretton-Woods period of twenty years (1972-1991). During the fixed exchange rate system of Bretton-Woods countries were fully committed to an exchange rate target and had no room to conduct and autonomous domestic monetary policy. Thus, before 1972 the empirical relation between central bank independence and inflation was much less straightforward than after 1972.[20]

Furthermore, the post-Bretton-Woods period is divided in two sub-periods of ten years each

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16 According to the Commission of the European Communities (1990) p. 98 the causal relation implied by their regression analysis runs from inflation to central bank independence. This is certainly incorrect.

17 See Bresciani-Turroni (1953).

18 In Eijffinger and Schaling (1993) we show that the Alesina (1988, 1989) synthetic indicator of central bank independence is internally inconsistent and does not qualify as an index.

19 In the case of the GMT index, there is no ranking for Sweden and so the sample is only made up of eleven countries.

20 Regression analysis by De Haan and Sturm (1992), pp.308-309 empirically supports this view.

(1972-1981 and 1982-1991 respectively) in order to distinguish between the EMS countries (Belgium, France, Germany, Italy, the Netherlands and partly the UK) and non-EMS countries (Australia, Canada, Japan, Switserland, the US and Sweden). Before 1982 the EMS countries participated - some like France, Italy and the UK only partly - in the snake arrangement and - except the UK - in the initial orientation phase of the EMS (1979-1982) which was characterized by frequent and large realisments of central rates. After 1982 a period of consolidation (1982-1987) can be discerned within the EMS. According to Ungever (1990), this period was marked by "... a widespread consensus to follow stability-oriented policies, an increasing convergence in the development of costs, prices and monetary aggregates, and by long periods without realignments of central rates" (p. 338).[21]

Consequently, during the second sub-period (1982-1991) the negative correlation between central bank independence and inflation is expected to be less clear cut than during the first sub-period (1972-1981) because of the consolidation in the EMS countries towards exchange rate stability. From 1982 the domestic monetary policy in these countries - besides Germany as the anchor country - could have become increasingly endogenous by focussing on the exchange rate target.

[21] Ungerer (1990) makes a distinction between three phases of development of the EMS: the first phase (1979-1982) as a period of initial orientation, the second phase (1982-1987) as a period of consolidation and the third phase (1987-present) as a period of re-examination, in the light of uneasiness about the "asymmetry" of the system.

Table 3 Average annual inflation and the various indices of central bank independence.

Explanatory variables	1972-1991	1972-1981	1982-1991
Constant	11.546	15.025	8.068
	(6.931)	(6.579)	(5.534)
Bade-Parkin (BP)	-1.850	-2.252	-1.449
	(-2.850)**	(-2.531)*	(-2.550)*
Adj. R^2	0.393	0.329	0.333
RMSE	1.939	2.658	1.697
Constant	11.778	15.358	8.199
	(8.205)	(7.686)	(6.302)
Alesina (AL)	-1.981	-2.432	-1.529
	(-3.501)**	(-3.088)**	(-2.982)**
Adj. R^2	0.506	0.437	0.418
RMSE	1.750	2.435	1.586
Constant	8.822	12.481	5.162
	(5.686)	(6.315)	(4.013)
Grilli et.al. (GMT)	-0.395	-0.846	-0.243
(Political)	(-1.380)	(-1.683)	(-0.743)
Adj. R^2	0.083	0.155	-0.047
RMSE	2.456	3.129	2.036
Constant	11.014	14.383	7.645
	(9.998)	(9.144)	(7.604)
Eijffinger-Schaling	-1.433	-1.746	-1.119
(ES)	(-3.955)**	(-3.376)**	(-3.386)**
Adj. R^2	0.571	0.486	0.488
RMSE	1.630	2.327	1.488

Notes: t-values are in parentheses. One asterisk indicates that the coefficient is significantly different from zero at a 95% confidence level and two asterisks indicate that the coefficient is significant at a 99% confidence level.

Table 3 shows the estimation result of equation (4.1), which explains average annual inflation by the four indices of central bank independence for the whole period (1972-1991) and for both sub-periods (1972-1981 and 1982-1991) respectively. Except for the GMT index of political independence, the inverse relationship between inflation and central bank independence is very clear, although the Alesina and ES index proved to be more significant (higher t-value) than the BP index.[22] In case of the latter three indices, central bank independence is less significant (lower t-value) during both sub-periods than during the whole post-Bretton-Woods period.

Besides the GMT index, the various indices have approximately the same significance in both the first and second sub-period, while that in the second sub-period was expected to be lower than in the first as a consequence of the six EMS countries within the sample of twelve. These outcomes could be the result of the practice that most EMS countries used fully the bilateral band of ± 2¼% and, for Italy and since October 1990 the UK, the band of ±6%. Only the Netherlands and, from 1986, also France had an explicit exchange rate target for their currency vis-à-vis the Deutsche Mark.

What may be conluded from the cross-section analysis of these twelve countries regarding the relationship between central bank independence and the level of inflation and the quality of the four indices of central bank independence in particular?

Firstly, the negative relation between central bank independence and inflation proved to be very significant for all indices, except for the GMT index of political independence.[23] Clearly, the more independent a central bank is, the lower rate of inflation in the long run.

[INSERT FIGURES 4 AND 5]

Figure 4 shows that the BP index of policy independence has a significant, negative relation to average annual inflation despite some positive outliers (Italy and the UK) and some negative (Belgium and the Netherlands). The ranking by Bade and Parkin of the latter two countries is evidently too low. Furthermore, from figure 5 it can be seen that the Alesina 'index' has a more significant, negative relation to inflation, merely by the ad hoc adjusted ranking of Italy.

[INSERT FIGURES 6 AND 7]

However, figure 6 shows that the GMT index bears no clear (negative) relation to inflation in most of the eleven countries considered. This could be explained by the broadness of the GMT index comprising many features (see Eijfffinger and Schaling (1992)). This index, thereby, waters down the essential features of policy independence, i.e. (i) the procedures for appointing the central bank board, (ii) the relationship between, the central bank and government concerning the formulation of monetary policy, and (iii) the policy goals of the central bank regarding monetary policy making.

Finally, figure 7 shows that the ES index has an even more significant, negative relation to

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[22] De Haan and Sturm (1992) find different empirical results for a modified GMT index, measuring both political and economic independence "... except for the entries which are related to supervision of the banking system. Whether or not a central bank has any responsibility for bank supervision provides, in our view, no information as to its independence" (p. 323).

[23] This is a consequence of the 'broadness' of the GMT-index. Because GMT use eight criteria in determining the degree of political independence, the essential characteristics of central bank independence are watered down. See Eijffinger and Schaling (1992), pp. 11-12.

inflation, although the positive outliers (Italy and the UK) remain. This could, perhaps, be explained by the half-fledged position of these countries with respect to the EMS. Nevertheless, the negative outliers (Belgium and the Netherlands) of the BP and Alesina index disappeared by the more consistent ranking of both countries according to their central bank laws within the context of monetary policy making.

Consequently, empirical evidence on the various indices of central bank independence supports Proposition 3.1 (see sub section 3.3) that the more independent the central bank - the lower d_2 - is, the lower the average inflation rate.

Of course, one should be well aware of the more or less subjective character of the research on central bank independence, which combines both legal-institutional and political-economic criteria and features in constructing indices.

4.2 Central Bank Independence and the Variability of Inflation

The variability of inflation reflects the degree of monetary and inflationary uncertainty in the economy.

Inflationary uncertainty implies that investers are not sure about the expected (ex ante) future level of inflation and, hence, about expected (ex ante) real interest rates. Therefore, they are less willing to take risks and to invest in either long-term financial assets or physical capital goods. As a consequence lenders demand a higher risk premium on their funds.[24] Thus, higher inflationary uncertainty - measured by the variability of realized inflation - will lead to higher expected real interest rates and to lower levels of investment and output growth.

What is the empirical relationship between central bank independence and the variability of inflation?

First of all, the variability of inflation is positively correlated with the level of inflation and, thereby, with the independence of central banks. Chowdhury (1991) investigated empirically the relation between the level and variability of inflation in 66 countries for the period from 1955 to 1985. He concluded that there is a significant, positive correlation between the level and the variability of inflation during this period. De Haan and Sturm (1992) also examined this relation in 18 industrial countries for the period from 1961 to 1987. They found a clear, positive correlation between both variables for the post-Bretton-Woods sub-periods 1970-1978 and 1979-1987, but not for the sub-period 1961-1969. Consequently, if a high degree of central bank independence results in a low level of inflation, this should also lead to a low variability of inflation. Nevertheless, the negative correlation between independence and inflation variability does not necessarily imply a causal relation from the first to the latter, but could be explained by a third factor. However, our regression analysis assumes the various indices of central bank independence (BP, AL, GMT and ES) to be the explanatory variables of the variance of monthly inflation (CPI) on an annual base in the twelve countries of our sample:

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24 Empirical research with respect to the influence of monetary and inflationary uncertainty on real interest rates in the United States is conducted by Mascaro and Meltzer (1983). They conclude that monetary uncertainty - measured by the variability of money growth - resulted in a risk premium for both the money and capital market interest rate in the period from October 1979.

$$(4.2)\ \text{variance inflation} = b_0 + \overset{(-)}{b_{1*}}\ \text{central bank independence} + \eta_t$$

Again, the relationship between the various indices and the variance of monthly inflation is examined for the complete post-Bretton-Woods period of twenty years (1972-1991) and its two sub-periods of ten years (1972-1981 and 1982-1991). During the second sub-period the negative correlation between central bank independence and inflation variability is also expected to be less clear cut than during the first sub-period by the consolidation of EMS countries to exchange rate stability.

Table 4 *Variance monthly inflation and the various indices of central bank independence.*

Explanatory variables	1972-1991	1972-1981	1982-1991
Constant	0.326	0.289	0.214
	(1.343)	(0.749)	(2.453)
Bade-Parkin (BP)	-0.007	0.034	-0.023
	(-0.070)	(0.225)	(-0.680)
Adj. R^2	-0.100	-0.095	-0.051
RMSE	0.283	0.449	0.102
Constant	0.330	0.298	0.206
	(1.422)	(0.809)	(2.458)
Alesina (AL)	-0.008	0.030	-0.020
	(-0.090)	(0.209)	(-0.607)
Adj. R^2	-0.099	-0.095	-0.061
RMSE	0.283	0.449	0.102
Constant	0.577	0.771	0.217
	(3.741)	(3.004)	(5.928)
Grilli et.al. (GMT)	-0.080	-0.118	-0.023
(Political)	(-2.044)*	(-1.802)	(-2.480)*
Adj. R^2	0.241	0.184	0.340
RMSE	0.244	0.406	0.058
Constant	0.391	0.421	0.218
	(2.068)	(1.385)	(3.239)
Eijffinger-Schaling	-0.029	-0.018	-0.022
(ES)	(-0.472)	(-0.183)	(-0.976)
Adj. R^2	-0.076	-0.096	-0.004
RMSE	0.280	0.449	0.099

Notes: t-values are in parentheses. One asterisk indicates that the coefficient is significantly different from zero at a 95% confidence level and two asterisks indicate that the coefficient is significant at a 99% confidence level.

Table 4 shows the outcomes of equation (4.2) explaining the variance of monthly inflation by the four independence indices. The inverse relationship between inflation variability and central bank independence is only significant for the GMT index, in particular for the second sub-period (!), but not for the other indices.[25] Generally, the latter indices do not support, except for the GMT index, Proposition 3.2 that the more independent the central bank - the lower d_2 - is, the lower the variance of the inflation rate.

4.3 Central Bank Independence and the Level of Output Growth

Given the inverse relationship between central bank independence and the level of inflation - see sub-section 4.1 - one could argue that the expected (ex ante) level of inflation influences expected (ex ante) real interest rates and, thereby, the level of output growth according to the Mundell-Tobin effect. A rise in expected inflation will lead - by Mundell (1963) - to substitution of liquid assets by long-term financial assets and - according to Tobin (1965) - to substitution of liquid assets by physical capital goods, lowering the marginal efficiency of capital, and will result in a decrease of expected real interest rates. Thus, more independent central banks will mitigate inflationary expectations inducing higher expected real interest rates and lower levels of investment and output growth.[26]

However, Proposition 3.5 (in sub-section 3.4) states that the mean or average rate of growth of output is independent from the prevailing monetary regime (d_2). Therefore, our regression analysis assumes the four indices of central bank independence (BP, AL, GMT and ES) to be the explanatory variables of average output growth (volume of GDP) on an annual base, without postulating an expected sign for these variables:

(4.3) average output growth $= c_0 + c_{1*}$ central bank independence $+ \vartheta_t$

Again, we examined the relationship between the various indices and level of real output growth for the post-Bretton-Woods period (1972-1990) and its two sub-periods (1972-1981 and 1982-1990).

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25 Our estimation results for the BP index are according with Bade and Pankin (1988). However, they contradict the findings of Alesina and Summers (1991) who averaged the Alesina index and the GMT index of political and economic independence.

26 Nevertheless, in theory it could be argued that a higher degree of central bank independence results in lower inflationary uncertainty leading to a decrease of expected real interest rates and, thereby, to an increase of investment and output growth. Empirical evidence in sub-section 4.2 rejects the first link of this transmission mechanism.

Table 5 Average annual output growth and the various indices of central bank independence.

Explanatory variables	1972-1990	1972-1981	1982-1990
Constant	3.039	3.459	2.575
	(4.563)	(4.191)	(4.428)
Bade-Parkin (BP)	-0.164	-0.366	0.061
	(-0.630)	(-1.139)	(0.269)
Adj. R^2	-0.058	0.026	-0.092
RMSE	0.775	0.960	0.677
Constant	3.064	3.153	2.567
	(4.843)	(4.532)	(4.627)
Alesina (AL)	-0.177	-0.396	0.065
	(-0.710)	(-1.295)	(0.299)
Adj. R^2	-0.047	0.058	-0.090
RMSE	0.771	0.945	0.676
Constant	3.153	3.113	3.202
	(6.653)	(4.900)	(8.046)
Grilli et.al. (GMT)	-0.129	-0.137	-0.122
(Political)	(-1.073)	(-0.848)	(-1.203)
Adj. R^2	0.015	-0.029	0.043
RMSE	0.750	1.006	0.630
Constant	3.268	3.627	2.870
	(6.708)	(6.221)	(6.293)
Eijffinger-Schaling	-0.227	-0.383	-0.054
(ES)	(-1.419)	(-1.999)*	(-0.359)
Adj. R^2	0.084	0.214	-0.086
RMSE	0.721	0.863	0.675

Notes: t-values are in parentheses. One asterisk indicates that the coefficient is significantly different from zero at a 95% confidence level and two asterisks indicate that the coefficient is significant at a 99% confidence level.

Table 5 shows the estimation results of equation (4.3). The relationship between real output growth and central bank independence proves to be insignificant, except for the ES index in the first sub-period. The BP and AL index also have higher t-values for the first sub-period than for the second.[27] These outcomes could be explained by relatively more restrictive monetary policies by independent central banks during the late 1970s - the high-days of monetary targeting - which resulted in a lower level of economic growth.

In general, empirical evidence on the various indices does support Proposition 3.5 stating that there is no relation between central bank independence and average real output growth. In other words, although a high degree of central bank independence is associated with a low level of inflation in the long run, it has no large costs or benefits in terms of real economic growth. Thus, in countries with an independent central bank no trade off can be found between inflation on the one hand and economic growth and unemployment on the other hand in the long term.

4.4 Central Bank Independence and the Variability of Output Growth

What is the relationship between the degree of central bank independence and the variability of real output growth? According to Rogoff (1985) independent central banks purchase a lower level of inflation at the price of a higher variability of real economic growth. By relying more on rules rather than discretion in policy making they tolerate more cyclical variability of economic growth. Consequently, Rogoff's conclusion corresponds very well with our Proposition 3.6 (see sub-section 3.4) stating that the more dependent the central bank - the higher d_2 - is, the lower the variance of the growth rate of output around its mean or average rate of growth.

Again, our regression analysis assumes the various independence indices (BP, AL, GMT and ES) to be the explanatory variables of the variance of monthly output growth (volume of GDP) on an annual base, postulating a positive sign for these variables:

$$(4.4) \text{ variance output growth} = d_0 + \overset{(+)}{d_{1*}} \text{ central bank independence} + \kappa_t$$

The empirical relationship between the four indices and the variability of real output growth is investigated also for the four independence indices. The coefficient for the BP and AL index do not have the expected, positive sign in any sample period. Besides, none of the coefficients appears to be significantly different from zero. The t-values prove to be the highest for the GMT index.[28] These estimation results imply, of course, that a higher degree of central bank independence does not lead to more variability of real economic growth, rejecting Proposition 3.6 quite clearly.

Therefore, having an independent central bank does not result in more variable inflation (see

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27 These estimation results for the AL and ES index correspond with De Haan and Sturm (1992). They are also in accordance with Alesina and Summers (1991) and De Long and Summers (1992) for their "single overall index" based on an average of the Alesina and GMT political and economic independence index. It should be noticed that De Long and Summers (1992) find, however, a positive relationship between central bank independence and economic growth, controlling for initial GDP per worker levels (see in this respect their chart 6 on p. 16).

28 Our empirical evidence for the AL and ES index is in accordance with that of De Haan and Sturm (1992). Alesina and Summers (1991) and De Long and Summers (1992) also find for their averaged Alesina-GMT index no support with respect to the relation between independence and the variability of output growth. The same holds for its relationship regarding the average and variance of unemployment rates.

sub-section 4.2) nor in more variable economic growth in the short term. So, inflation-averse central banks do not trigger off recessions nor do politically sensitive central banks avoid recessions.

Table 6 Variance monthly output growth and the various indices of central bank independence.

Explanatory variables	1972-1990	1972-1981	1982-1990
Constant	1.812	2.898	0.981
	(2.901)	(2.037)	(2.620)
Bade-Parkin (BP)	-0.232	-0.419	-0.114
	(-0.954)	(-0.756)	(-0.781)
Adj. R^2	-0.008	-0.041	-0.037
RMSE	0.727	1.656	0.436
Constant	1.731	2.777	0.897
	(2.877)	(2.036)	(2.473)
Alesina (AL)	-0.202	-0.376	-0.080
	(-0.852)	(-0.699)	(-0.563)
Adj. R^2	-0.026	-0.049	-0.066
RMSE	0.733	1.662	0.442
Constant	0.784	0.889	0.406
	(1.748)	(0.837)	(1.633)
Grilli et.al. (GMT)	0.114	0.265	0.070
(Political)	(0.996)	(0.981)	(1.110)
Adj. R^2	-0.001	-0.004	0.023
RMSE	0.710	1.681	0.394
Constant	1.203	1.375	0.840
	(2.345)	(1.209)	(2.803)
Eijffinger-Schaling	0.018	0.185	-0.049
(ES)	(0.104)	(0.496)	(-0.497)
Adj. R^2	-0.099	-0.074	-0.074
RMSE	0.759	1.682	0.443

Notes: t-values are in parentheses. One asterisk indicates that the coefficient is significantly different from zero at a 95% confidence level and two asterisks indicate that the coefficient is significant at a 99% confidence level.

4.5 Conclusion

The main conclusions of this theoretical and empirical analysis of central bank independence with respect to the level and variability of inflation and economic growth are the following.

First of all, both our model and estimation results, give further support to the well-known inverse relationship between the degree of central bank independence and the level of inflation found by Alesina (1988, 1989). However, it should be emphasized that these results are particularly sensitive to the numerical values of indices. For example, the GMT index shows no clear inverse relation to inflation, whereas the ES index proves to have a very significant, negative relation.

Secondly, contrary to Alesina and Summers (1991) we find no empirical evidence - except for the GMT index - supporting our proposition that the more independent the central bank is, the lower the variability of inflation.

Thirdly, according to our proposition that the level of economic growth does not depend on the prevailing monetary regime, no relationship can be found between central bank independence and the level of real output growth in the long run. Our interpretation of this outcome is that the attainment and maintenance of low inflation by an independent central bank is not accompanied by large costs or benefits in terms of sustainable economic growth. The absence of a long-run trade off between inflation and growth implies that the establishment of central bank independence in countries, which did not use to have this, is a free lunch.

Fourthly and finally, our estimation results reject clearly the proposition of a positive relation between independence and the variability of real output growth. An independent central bank does not lead to more variable economic growth in the short run. In other words, inflation-averse central banks do not bear the costs of triggering recessions nor do politically sensitive central banks reap the benefits of the avoiding recessions.

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Figure 1
Actual and Expected Inflation with an Inefficient Natural Rate

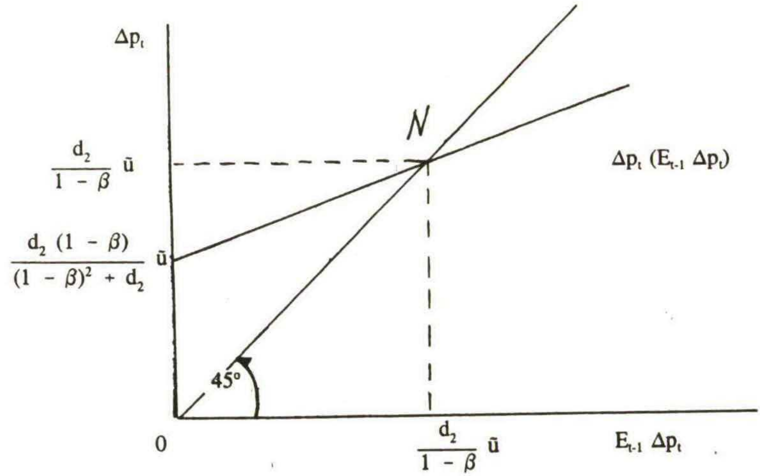


Figure 2 Central Bank Independence and the Variance of Inflation

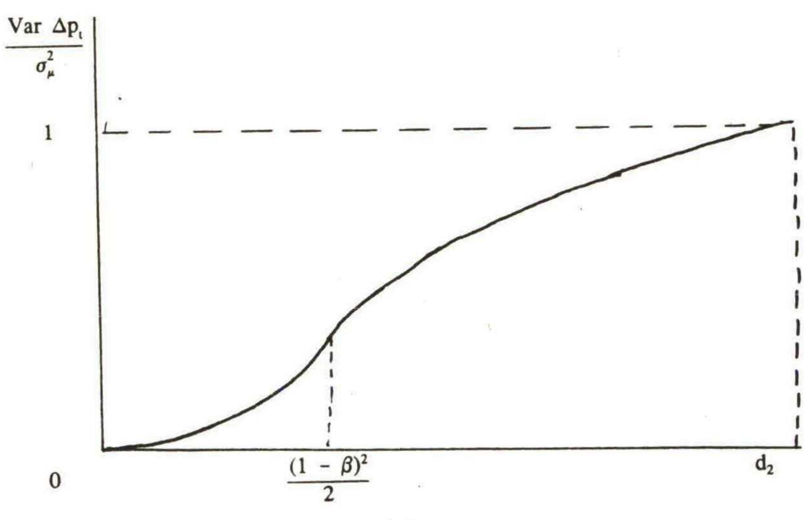


Figure 3 Central Bank Independence and the Variance of Output

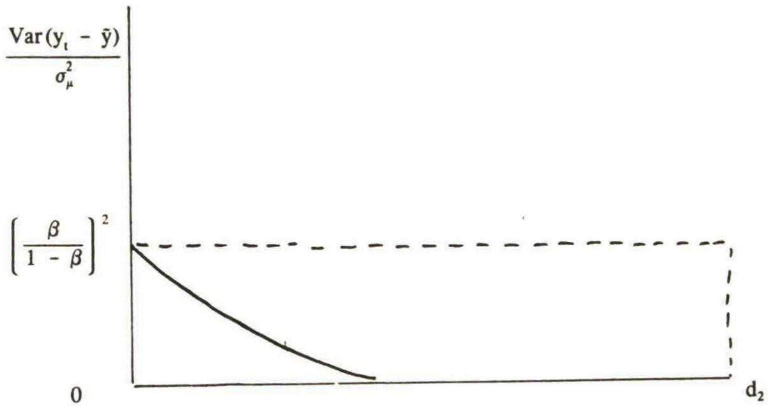
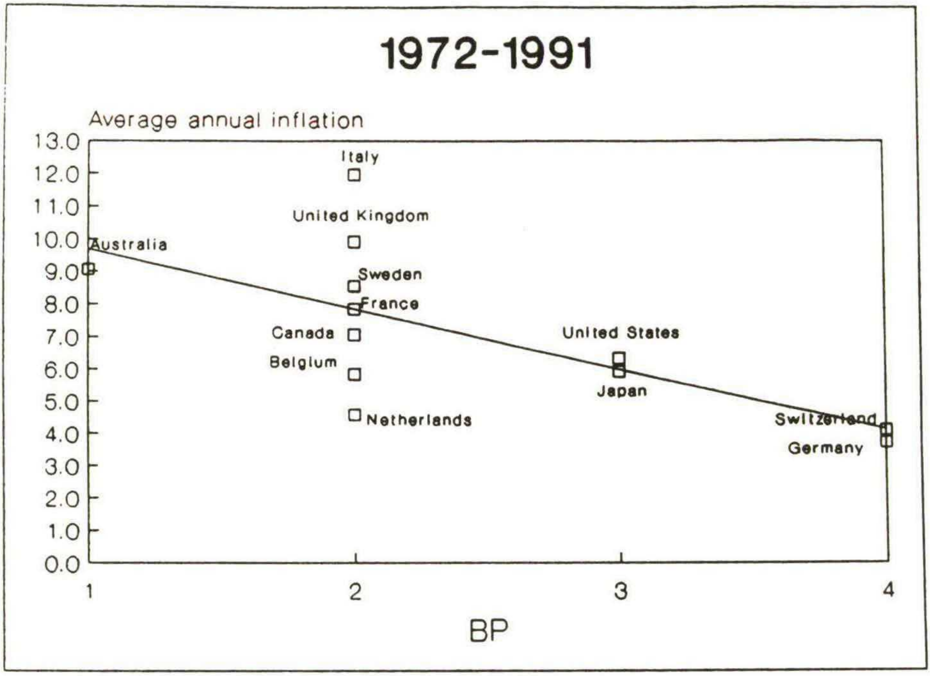


*Table 2 Central Bank Independence, Growth and Inflation**

Inflation		Growth	
Mean	Variance	Mean	Variance
$\frac{\partial \Delta \bar{p}_t}{\partial d_2} > 0$	$\frac{\partial \left[\frac{\mathrm{Var}\, \Delta p_t}{\sigma^2 \mu} \right]}{\partial d_2} > 0$	$\frac{\partial \Delta \tilde{y}_t}{\partial d_2} = 0$	$\frac{\partial \left[\frac{\mathrm{Var}(\Delta y_t - \Delta \tilde{y}_t)}{\sigma^2 \Delta \mu} \right]}{\partial d_2} < 0$
PROPOSITION 3.1	**PROPOSITION 3.2**	**PROPOSITION 3.5**	**PROPOSITION 3.6**

* Note degree of central bank independence $\equiv 1/d_2$.

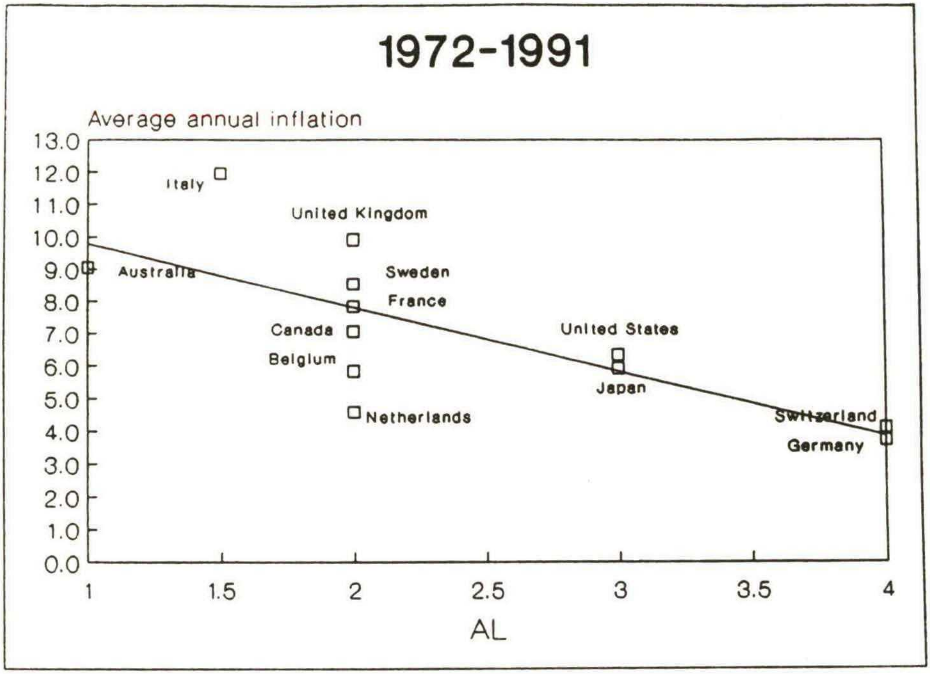
Figure 4. The Bade-Parkin index and the level of inflation.



Root MSE	1.93880	R-square	0.4482
Dep Mean	7.07434	Adj R-sq	0.3930

Average inflation = 11.546 - 1.850 * BP
(6.931) (-2.850)

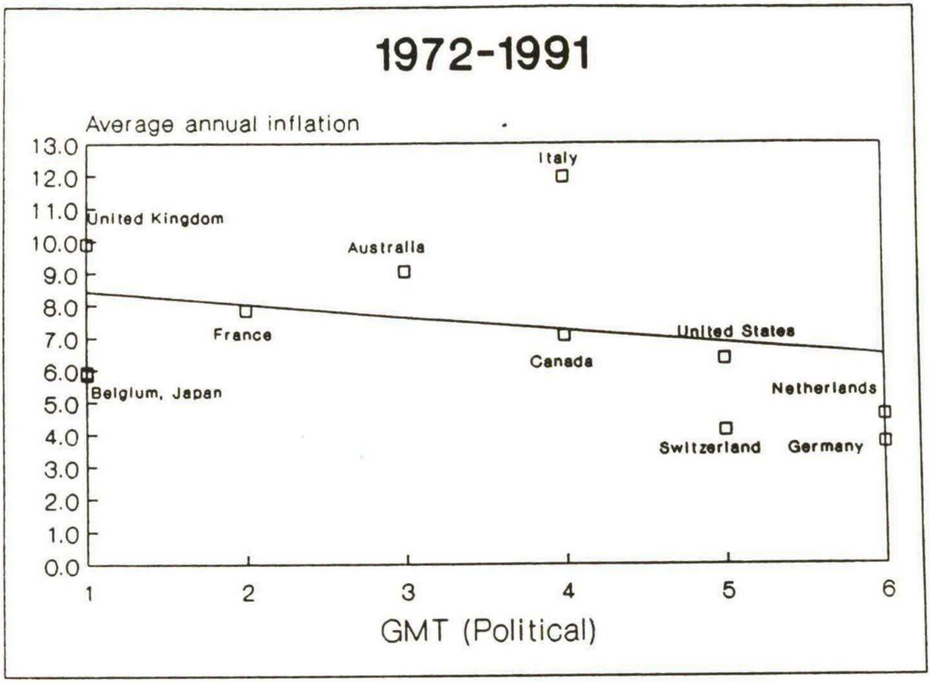
Figure 5. The Alesina index and the level of inflation.



Root MSE	1.74958	R-square	0.5507
Dep Mean	7.07434	Adj R-sq	0.5057

Average inflation = 11.778 - 1.981 * AL
(8.205) (-3.501)

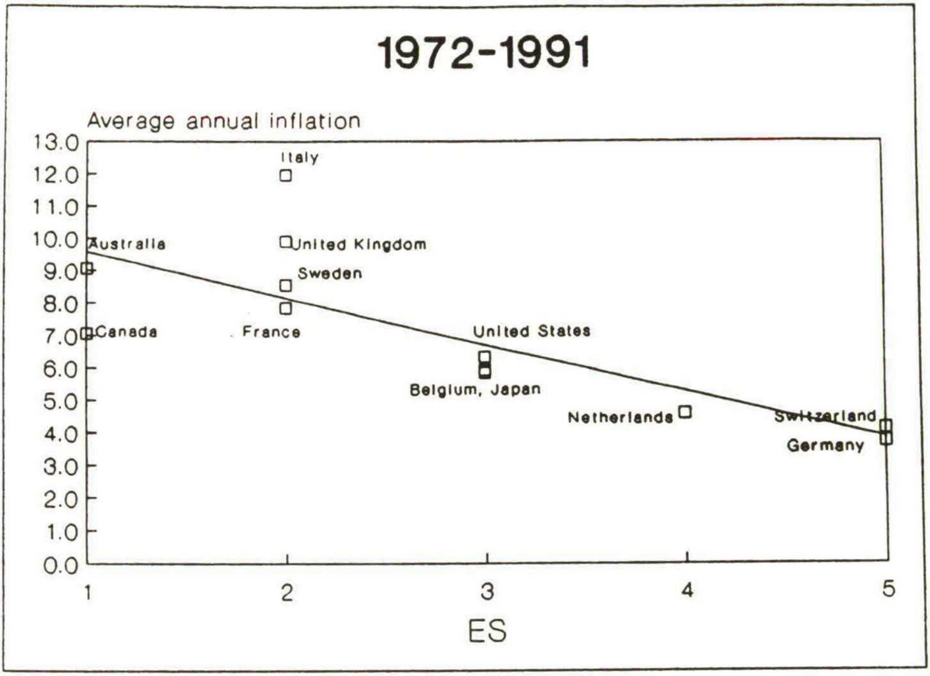
Figure 6. The Grilli-Masciandaro-Tabellini index and the level of inflation.



Root MSE	2.45595	R-square	0.1746
Dep Mean	6.94071	Adj R-sq	0.0828

Average inflation = 8.822 - 0.395 * GMT(Political)
(5.686) (-1.380)

Figure 7. The Eijffinger-Schaling index and the level of inflation.



Root MSE	1.62994	R-square	0.6100
Dep Mean	7.07434	Adj R-sq	0.5710

Average inflation = 11.014 - 1.433 * ES
(9.998) (-3.955)

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