

# THE ULTIMATE DETERMINANTS OF CENTRAL BANK INDEPENDENCE

by

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## Abstract

Using a graphical method, a new way of determining the optimal degree of central bank conservativeness is developed in this paper. Unlike Lohmann (1992) and Rogoff (1985), we are able to express the upper and lower bounds of the interval containing the optimal degree of conservativeness in terms of the structural parameters of the model.

Next, we show that optimal central bank independence is higher, the higher the natural rate of unemployment, the greater the benefits of unanticipated inflation, the less inflation-averse society, and the smaller the variance of productivity shocks. These propositions are tested for nineteen industrial countries (Australia, Austria, Belgium, Canada, Denmark, Finland, France, Germany, Ireland, Italy, Japan, New Zealand, the Netherlands, Norway, Spain, Sweden, Switzerland, the United Kingdom and the United States) for the post-Bretton-Woods period (1960-1993). In testing the model we employ a latent variables method (LISREL) in order to distinguish between actual and optimal monetary regimes.

## I. INTRODUCTION<sup>1)</sup>

Recently, in many countries both political and monetary authorities have shown an increasing interest in the objective of monetary stability and the position of the central bank. As pointed out by Persson and Tabellini (1993) recent policy reform, as well as historical experience, suggests two different routes to price stability.

The first way is the *legislative* approach, namely to create by law a very independent central bank with an unequivocal mandate to focus on price stability. Interest in this approach is motivated by the success of the Deutsche Bundesbank in maintaining one of the lowest rates of inflation for several decades. Moreover, the accepted statute of the European Central Bank is strongly influenced by the law governing the Bundesbank. Moreover, France and Spain reformed their central bank laws that made the Banque de France and the Banco de España more independent of government. Furthermore, countries in Central and Eastern Europe, such as the Czech Republic, Hungary and Poland, increased the legal independence of their central banks. Finally, in Latin America there are also tendencies toward granting more independence to the central banks in countries like Argentina, Chile, Mexico and Venezuela. Academic contributions in this area are Rogoff (1985), Neumann (1991) and Lohmann (1992).

The second way is the *targeting* or *contracting* approach, namely to let the political principal of the central bank impose an explicit inflation target for monetary policy, and make the central bank governor explicitly accountable for his success in meeting this target. Recently, New Zealand, Canada, and the United Kingdom have made some progress on this route. Along these lines New Zealand enacted legislation that increased the independence of its Reserve Bank, whereas in the United Kingdom there is now a lively discussion of the desirability of making the Bank of England more independent.<sup>2)</sup> Important theoretical work on this approach is done by Walsh (1993) and Persson and Tabellini (1993).

Empirical work on the legislative approach [Alesina (1988, 1989), Grilli, Masciandaro and Tabellini (1991), Cukierman (1992), Eijffinger and Schaling (1992, 1993a, 1993b), De Haan and Sturm (1992), Alesina and Summers (1993)] has focused on the quantification of independence using a number of legal attributes from central bank laws. These studies focus on the *positive* issue of the relation between monetary regimes and economic performance. Broadly speaking, the conclusion is that the more independent the central bank, the lower the inflation rate, whilst the rate of output growth is unaffected.

However, this literature does not explain the observed differences in central bank

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<sup>1)</sup> The authors owe a debt of gratitude to Marco Hoeberichts for his empirical support. They are also grateful to Marno Verbeek for his valuable suggestions with respect to the latent variables method.

<sup>2)</sup> For a recent discussion about the independence of the Bank of England and the associated inflation targeting framework see Centre for Economic Policy Research (1993).

independence. For instance, no explanation is offered for the very high independence of the Bundesbank. It has often been pointed out that this independence may be explained by Germany's underlying aversion to inflation associated with its experience of hyperinflation in the 1920s.<sup>3)</sup>

This brings us to a key issue in the political economy of central banking: the relation between institutional design and individual and collective preferences. Here the question to be dealt with is the *normative* issue of how independent a central bank should be, i.e. the optimal degree of central bank independence.

An important study in this field is Cukierman (1994). Building on the seminal paper of Lohmann (1992), he wants to identify the economic and political factors that induce politicians to delegate more or less authority to the central bank. His theory predicts that central bank independence will be higher the larger the employment-motivated inflationary bias, the higher political instability and the larger the government debt.

These predictions were tested and, subsequently, rejected by De Haan and Van 't Hag (1994) using regression analysis (OLS method). In testing Cukierman's model, they employ measures of central bank independence that in - Rogoff's (1985) terminology - reflect the strength of the 'conservative bias' of the central bank as embodied in the law. In Cukierman's model, following Lohmann (1992), central bank independence is defined as the *cost of overriding* the central bank, rather than as the degree of *conservativeness*. Cukierman's (1994) theory also generates propositions about *optimal* regimes, whilst the legal measures describe *actual* monetary regimes.

In this paper we try to overcome these pitfalls. Building on the Rogoff (1985) model, we identify central bank independence as the degree of conservativeness rather than the political cost of overriding the central bank. Using a graphical method, we develop a new way of determining the optimal degree of conservativeness. As in Lohmann (1992), this degree depends on the balance between *credibility* and *flexibility*. However, unlike Rogoff and Lohmann, we are able to express the upper and lower bounds of the interval containing the optimal degree of conservativeness in terms of the structural parameters of the model.

Furthermore, we derive several propositions concerning the relation between economic and political factors and the optimal degree of central bank independence. We show that optimal central bank independence is higher, the higher the natural rate of unemployment, the greater the benefits of unanticipated inflation (the slope of the Phillips curve), the less inflation-averse society, and the smaller the variance of productivity shocks. These propositions are tested for nineteen industrial countries (Australia, Austria, Belgium, Canada, Denmark, Finland, France, Germany, Ireland, Italy, Japan, New Zealand, the Netherlands, Norway, Spain, Sweden, Switzerland, the United Kingdom and the United States) for the post-Bretton-Woods period (1960-1993). In testing the model we employ a

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<sup>3)</sup> See for instance Issing (1993).

*latent variables* method (LISREL) in order to distinguish between actual and optimal monetary regimes.

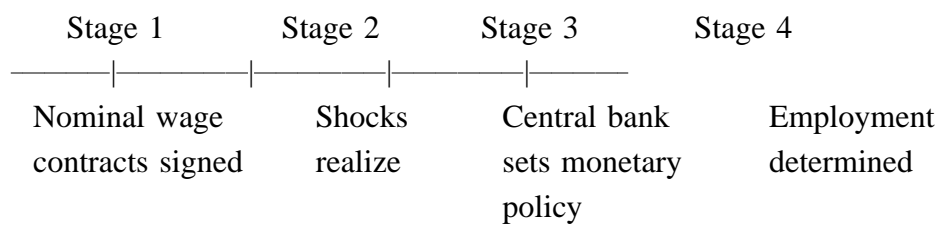
The paper is organized into four remaining sections, followed by three appendices. In section II we present the theoretical model. Section III contains the derivation of the optimal degree of central bank independence. In section IV we test the model with the latent variables method. Our conclusions are given in Section V.

## II.A SIMPLE MACROMODEL

The main purpose of this section is to combine the Alogoskoufis (1994) model of wage and employment determination with the Rogoff (1985) model. We assume that there are two types of agents, *wage-setters (the union)* and the *central bank*. Wage-setters unilaterally choose the nominal wage every period, and the central bank controls monetary policy.

The sequence of events is as follows. In the first stage wage-setters sign each period nominal wage contracts [Gray (1976), Fischer (1977a)]. Wage-setters know the domestic monetary regime. They take this information into account in forming their expectations. In the second stage stochastic shocks to productivity realize. These shocks are random and cannot be observed at the time wage contracts are signed. In the third stage the central bank observes the values of the shocks and — contingent on the chosen regime — reacts to the shocks accordingly. In the fourth and final stage employment is determined by competitive firms. This timing of events is summarized in Figure 2.1.

**Figure 2.1. The sequence of events.**



We now move to the supply side of the model.

### II.1. Aggregate supply

Consider the following supply block. Capital will be assumed fixed, and output is given by a short-run Cobb-Douglas production function

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

where lower-case letters refer to logarithmic deviations from steady state values. Thus,  $y$  is the log of output,  $\ell$  the log of employment, and  $\mu_t$  a measure of productivity.  $\beta$  is the exponent of labour and is less than unity.

Having described the level of output, it remains to be specified how productivity evolves over time. For simplicity we assume that shocks to productivity are normally distributed with zero mean and finite variance

$$\mu_t = v_t^\mu \quad v_t^\mu \sim N(0, \sigma_\mu^2) \quad (2.2)$$

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

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

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 real wages and employment around their target levels. Thus wages in each period are set to minimize

$$W_t = E_{t-1} \left[ \frac{1}{2} (\ell - \ell^*)^2 \right] \quad (2.4)$$

where  $E_{t-1}$  is the operator of rational expectations, conditional on information at the end of period  $t - 1$ .  $\ell^*$  is the employment target of the union. We assume that  $\ell^* \equiv \ell_1^s$  where  $\ell_1^s$  is the number of insiders. Denoting the log of the labour force by  $\ell^s$ , we assume  $\ell_1^s < \ell^s$ . Thus we employ a variant of the insider—outsider approach to the labour market [Blanchard and Summers (1986), Lindbeck and Snower (1986)]. The minimization of (2.4) is subject to the labour demand function (2.3).

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

$$w_t = E_{t-1} p_t - (1-\beta) \ell^* \quad (2.5)$$

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

$$\ell_t = \ell^* + \frac{1}{1-\beta} (p_t - E_{t-1} p_t + \mu_t) \quad (2.6)$$

An unanticipated rise in prices  $p_t - E_{t-1} p_t$  reduces the real wage, and causes firms to employ more labour. Thus, aggregate employment exhibits a transitory deviation from its

equilibrium or "natural" rate  $\ell^*$ .<sup>4)</sup>

Subtracting (2.6) from the labour force  $\ell^s$ , using the approximation that the rate of unemployment  $u \approx \ell^s - \ell$ , we get the following expression for the short—run determination of unemployment

$$u_t = \tilde{u} - \frac{1}{1-\beta} (p_t - E_{t-1}p_t + \mu_t) \quad (2.7)$$

where  $\tilde{u} = \ell^s - \ell^*$ .  $\tilde{u}$  can be thought of as the *equilibrium* or "*natural*" rate of unemployment in this model. Thus, (2.7) 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 reflected in wages (equation (2.5) and do not affect unemployment. We can now incorporate the Phillips curve into a monetary policy game. This is the subject of the next section.

## II.2. Time-Consistent Equilibrium under a "Conservative" Central Banker

As stated by Rogoff (1985, p. 1180), the adoption of central bank independence may be viewed as an institutional response to the time-consistency problem.

Suppose, for example, that through a system of rewards and punishments the central bank's incentives are altered so that it places some direct weight on achieving a low rate of growth for a nominal variable such as the price level, nominal GNP, or the money supply. Rogoff demonstrates that society can make itself better off by selecting an agent to head the central bank who is known to place a greater weight on inflation stabilization (relative to unemployment stabilization) than is embodied in the social loss function  $L_t$ . The social loss function  $L$  depends on deviations of unemployment and inflation from their *optimal* (socially desired) levels

$$L_t = \frac{1}{2} (\Delta p_t - \Delta p^*) + \frac{\chi}{2} (u_t - u^*)^2 \quad (2.8)$$

where  $0 < \chi < \infty$  and  $\Delta p^*$  and  $u^*$  are society's inflation and unemployment targets. The parameter  $\chi$  is the relative weight of unemployment stabilization relative to inflation stabilization in the preferences of society. Normalizing  $\Delta p^*$ ,  $u^*$  and  $p_{t-1}$  at zero we get <sup>5)</sup>

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<sup>4)</sup> Actual employment equals its natural rate when all expectations are fulfilled. Hence, the natural rate of employment equals  $\ell^*$ .

<sup>5)</sup> Price-level targeting and inflation-rate targeting are equivalent here, since  $p_{t-1}$  is known at the time the central bank commits itself to achieving a target for  $p_t - p_{t-1}$ . Once monetary control errors are taken into account it becomes important to make the distinction between a *zero inflation target* and a *target of price*

$$L_t = \frac{1}{2} p_t^2 + \frac{\chi}{2} u_t^2 \quad (2.9)$$

Rogoff shows that, in choosing among potential candidates, it is never optimal to choose an individual who is known to care "too little" about unemployment.

Suppose, for example that in period  $t - 1$  society selects an agent to head the central bank in period  $t$ . The reputation of this individual is such that it is known that, if he is appointed to head the central bank, he will minimize the following loss function

$$I_t = \frac{(1 + \varepsilon)}{2} p_t^2 + \frac{\chi}{2} u_t^2 \quad 0 < \varepsilon < \infty \quad (2.10)$$

When  $\varepsilon$  is strictly greater than zero, then this agent places a greater relative weight on inflation stabilization than society does. Hence, following Eijffinger and Schaling (1993b, p. 5) we view the coefficient  $\varepsilon$  as a measure of the *political independence* of the central bank. The higher  $\varepsilon$  the more independent the central bank. Note that, if  $\varepsilon = 0$ , equation (2.10) reduces to the social loss function (2.9).

Thus, stochastic equilibrium is derived under the assumption that the monetary authorities attempt to minimize loss function  $I$ , given by equation (2.10) above.

Substituting the Phillips curve (2.7) in the loss function (2.10) yields

$$I_t = \frac{1 + \varepsilon}{2} p_t^2 + \frac{\chi}{2} \left[ \tilde{u} - \frac{1}{1 - \beta} p_t + \frac{1}{1 - \beta} E_{t-1} p_t - \frac{1}{1 - \beta} \mu_t \right]^2 \quad (2.11)$$

From the first-order conditions for a minimum of (2.11), i.e.  $\partial I_t / \partial p_t = 0$ , we obtain the central bank's reaction function to the union's inflationary expectations

$$p_t^I = \frac{\chi (1 - \beta)}{(1 - \beta)^2 (1 + \varepsilon) + \chi} \tilde{u} + \frac{\chi}{(1 - \beta)^2 (1 + \varepsilon) + \chi} E_{t-1} p_t^I - \frac{\chi}{(1 - \beta)^2 (1 + \varepsilon) + \chi} \mu_t \quad (2.12)$$

where superscript  $I$  stands for *independent* central bank regime.

Taking expectations conditional on information at  $t - 1$  of (2.12) gives

$$E_{t-1} p_t^I = \frac{\chi}{(1 - \beta)(1 + \varepsilon)} \tilde{u} \quad (2.13)$$

Equation (2.13) is the reaction function of the union. The resulting price level and unemployment rate are

$$p_t^I = \frac{\chi}{(1 - \beta)(1 + \varepsilon)} \tilde{u} - \frac{\chi}{(1 - \beta)^2 (1 + \varepsilon) + \chi} \mu_t \quad (2.14)$$

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*stability*. See Fischer (1994, pp. 33-34).

$$u_t^I = \tilde{u} - \frac{(1-\beta)(1+\varepsilon)}{(1-\beta)^2(1+\varepsilon) + \chi} \mu_t \quad (2.15)$$

### III. OPTIMAL COMMITMENT IN MONETARY POLICY: CREDIBILITY VERSUS FLEXIBILITY

#### III.1. Social Welfare under Central Bank Independence

We are now able to evaluate central bank independence from the perspective of society. To facilitate exposition in later sections, following Rogoff (1985, pp. 1175—1176), we shall first develop a notation for evaluating the expected value of society's loss function under any arbitrary monetary policy regime "A",  $E_{t-1}L_t^A$ :

$$E_{t-1}L_t^A = \frac{1}{2}[\chi \tilde{u}^2] + \Pi^A + \Gamma^A \quad (3.1)$$

where  $\Pi^A \equiv 1/2 (\tilde{p}_t^A)^2$ ,  $\tilde{p}_t^A$  is the mean price level in period t, and

$$\Gamma^A \equiv \frac{1}{2} E_{t-1} \left\{ \chi \left[ \frac{\mu_t}{1-\beta} + (p_t^A - E_{t-1}p_t^A)/(1-\beta) \right]^2 + (p_t^A - E_{t-1}p_t^A)^2 \right\}.$$

Again, the first component of  $E_{t-1}L_t^A$ ,  $1/2[\chi \tilde{u}^2]$  is non-stochastic and invariant across monetary regimes. It represents the *deadweight loss* due to the labour market distortion ( $\tilde{u} > 0$ ). This loss cannot be reduced through monetary policy in a time-consistent rational expectations equilibrium. The second term,  $\Pi^A$ , depends on the mean inflation rate. This term is also non-stochastic but does depend on the *choice* of monetary policy regime.

The final term,  $\Gamma^A$ , represents the *stabilization component* of the loss function. It measures how successfully the central bank offsets disturbances to stabilize unemployment and inflation around their mean values.

By substituting the results relevant for the central bank [(2.14) and (2.15)] into society's loss function (2.9) and taking expectations we obtain the I and regime counterpart of expression (3.1). Abstracting from the (common) deadweight loss, one gets

$$\Pi^I + \Gamma^I = \frac{\chi^2}{2[(1+\varepsilon)(1-\beta)]^2} \tilde{u}^2 + \frac{\chi[(1+\varepsilon)^2(1-\beta)^2 + \chi]}{2[(1+\varepsilon)(1-\beta)^2 + \chi]^2} \sigma_\mu^2 \quad (3.2)$$

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<sup>6)</sup> We derive equation (3.1) in Appendix A.



### III.2. The Rogoff Theorem

First, we reproduce Rogoff's (1985) proof that it is optimal for society (principal) to select an agent to head the independent central bank that places a large, but finite weight on inflation. The *optimal degree* of central bank independence  $\varepsilon^*$  is defined as that value of  $\varepsilon$  that minimizes the expected value of the loss function of society  $E_{t-1} L_t^I$ .

To solve for the value of  $\varepsilon$  that minimizes  $E_{t-1} L_t^I$ , differentiate (3.2) with respect to  $\varepsilon$

$$\frac{\partial E_{t-1} L_t^I}{\partial \varepsilon} = \frac{\partial \Pi^I}{\partial \varepsilon} + \frac{\partial \Gamma^I}{\partial \varepsilon} \quad (3.3)$$

$$\frac{\partial \Gamma^I}{\partial \varepsilon} = \frac{\chi^2(1-\beta)^2 \varepsilon \sigma_\mu^2}{[(1+\varepsilon)(1-\beta)^2 + \chi]^3} \quad (3.4)$$

$$\frac{\partial \Pi^I}{\partial \chi} = \frac{-\chi^2 \tilde{u}^2}{(1+\varepsilon)^3 (1-\beta)^2} \quad (3.5)$$

We are now ready to prove:

**PROPOSITION 3.1:** With a *positive* natural rate of unemployment, the optimal degree of central bank independence lies between *zero* and *infinity* (For  $\tilde{u} > 0$ ,  $0 < \varepsilon^* < \infty$ ).

*Proof:* Note that  $\varepsilon > -1$  by assumption. Thus, by inspection of (3.5),  $\partial \Pi^I / \partial \varepsilon$  is strictly negative. Note also, by inspection of (3.4), that  $\partial \Gamma^I / \partial \varepsilon$  is strictly negative for

$$\frac{-[\chi + (1-\beta)^2]}{(1-\beta)^2} < \varepsilon < 0, \text{ zero when } \varepsilon = 0 \text{ and positive for } \varepsilon > 0.$$

Therefore,  $\partial E_{t-1} L_t^I / \partial \varepsilon$  is strictly negative for  $\varepsilon \leq 0$ .  $\partial E_{t-1} L_t^I / \partial \varepsilon$  must change from negative to positive at some sufficiently large value of  $\varepsilon$ , since as  $\varepsilon$  approaches positive infinity,  $\partial \Gamma^I / \partial \varepsilon$  converges to zero at rate  $\varepsilon^{-2}$ , whereas  $\partial \Pi^I / \partial \varepsilon$  converges to zero at rate  $\varepsilon^{-3}$ . Consequently,  $\varepsilon^* < \infty$ <sup>7)</sup>

The intuition behind this result is the following. From (3.5) it can be seen that increasing the central bank's commitment to inflation stabilization decreases the credibility component of the social loss function. On the other hand, from (3.4) it follows that having a more independent central bank increases the stabilization component of the loss

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<sup>7)</sup> As pointed out by Rogoff (1985, p. 1178), it is extremely difficult to write down a closed-form solution for  $\varepsilon^*$ .

function.

Hence, optimal commitment in monetary policy involves trading off the *credibility* gains associated with lower average inflation versus loss of *flexibility* due to a distorted response to output shocks.

### III.3. The Ultimate Determinants of Central Bank Independence

Proposition (3.1) is Rogoff's theorem. Rogoff is unable to write down a closed-form solution for  $\varepsilon^*$ . Therefore, he is also unable to derive propositions concerning the comparative static properties of this equilibrium. The following section can be seen as an *extension* of the Rogoff theorem.

Using a graphical method, we develop an alternative way of determining the optimal degree of central bank independence. Next, we show how this result is conditioned on the natural rate of unemployment ( $\tilde{u}$ ), society's preferences for unemployment stabilization ( $\chi$ ), the variance of productivity shocks ( $\sigma_\mu^2$ ) and the slope of the Phillips curve ( $(1-\beta)^{-1}$ ).

By setting (3.3) equal to zero we obtain the first-order condition for a minimum of  $E_{t-1} L_t^1$

$$0 = \frac{\partial \Pi^1}{\partial \varepsilon} + \frac{\partial \Gamma^1}{\partial \varepsilon} \quad (3.6)$$

Substituting (3.4) and (3.5) into (3.6), yields

$$\frac{-\chi^2 \tilde{u}^2}{(1-\beta)^2 (1+\varepsilon)^3} + \frac{\chi^2 (1-\beta)^2 \varepsilon \sigma_\mu^2}{[(1+\varepsilon)(1-\beta)^2 + \chi]^3} = 0 \quad (3.7)$$

Equation (3.7) determines  $\varepsilon^*$  as an implicit function of  $\chi$ ,  $\tilde{u}$ ,  $\sigma_\mu^2$  and  $\beta$ . A solution for  $\varepsilon^*$  always exists and is unique.

To show this we adapt a graphical method used by Cukierman (1992, pp. 170-172) in the context of a dynamic game.

Rewrite (3.7) as

$$\varepsilon = \frac{[(1+\varepsilon)(1-\beta)^2 + \chi]^3 \tilde{u}^2}{\sigma_\mu^2 (1-\beta)^4 (1+\varepsilon)^3} \equiv F(\varepsilon) \quad (3.8)$$

The function  $F(\varepsilon)$  on the right-hand side of equation (3.8) is monotonically decreasing in

$\varepsilon$  that<sup>8)</sup>

$$F(0) = \frac{[(1-\beta)^2 + \chi]^3 \tilde{u}^2}{\sigma_\mu^2 (1-\beta)^4}, \quad \lim_{\varepsilon \rightarrow \infty} F(\varepsilon) = \frac{(1-\beta)^2 \tilde{u}^2}{\sigma_\mu^2} \quad \text{and}$$

$$\frac{(1-\beta)^2 \tilde{u}^2}{\sigma_\mu^2} < F(\varepsilon) < \frac{[(1-\beta)^2 + \chi]^3 \tilde{u}^2}{\sigma_\mu^2 (1-\beta)^4}$$

We are now ready to prove:

**PROPOSITION 3.2:**  $\frac{(1-\beta)^2 \tilde{u}^2}{\sigma_\mu^2} < \varepsilon^* < \frac{[(1-\beta)^2 + \chi]^3 \tilde{u}^2}{\sigma_\mu^2 (1-\beta)^4}$

*Proof:* The left-hand side of (3.8) is a 45-degree straight line through the origin. Since

$$F(0) = \frac{[(1-\beta)^2 + \chi]^3 \tilde{u}^2}{\sigma_\mu^2 (1-\beta)^4} \quad \text{and} \quad \frac{\partial F}{\partial \varepsilon} < 0, \quad \text{these two functions must intersect at one and only}$$

one point. Moreover, since

$$\frac{\tilde{u}^2 (1-\beta)^2}{\sigma_\mu^2} < F(\varepsilon) < \frac{[(1-\beta)^2 + \chi]^3 \tilde{u}^2}{\sigma_\mu^2 (1-\beta)^4}, \quad \text{the intersection occurs at a}$$

value of  $\varepsilon$  that is bounded between  $\frac{(1-\beta)^2 \tilde{u}^2}{\sigma_\mu^2}$  and  $\frac{[(1-\beta)^2 + \chi]^3 \tilde{u}^2}{\sigma_\mu^2 (1-\beta)^4}$

Figure 3.1 illustrates the argument graphically. Clearly, a solution for  $\varepsilon$  exists and is unique.

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<sup>8)</sup> These statements are demonstrated in Appendix B to this paper.

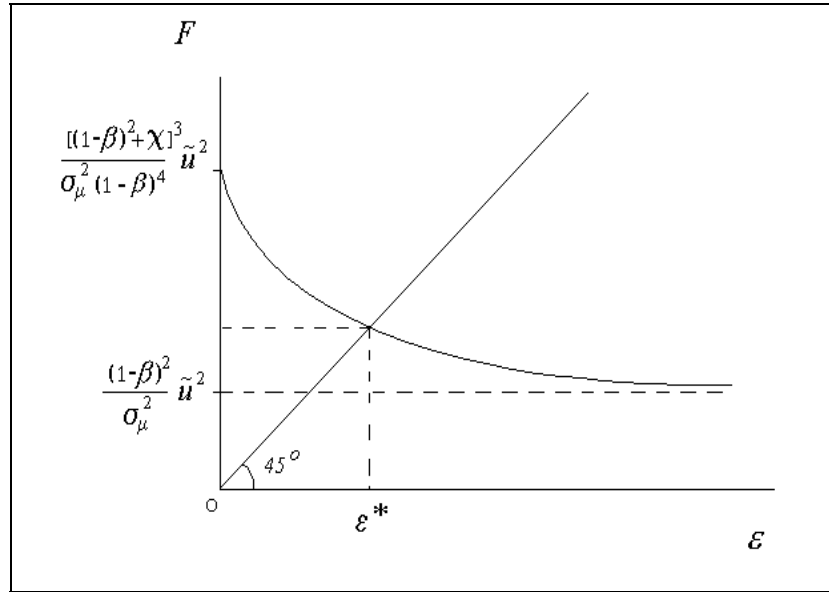


Figure 3.1. The optimal degree of central bank independence

We are now ready to investigate the factors affecting the optimal degree of central bank independence. Hence, we identify *economic* and *political* factors that induce politicians to delegate more or less authority to this institution. We show that the delegation of authority to the central bank depends on the natural rate of unemployment, society's preferences for unemployment stabilization, the variance of productivity shocks and the slope of the Phillips curve. The results are derived by performing comparative static experiments with respect to various parameters on Figure 3.1. Derivations appear in Appendix B. We summarize the main results in four propositions.

**PROPOSITION 3.3:** The higher the *natural rate of unemployment* (the higher  $\tilde{u}$ ), the higher the optimal degree of central bank independence.

*Proof:* Appendix B shows that  $\frac{\partial F}{\partial \tilde{u}} > 0$ , implying that when  $\tilde{u}$  goes up, the curve  $F(\varepsilon)$

in Figure 3.1 shifts upward. As a consequence, the equilibrium value of  $\varepsilon$  increases.

The intuition behind this result is the following. A higher natural rate of unemployment implies a higher time-consistent rate of inflation (See equation (2.14)) and, consequently, a higher credibility component of the social loss function. This means that society's credibility problem is increased. Hence, with an unaltered relative weight placed on inflation versus unemployment stabilization the monetary authorities' commitment to fight inflation is now too low.

**PROPOSITION 3.4:** The higher *society's preferences for unemployment stabilization relative to inflation stabilization* (the higher  $\chi$ ), the higher the optimal degree of central bank independence.

*Proof:* Appendix B shows that  $\frac{\partial F}{\partial \chi} > 0$ , implying that when  $\chi$  goes up, the curve  $F(\varepsilon)$

in Figure 3.1 shifts upward. Thus, the equilibrium value of  $\varepsilon$  increases.

The underlying intuition is that, if society becomes more concerned with unemployment, the time-consistent inflation rate goes up (See equation (2.14)). Therefore, society's credibility problem becomes more pressing. With an unchanged relative weight placed on inflation stabilization, the balance between credibility and flexibility needs to be adjusted in favour of increased commitment of fighting inflation.

**PROPOSITION 3.5:** The higher the *variance of productivity shocks* (the higher  $\sigma_\mu^2$ ), the lower the optimal degree of central bank independence.

*Proof:* Appendix B shows that  $\frac{\partial F}{\partial \sigma_\mu^2} < 0$ , implying that when  $\sigma_\mu^2$  goes up, the curve

$F(\varepsilon)$  in Figure 3.1 shifts downward. Therefore, the equilibrium value of  $\varepsilon$  decreases.

This result may be explained as follows. If the variance of productivity shocks increases, *ceteris paribus*, the economy becomes more unstable. Thus, the need for active stabilization policy increases (the  $\Gamma^1$  component of the social loss function goes up).

With an unaltered relative weight placed on inflation stabilization the balance between credibility and flexibility needs to be shifted towards more monetary accommodation.

**PROPOSITION 3.6:** If society is relatively unconcerned with inflation  $\left( \chi > \frac{(1+\varepsilon)(1-\beta)^2}{2} \right)$  the greater the *benefits of unanticipated inflation* (the higher  $(1-\beta)^{-1}$ ), the higher the optimal degree of central bank independence.

*Proof:* Appendix B shows that, if  $\chi > \frac{(1+\varepsilon)(1-\beta)^2}{2}$ ,  $\frac{\partial F}{\partial (1-\beta)^{-1}} > 0$ , implying that

when  $(1-\beta)^{-1}$  goes up, the curve  $F(\varepsilon)$  shifts upward. Consequently, the equilibrium value of  $\varepsilon$  increases.

The intuition behind this proposition is that, if the benefits of unanticipated inflation rise (See equation (2.7)), it becomes more tempting to inflate the economy. Therefore, society's credibility problem gains in importance. With the same emphasis on inflation

stabilization, the balance between credibility and flexibility needs to be shifted towards increased commitment to price stability.

Finally, we summarize the propositions from this section in Table 3.1.

**Table 3.1. The ultimate determinants of central bank independence**

Economic and political factors			
$\bar{u}$	$\chi$	$\sigma_{\mu}^2$	$(1-\beta)^{-1}$
Natural rate of unemployment	Society's preferences for unemployment stabilization	Variance of productivity shocks	Gains from unanticipated inflation (slope of Phillips curve)
$\frac{\partial \varepsilon^*}{\partial \bar{u}} > 0$	$\frac{\partial \varepsilon^*}{\partial \chi} > 0$	$\frac{\partial \varepsilon^*}{\partial \sigma_{\mu}^2} < 0$	$\frac{\partial \varepsilon^*}{\partial (1-\beta)^{-1}} > 0$

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

#### IV. EMPIRICAL EVIDENCE

In this section, the ultimate determinants of central bank independence discussed before are empirically investigated. We will use, for that purpose, the *latent variables* method (LISREL) to make a distinction between the *optimal* and *actual (legal)* degree of central bank independence. The reasons for this distinction are two-fold. First, the propositions derived in the former section are related to the optimal degree of central bank independence and *not* to the actual (legal) degree. These propositions formulate the relationship between the optimal degree and four *economic* and *political* factors in a country:

- the natural rate of unemployment (positive relation);
- society's preferences for unemployment stabilization relative to inflation stabilization (positive relation);
- the variance of productivity shocks (negative relation); and
- the slope of the Phillips curve (conditional positive relation).

These determinants, reflecting the economic and political structure of a country, explain theoretically the optimal degree of central bank independence in that country.

Second, there is also an identification and measurement problem. Whereas the determinants of central bank independence will change *frequently* during the sample period (i.e. the period 1960-1993), the actual degree - approximated by the legal indices of central

bank independence - will hardly change in the same period. The stickiness of actual (legal) central bank independence results from the fact that central bank laws are *very occasionally* adjusted in practice, especially in the industrial countries during the post-war period.<sup>9)</sup> Moreover, it could be questioned whether the legal indices of central bank independence are a good measure of actual central bank independence (See also: Eijffinger and De Haan, 1995).

#### IV.1. The data

As proxies for the ultimate determinants of central bank independence, we have chosen the following economic and political variables (See for a detailed account of these variables: Appendix C). For the natural rate of unemployment, the *non-accelerating inflation rate of unemployment* (NAIRU) is taken from Layard, Nickell and Jackman (1991). They estimated the NAIRU for nineteen industrial countries in the period 1960-1988. The proxy for society's preferences for unemployment stabilization relative to inflation stabilization is the number of years that a *left-wing (socialist) party* has been in government as a share of the *total* number of years (WLEFT). For, a left-wing government has a higher preference for unemployment stabilization and, thereby, the optimal degree of central bank independence increases under a left-wing government. The variance of productivity shocks is proxied by the *variance of output growth* (GDP) on an annual basis (VPROD). We compute the slope of the Phillips curve, using labour's income share in GDP.<sup>10)</sup> Because data for labour's income share are not available for all countries in our sample, we have taken the ratio between the *compensation of employees* paid by resident producers to resident households and GDP (SLOPE).

Therefore, the *optimal* degree of central bank independence (OPCBI) is explained by the following variables, taken in deviation from their mean (M)

$$\begin{aligned} \text{OPCBI} = & a_1 \cdot \overset{(+)}{[\text{NAIRU\_M}]} + a_2 \cdot \overset{(+)}{[\text{WLEFT\_M}]} + a_3 \cdot \overset{(-)}{[\text{VPROD\_M}]} + \\ & a_4 \cdot \overset{(+)}{[\text{SLOPE\_M}]} \end{aligned} \quad (4.1)$$

<sup>9)</sup> Very recently, some countries within the European Union - e.g. France and Spain - have made their central banks more independent from government because this is required by the Maastricht Treaty on Economic and Monetary Union. These changes of central bank laws are, however, too infrequent to be applicable for our empirical analysis of the determinants in the industrial countries.

<sup>10)</sup> Since we use a Cobb-Douglas production function (equation (2.1)), the production elasticity of labour,  $\beta$ , equals labour's income share in GDP.

The expected signs are denoted above the explanatory variables. The optimal degree of central bank independence is assumed to be a *latent* variable in our empirical model. Next to the *observed* explanatory variables measured in deviation from their mean (NAIRU\_M, WLEFT\_M, VPROD\_M and SLOPE\_M), we need the actual (legal) degree of central bank independence as an *observed* variable. The actual degree of central bank independence is approximated by the legal degree, according to the four main indices of central bank independence in the literature.

The index of Alesina (AL) is a narrow measure of independence and based on Alesina (1988, 1989). The total index of political and economic independence of Grilli, Masciandaro and Tabellini (GMT) is a broad measure based on Grilli, Masciandaro and Tabellini (1991). The index of policy independence of Eijffinger and Schaling (ES) is, however, a narrow measure based on Eijffinger and Schaling (1992, 1993a) and extended by Eijffinger en Van Keulen (1994). The unweighted legal index of Cukierman (LVAU) is a very broad measure of independence and derived from Cukierman (1992).<sup>11)</sup>

For our cross-country analysis, a set of nineteen industrial (OECD) countries is taken which are ranked - with some exceptions - by the above-mentioned indices. The sample period that we have chosen covers more than thirty years, namely the period 1960-1993 (for NAIRU: 1960-1988). The argument to choose such a long period is that it contains many political and business cycles and, thus, comprises changes of the political and economic structure affecting the optimal degree of central bank independence.

#### IV.2. The latent variables method

According to Bentler (1982), the essential characteristic of a *latent variable* is revealed by the fact that the system of linear structural equations in which the latent variable appears cannot be manipulated so as to express this variable as a function of *measured* variables only.<sup>12)</sup>

Aigner, Hsiao, Kapteyn and Wansbeek (1984) state that, since 1970, there has been a resurgence of interest in econometrics in the topic of models involving latent variables.

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<sup>11)</sup> As a consequence of the latent variables method (LISREL), these observed indices of central bank independence are also measured in deviation from their means: AL\_M, GMTT\_M, ES\_M and LVAU\_M. If all variables have an expected value zero, than their covariance equals  $E[x y]$ .

<sup>12)</sup> For this definition of a latent variable, see: P.M. Bentler (1982), 'Linear Systems with Multiple Levels and Types of Latent Variables', Chapter 5 in: K.G. Jöreskog and H. Wold (eds.), *Systems Under Indirect Observations: Causality, Structure, Prediction*, Part I, Amsterdam: North-Holland Publishing Company, pp. 101-130. A clear overview of the latent variable method is given by: D.J. Aigner, C. Hsiao, A. Kapteyn and T. Wansbeek (1984), 'Latent Variable Models in Econometrics', Chapter 23 in: Z. Griliches and M.D. Intriligator (eds.), *Handbook of Econometrics*, Vol. II, Amsterdam: Elsevier Science Publishers, pp. 1321-1393.



"That interest in such models had to be restimulated at all may seem surprising", in the opinion of Aigner et al., "since there can be no doubt that economic quantities frequently are measured with error and, moreover, that many applications depend on the use of observable proxies for otherwise unobservable conceptual variables" (p. 1323).

Estimation of a simultaneous equations model with latent variables can be done by means of a computer program for the analysis of covariance structures, such a LISREL (Linear Structural Relations). The idea behind LISREL is to compare a sample covariance matrix with the parametric structure imposed on it by the hypothesized model. Under normality, LISREL delivers *Full Information Maximum Likelihood* (FIML) estimates of the model parameters. Because of its general availability, LISREL is the most important tool for handling latent variables.

The specification of the latent variables model to be analyzed by LISREL is as follows.<sup>13)</sup> Let  $\eta$  be the latent *dependent* variable, i.e. the latent optimal degree of central bank independence, and  $\xi$  be the latent *explanatory* variables, in our case the four ultimate determinants of central bank independence, satisfying a system of linear structural relations

$$\eta = B \cdot \xi + \zeta, \quad (4.2)$$

with  $B$  being the coefficient matrix and  $\zeta$  the disturbances. It is assumed that  $\eta$ ,  $\xi$  and  $\zeta$  have *zero* expectations, and that  $\xi$  and  $\zeta$  are *uncorrelated*. Instead of the latent vectors  $\eta$  and  $\xi$ , the vectors  $y$  and  $x$  are *observed*, such that

$$y = \Lambda_y \cdot \eta + \gamma \quad (4.3)$$

and

$$x = \Lambda_x \cdot \xi + \delta, \quad (4.4)$$

with  $\Lambda_y$  and  $\Lambda_x$  the coefficient matrices, and  $\gamma$  and  $\delta$  the vectors of measurement errors, *uncorrelated* with  $\eta$ ,  $\xi$ ,  $\zeta$  and each other, but possibly correlated among themselves. The observed vectors  $y$  and  $x$  are measured as deviations from their means, thus, having *zero* expectations and a covariance equal to  $E[x \ y]$ . This implies, of course, that  $\gamma$  and  $\delta$  have

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<sup>13)</sup> In order to avoid overlapping symbols between sections II and III (theoretical model) and section IV (latent variables model), our notation differs from that of the LISREL manual. Having one latent dependent variable, we use  $B$  and  $\gamma$ , respectively, instead of the symbols  $\Gamma$  and  $\varepsilon$  for the LISREL manual. Compare also Aigner et al. (1984, pp. 1370-1371) in this respect.

also zero expectations.

Therefore,  $y$  is a vector of *observed* legal indices of central bank independence (AL, GMTT, ES and LVAU), measured in deviation from their means

$$y = \begin{bmatrix} AL\_M \\ GMTT\_M \\ ES\_M \\ LVAU\_M \end{bmatrix} \quad (4.5)$$

, and  $x$  is a vector of *observed* explanatory variables, being the non-accelerating inflation rate of unemployment (NAIRU), the percentage of years of a left-wing government (WLEFT), the variance of output growth (VPROD) and the compensation of employees as share of GDP (SLOPE), measured in deviation from their means

$$x = \begin{bmatrix} NAIRU\_M \\ WLEFT\_M \\ VPROD\_M \\ SLOPE\_M \end{bmatrix} \quad (4.6)$$

So, equations (4.3) and (4.4) become, respectively

$$\begin{bmatrix} AL\_M \\ GMTT\_M \\ ES\_M \\ LVAU\_M \end{bmatrix} = \begin{bmatrix} \lambda_{y1} \\ \lambda_{y2} \\ \lambda_{y3} \\ \lambda_{y4} \end{bmatrix} \cdot \eta + \begin{bmatrix} \gamma_1 \\ \gamma_2 \\ \gamma_3 \\ \gamma_4 \end{bmatrix} \quad (4.3')$$

and

$$\begin{bmatrix} NAIRU\_M \\ WLEFT\_M \\ VPROD\_M \\ SLOPE\_M \end{bmatrix} = \begin{bmatrix} \lambda_{x1} & & & \\ & \lambda_{x2} & & \\ & & \lambda_{x3} & \\ & & & \lambda_{x4} \end{bmatrix} \cdot \begin{bmatrix} \xi_1 \\ \xi_2 \\ \xi_3 \\ \xi_4 \end{bmatrix} + \begin{bmatrix} \delta_1 \\ \delta_2 \\ \delta_3 \\ \delta_4 \end{bmatrix} \quad (4.4')$$

Furthermore,  $\Phi$  and  $\Psi$  are defined as the covariance matrix of  $\xi$  and the variance of  $\zeta$ , respectively, and  $\Theta_\gamma$  and  $\Theta_\delta$  as the true variance-covariance matrices of  $\gamma$  and  $\delta$ , respectively. Then it follows from the above assumptions that the variance-covariance matrix  $\Sigma$  of

$[y', x']'$  is

$$\Sigma = \left[ \begin{array}{c|c} \Lambda_y [B\Phi B' + \Psi] \Lambda'_y + \Theta_\gamma & \Lambda_y B\Phi \Lambda'_x \\ \hline \Lambda_x \Phi B' \Lambda'_y & \Lambda_x \Phi \Lambda'_x + \Theta_\delta \end{array} \right] \quad (4.7)$$

Assuming that the latent explanatory variables ( $\xi$ ) equal the observed ( $x$ ), thus  $\xi = x$ , then  $\Theta_\delta = 0$  and  $\Lambda_x = I$ , and equation (4.7) simplifies to<sup>14)</sup>

$$\Sigma = \left[ \begin{array}{c|c} \Lambda_y [B\Phi B' + \Psi] \Lambda'_y + \Theta_\gamma & \Lambda_y B\Phi \\ \hline \Phi B' \Lambda'_y & \Phi \end{array} \right] \quad (4.8)$$

The parameters occurring in  $\Sigma$  ( $\Lambda_y$ ,  $B$ ,  $\Phi$ ,  $\Psi$ ,  $\Theta_\gamma$ ) are estimated on the basis of the matrix  $S$  of second sample moments of  $x$  and  $y$ . In order to identify all parameters, *additional* restrictions on the parameters have to be imposed. Given these restrictions and the structure that equation (4.8) imposes on the data, LISREL computes FIML estimates of the parameters when  $[y', x']$  is normally distributed, i.e. when the following criterion is minimized

$$\ln |\Sigma| + \text{tr} [S\Sigma^{-1}] \quad (4.9)$$

To be able to identify all parameters of the model, we have made the following two additional restrictions:

- (i)  $\lambda_{y3} = 1$ , which implies that the latent optimal degree of central bank independence ( $\eta$ ) has the *same* unit of measurement as the observed legal index of Eijffinger and Schaling (ES\_M);<sup>15)</sup> and

<sup>14)</sup> So, we make only a distinction between the *latent* optimal degree of central bank independence ( $\eta$ ) and the *observed* actual degree ( $y$ ) measured by the legal indices of central bank independence. Thus, the optimal degree of central bank independence is derived from the covariances of the four legal indices.

<sup>15)</sup> It is, however, also possible to choose as the unit of measurement for the latent optimal degree *one* of the other observed legal indices ( $\lambda_{y1} = 1$ ,  $\lambda_{y2} = 1$  or  $\lambda_{y4} = 1$ ). In principal, this choice will not make a difference regarding the identification of the parameters.

- (ii)  $\Theta_\gamma$  is diagonal, which implies that the correlation between the observed legal indices of central bank independence ( $y$ ) is *only* caused by the latent optimal degree ( $\eta$ ).<sup>16)</sup>

### IV.3. The empirical results

On the basis of the restrictions given in the former section, LISREL computes *Full Information Maximum Likelihood* estimates of the parameters of the model. Computation with LISREL renders two different kind of estimations. First, the relationship between the *optimal* degree of central bank independence ( $\eta$ , here renamed as OPCBI) and the explanatory variables (NAIRU\_M, WLEFT\_M, VPROD\_M and SLOPE\_M), reflecting the ultimate *determinants* of central bank independence, is estimated.<sup>17)</sup> Second, by estimating this relationship and calculating the optimal degree of central bank independence for each country (OPCBI), the comparison between the *optimal* degree and the *legal* indices of central bank independence (AL, GMTT, ES and LVAU) can be made. Such a comparison is only possible if both the optimal degree and the legal indices are *normalized* on their theoretical scale (OPCBI\_N, AL\_N, GMTT\_N and ES\_N, respectively).<sup>18)</sup> Next to the differences of individual legal indices with the optimal degree, the *average difference* (AvDIFF) may be calculated in the following way:

$$\text{AvDIFF} = \frac{[\text{AL\_N}] + [\text{GMTT\_N}] + [\text{ES\_N}] + \text{LVAU}}{4} - [\text{OPCBI\_N}] \quad (4.10)$$

This average difference is *positive*, if the average of legal indices exceeds the optimal degree, and *negative*, if the optimal degree exceeds the average of legal indices.

A positive average difference indicates that the legal degree of central bank independence should be *decreased*, whereas a negative average difference that the legal degree should be *increased* in order to bring it closer to the optimal degree based on the ultimate determinants of central bank independence.

Table 4.1 shows the estimation results, with all restrictions imposed in the former section, for the sample period 1960-1993 (for NAIRU, the sample period 1960-1988).

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<sup>16)</sup> The measurement errors ( $\gamma$ ) in equation (4.3) are, thereby, uncorrelated.

<sup>17)</sup> Because all variables are measured in deviation form their mean and have, thus, zero expectations, the constant is eliminated from the model.

<sup>18)</sup> Note that the legal index of Cukierman (LVAU) is already normalized on its theoretical scale, i.e. in theory its lowest value is 0 and its highest value 1.

**Table 4.1. Table based on estimation with all restrictions.**

Sample period 1960 - 1993 for all variables (except for NAIRU: 1960 - 1988).

$$\text{OPCBI} = -0.098 * \text{NAIRU\_M} + 0.038 * \text{WLEFT\_M} - 0.039 * \text{VPROD\_M} + 2.025 * \text{SLOPE\_M} \\ (-1.296) \quad (0.054) \quad (-0.638) \quad (2.008)$$

Note:  $\_M$  means that variables are taken in deviation form their mean.  
T-values in parentheses.

Country	Indices				Transformed Indices				Differences (INDEX-OPCBI)				
	AL	GM	ES	LVAU	AL_N	GM	ES_N	LVAU	AL_N	GM	ES_N	LVAU	AvDIFF
Australia	1	9	1	0.31	0.00	0.56	0.00	0.415	-0.42	0.15	-0.42	-0.11	-0.20
Austria		9	3	0.58		0.56	0.50	0.460		0.10	0.04	0.12	0.09
Belgium	2	7	3	0.19	0.33	0.44	0.50	0.401	-0.07	0.04	0.10	-0.21	-0.04
Canada	2	11	1	0.46	0.33	0.69	0.00	0.381	-0.05	0.31	-0.38	0.08	-0.01
Denmark	2	8	4	0.47	0.33	0.50	0.75	0.430	-0.10	0.07	0.32	0.04	0.08
Finland	2		3	0.27	0.33		0.50	0.386	-0.06		0.11	-0.12	-0.02
France	2	7	2	0.28	0.33	0.44	0.25	0.386	-0.06	0.05	-0.14	-0.11	-0.07
Germany	4	13	5	0.66	1.00	0.81	1.00	0.482	0.52	0.33	0.52	0.18	0.39
Ireland		7		0.39		0.44		0.300		0.14		0.09	0.12
Italy	1.5	5	2	0.22	0.17	0.31	0.25	0.256	-0.09	0.05	-0.01	-0.04	-0.02
Japan	3	6	3	0.16	0.67	0.38	0.50	0.320	0.35	0.06	0.18	-0.16	0.11
Netherlands	2	10	4	0.42	0.33	0.63	0.75	0.459	-0.13	0.17	0.29	-0.04	0.07
NewZealand	1	3	3	0.27	0.00	0.19	0.50	0.323	-0.32	-0.13	0.18	-0.05	-0.08
Norway	2		2	0.14	0.33		0.25	0.491	-0.16		-0.24	-0.35	-0.25
Spain	1	5	1	0.21	0.00	0.31	0.00	0.118	-0.12	0.19	-0.12	0.09	0.01
Sweden	2		2	0.27	0.33		0.25	0.689	-0.36		-0.44	-0.42	-0.41
Switzerland	4	12	5	0.68	1.00	0.75	1.00	0.634	0.37	0.12	0.37	0.05	0.23
UK	2	6	2	0.31	0.33	0.38	0.25	0.559	-0.23	-0.18	-0.31	-0.25	-0.24
US	3	12	3	0.51	0.67	0.75	0.50	0.579	0.09	0.17	-0.08	-0.07	0.03

From Table 4.1, it can be seen that all explanatory variables of the optimal degree, except NAIRU, have the expected sign.<sup>19)</sup> Only one explanatory variable (SLOPE) is significant at a 90% confidence level. The other explanatory variables have relatively low t-values. Nevertheless, we have calculated the optimal degree on the basis of the ultimate determinants for each country and, after normalization of the optimal degree and the legal indices, the average difference between these variables. Positive average differences - of 0.20 or higher - are found for Germany and Switzerland, implying that the legal degree of central bank independence exceeds the optimal degree and that the legal degree should be decreased. Negative average differences - of 0.20 or lower - are observed for Australia, Norway, Sweden and the United Kingdom, meaning that the optimal degree exceeds the legal degree and that the legal degree should be increased.

For the other countries - Austria, Belgium, Canada, Denmark, Finland, France, Ireland, Italy, Japan, the Netherlands, New Zealand, Spain and the United States - the average differences are relatively small, indicating that there is no reason to adjust the central bank law in these countries from the perspective of the ultimate determinants. In some countries - notably France and Spain - the central bank has, recently, been made more independent from government which can be explained by another argument: a prerequisite for entering the third phase of Economic and Monetary Union in Europe is, among others, the independence of the *national* central banks of the participating countries.

The relatively low t-values for the explanatory variables in Table 4.1 could, probably, be attributed to the many severe restrictions imposed on the model by LISREL and the two additional restrictions made by us ( $\lambda_{y_3} = 1$  and  $\Theta_\gamma$  is diagonal) to identify all parameters of the model. Relaxing some of these restrictions might improve the t-values of the explanatory variables.<sup>20)</sup>

Table 4.2 gives the empirical results, if we relax *only two* restrictions on the covariances, for the sample period 1960-1993 (for NAIRU: 1960-1988). First, the restriction on the covariance of  $[\gamma_2, \gamma_3]$  between the GMTT- and ES-index is eliminated. This implies that the disturbances of these indices may be correlated. Second, the restriction on the covariance of  $[\gamma_2, \zeta]$  between the GMTT-index and the regression equation - equation (4.2) with  $\xi = x$  - is lifted. This means that the disturbances between the GMTT-index and the regression equation can be correlated. All other restrictions on the model remain imposed.

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<sup>19)</sup> The negative coefficient for the variable NAIRU may, however, be explained by the existence of *reverse causation*: a high degree of central bank independence leads, apparently, to a low NAIRU in the long run. Moreover, there is empirical evidence for an increase of NAIRU in the OECD countries during the last decades.

<sup>20)</sup> See in this respect: Aigner, Hsiao, Kapteyn and Wansbeek (1984, p. 1371). The relaxing of restrictions could imply that, although the latent variables method is still used, the assumptions of LISREL are not valid anymore.

**Table 4.2. Table based on estimation without restrictions on the covariances of  $(\gamma_2, \gamma_3)$  and  $(\gamma_2, \zeta)$ .**  
 Sample period 1960 - 1993 for all variables (except for NAIRU: 1960 - 1988).

$$\text{OPCBI} = -0.008 * \text{NAIRU\_M} + 0.807 * \text{WLEFT\_M} - 0.436 * \text{VPROD\_M} + 0.923 * \text{SLOPE\_M} \\
 (-0.237) \quad (1.529) \quad (-1.784) \quad (1.452)$$

Note:  $\_M$  means that variables are taken in deviation form their mean.  
 T-values in parentheses.

Country	Indices				Transformed Indices				Differences (INDEX-OPCBI)					
	AL	GM	ES	LVAU	AL_N	GM	ES_N	OPCBI	OPCBI_N	AL_N	GM	ES_N	LVAU	AvDIFF
Australia	1	9	1	0.31	0.00	0.56	0.00	0.461	0.536	-0.54	0.03	-0.54	-0.23	-0.32
Austria		9	3	0.58		0.56	0.50	1.223	0.727		-0.16	-0.23	-0.15	-0.18
Belgium	2	7	3	0.19	0.33	0.44	0.50	0.518	0.550	-0.22	-0.11	-0.05	-0.36	-0.19
Canada	2	11	1	0.46	0.33	0.69	0.00	0.438	0.530	-0.20	0.16	-0.53	-0.07	-0.16
Denmark	2	8	4	0.47	0.33	0.50	0.75	0.270	0.488	-0.16	0.01	0.26	-0.02	0.02
Finland	2		3	0.27	0.33		0.50	0.625	0.577	-0.24		-0.08	-0.31	-0.21
France	2	7	2	0.28	0.33	0.44	0.25	0.959	0.661	-0.33	-0.22	-0.41	-0.38	-0.34
Germany	4	13	5	0.66	1.00	0.81	1.00	0.655	0.585	0.42	0.23	0.42	0.08	0.28
Ireland		7		0.39		0.44		0.238	0.480		-0.04		-0.09	-0.07
Italy	1.5	5	2	0.22	0.17	0.31	0.25	0.126	0.453	-0.29	-0.14	-0.20	-0.23	-0.22
Japan	3	6	3	0.16	0.67	0.38	0.50	-3.410	0.000	0.67	0.38	0.50	0.16	0.43
Netherlands	2	10	4	0.42	0.33	0.63	0.75	0.260	0.486	-0.15	0.14	0.26	-0.07	0.05
NewZealand	1	3	3	0.27	0.00	0.19	0.50	-3.200	0.000	0.00	0.19	0.50	0.27	0.24
Norway	2		2	0.14	0.33		0.25	1.579	0.816	-0.48		-0.57	-0.68	-0.57
Spain	1	5	1	0.21	0.00	0.31	0.00	-1.925	0.000	0.00	0.31	0.00	0.21	0.13
Sweden	2		2	0.27	0.33		0.25	1.915	0.900	-0.57		-0.65	-0.63	-0.62
Switzerland	4	12	5	0.68	1.00	0.75	1.00	0.065	0.437	0.56	0.31	0.56	0.24	0.42
UK	2	6	2	0.31	0.33	0.38	0.25	1.077	0.690	-0.36	-0.32	-0.44	-0.38	-0.37
US	3	12	3	0.51	0.67	0.75	0.50	0.741	0.606	0.06	0.14	-0.11	-0.10	0.00

From Table 4.2, it is clear that the t-values of all explanatory variables, except SLOPE, improve considerably. One of these explanatory variables (VPROD) becomes even significant at a 90% confidence level. All explanatory variables, except NAIRU, have the expected sign. If we compare the coefficients of the explanatory variables in this table with those in Table 4.1, the estimated coefficients do not seem very robust.

Therefore, we have also calculated the optimal degree of central bank independence and the average difference with the legal indices for each country. The positive average differences for Germany and Switzerland appear to be still in place, while Japan and New Zealand join this group too. The negative average differences for Australia, Norway, Sweden and the United Kingdom still remain, although these differences become generally bigger. Now this group is, however, joined by Finland, France and Italy (negative average difference is -0.20 or lower). Almost no average differences are found for countries, like Denmark, Ireland, the Netherlands and the United States. Apparently, these countries have central bank laws which correspond with their optimal degree based on the ultimate determinants, insofar as they are captured in our empirical model.

## V. CONCLUSION

What may be concluded from the previous sections?

First, it is possible to derive propositions on the basis of our theoretical model which formulates the relationship between the optimal degree of central bank independence and four ultimate determinants in a country, namely the natural rate of employment, the society's preferences for unemployment stabilization relative to inflation stabilization, the variance of productivity shocks, and the slope of the Phillips curve. These determinants, reflecting the economic and political structure of a country, refer only indirectly to the actual (legal) degree of central bank independence.

Second, to distinguish between the optimal and actual (legal) degree of central bank independence the latent variables method (LISREL) appears to be very fruitful as an empirical model. Not only enables this method us to explain the optimal degree by proxies for the ultimate determinants (NAIRU, WLEFT, VPROD and SLOPE), but also to compare the optimal degree with the legal indices of central bank independence (AL, GMTT, ES and LVAU). The latent variables method, based on nineteen industrial countries, for the sample period 1960-1993 (for NAIRU: 1960-1988) leads to estimations which support our theoretical model reasonably, if we relax two restrictions on the covariances.

Third, the comparison between the optimal degree and the legal indices of central bank independence renders some interesting results. Some countries - like Germany and Switzerland - seem to have a suboptimally high degree of central bank independence, whereas other - such as Australia, Norway, Sweden and the United Kingdom - appear to



have a suboptimally low degree. For Denmark, Ireland, the Netherlands and the United States, it is fair to conclude that these countries have more or less an optimal degree of independence.

Finally, it should be mentioned that both our theoretical and empirical model can be extended with other economic and political determinants of central bank independence. One could, for example, extend the model with the degree of openness of a country to comply with differences between small and large countries. These extensions constitute our research agenda for the future.

### **APPENDIX A. THE DERIVATION OF THE EXPECTED VALUE OF SOCIETY'S LOSS FUNCTION UNDER AN ARBITRARY MONETARY POLICY REGIME**

In this Appendix, following Rogoff (1985), pp. 1175—1176, we develop a notation for evaluating the expected value of society's loss function under any arbitrary monetary policy regime "A",  $E_{t-1} L_t^A$  (equation (3.1) of the text). Unemployment under regime A is given by

$$u_t^A = \tilde{u} - \frac{1}{1-\beta} (p_t^A - E_{t-1} p_t^A + \mu_t) \quad (\text{A.1})$$

Squaring and taking expectations yields

$$E_{t-1} (u_t^A)^2 = \tilde{u}^2 + E_{t-1} \left[ \frac{\mu_t}{1-\beta} + \frac{1}{1-\beta} (p_t^A - E_{t-1} p_t^A) \right]^2 \quad (\text{A.2})$$

The price level under regime A can be expanded as

$$p_t^A = \tilde{p}_t^A + (p_t^A - E_{t-1} p_t^A) \quad (\text{A.3})$$

where  $\tilde{p}_t^A$  is the mean (expected) price level in period t. Squaring and taking expectations, in turn, yields

$$E_{t-1} (p_t^A)^2 = (\tilde{p}_t^A)^2 + E_{t-1} (p_t^A - E_{t-1} p_t^A)^2 \quad (\text{A.4})$$

The expected value of society's loss function under regime A is

$$E_{t-1} L_t^A = \frac{1}{2} E_{t-1} (p_t^A)^2 + \frac{\varepsilon}{2} E_{t-1} (u_t^A)^2 \quad (\text{A.5})$$

Substituting (A.2) and (A.4) into (A.5), one obtains equation (3.1) of the text.

**APPENDIX B. DERIVATION OF THE PROPERTIES OF THE FUNCTION  $F(\varepsilon)$  IN THE FIRST-ORDER CONDITION.**

(1) Demonstration that  $\frac{\partial F}{\partial \varepsilon} < 0$ .

The first derivative of F with respect to  $\varepsilon$  is given by

$$\frac{\partial F}{\partial \varepsilon} = \frac{-3\tilde{u}^2\chi[(1+\varepsilon)(1-\beta)^2 + \chi]^2}{\sigma_\mu^2(1-\beta)^4(1+\varepsilon)^4} \quad (\text{B.1})$$

which is negative.

(2) Demonstration that  $\frac{\partial^2 F}{\partial \varepsilon^2} > 0$ .

The second derivative fo F with respect to  $\varepsilon$  is given by

$$\frac{\partial^2 F}{\partial \varepsilon^2} = \frac{6\tilde{u}^2\chi\Gamma[\Gamma-\chi]}{(1-\beta)^4(1+\varepsilon)^5\sigma_\mu^2} \quad (\text{B.2})$$

where  $\Gamma \equiv (1+\varepsilon)(1-\beta)^2 + 2\chi$ , (B.2) is positive.

(3) Demonstration that  $F(0) = \frac{[(1-\beta)^2 + \chi]^3\tilde{u}^2}{(1-\beta)^4}$ .

This can be shown by direct examination of the right-hand side of equation (3.8) at  $\varepsilon = 0$ .

(4) Demonstration that  $\frac{\tilde{u}^2(1-\beta)^2}{\sigma_\mu^2} < F(\varepsilon) < \frac{[(1-\beta)^2 + \chi]^3\tilde{u}^2}{(1-\beta)^4\sigma_\mu^2}$ .

Since  $F(0) = \frac{[(1-\beta)^2 + \chi]^3\tilde{u}^2}{\sigma_\mu^2(1-\beta)^4}$ ,

$\lim_{\varepsilon \rightarrow \infty} = \frac{\tilde{u}^2(1-\beta)^2}{\sigma_\mu^2}$  and  $\frac{\partial F}{\partial \varepsilon} < 0$ ,  $F(\varepsilon)$  must be bounded between

$\frac{\tilde{u}^2(1-\beta)^2}{\sigma_\mu^2}$  and  $F(0)$ .

(5) Demonstration that  $\frac{\partial F}{\partial \tilde{u}} > 0$ .

The first derivative of F with respect to  $\tilde{u}$  is given by

$$\frac{\partial F}{\partial \tilde{u}} = \frac{2[(1+\varepsilon)(1-\beta)^2 + \chi]^3 \tilde{u}}{\sigma_\mu^2 (1-\beta)^4 (1+\varepsilon)^3} \quad (\text{B.3})$$

(B.3) is positive.

(6) Demonstration that  $\frac{\partial F}{\partial \chi} > 0$

The first derivative of F with respect to  $\chi$  is given by

$$\frac{3[(1+\varepsilon)(1-\beta) + \chi]^2 \tilde{u}^2}{\sigma_\mu^2 (1-\beta)^4 (1+\varepsilon)^3} \quad (\text{B.4})$$

It can easily be checked that (B.4) is positive.

(7) Demonstration that  $\frac{\partial F}{\partial \sigma_\mu^2} < 0$ .

The first derivative of F with respect to  $\sigma_\mu^2$  is given by

$$\frac{\partial F}{\partial \sigma_\mu^2} = \frac{-[(1+\varepsilon)(1-\beta)^2 + \chi]^3 \tilde{u}^2}{[\sigma_\mu^2 (1-\beta)^2]^2 (1+\varepsilon)^3} \quad (\text{B.5})$$

(B.5) is negative.

(8) Demonstration that  $\frac{\partial F}{\partial (1-\beta)^{-1}} > 0$ .

The first derivative of F with respect to  $(1-\beta)^{-1}$  is given by

$$\frac{\partial F}{\partial (1-\beta)^{-1}} = \frac{2\tilde{u}^2 [2\chi - (1+\varepsilon)(1-\beta)^2] [(1+\varepsilon)(1-\beta)^2 + \chi]^2}{\sigma_\mu^2 (1-\beta)^3 (1+\varepsilon)^3} \quad (\text{B.6})$$

(B.6) is positive if  $\chi > \frac{(1+\varepsilon)(1-\beta)^2}{2}$ .

## APPENDIX C. THE DATA

- VPROD: OECD Main Economic Indicators.  
Growth rate of GDP in US\$ in 1985 prices and exchange rates, 1960-1993.
- NAIRU: R. Layard, S. Nickell and R. Jackman,  
*Unemployment, Macroeconomic Performance and the Labour Market*, Oxford:  
Oxford University Press, 1991.  
Estimates for NAIRU 1960-1988, Table 14, Chapter 9.
- WLEFT: Winkler Prins Encyclopedie, 1990.  
A.J. Day (ed.), *Political Parties of the World*, Longman, 1988, (# years that a  
left-wing party has been in the government, either alone or in a coalition)/(total  
# years), 1960-1993.
- SLOPE: National Accounts of OECD Countries, 1960-1977, 1977-1989, 1978-1992.  $1/[1$   
- (Compensation of employees paid by resident producers/GDP)], in current  
prices.  
OECD, Paris 1979, 1991, 1994.

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