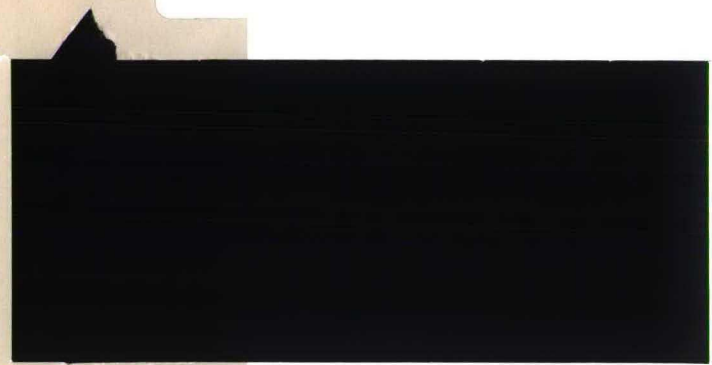
entER for omic Research

# Discussion paper





TILBURG UNIVERSITY

Center
for
Economic Research

No. 9493

# CENTRAL BANK INDEPENDENCE: A PANELDATA APPROACH

By Sylvester Eijffinger, Maarten van Rooij
and Eric Schaling



November 1994

ISSN 0924-7815

# CENTRAL BANK INDEPENDENCE: A PANELDATA APPROACH

by

Sylvester Eijffinger, Maarten van Rooij and Eric Schaling

Department of Economics and CentER
Tilburg University
P.O. BOX 90153
5000 LE TILBURG
The Netherlands

First Version August 1994

## ABSTRACT

The present paper uses a paneldata estimation technique to combine the time series for individual countries (Australia, Canada, France, Germany, Italy, Japan, the Netherlands, the United Kingdom, the United States and Switzerland). We postulated the response of central banks in these countries to inflation and economic growth given the contraintsto be the same among the sample countries. Differences between central bank independence come forward in a different structural pressure to lower or raise money market rates in these countries. The empirical results in this study coincide remarkably well with the legal indices of central bank independence (Bade and Parkin (1988); Alesina (1988, 1989); Grilli, Masciandaro and Tabellini (1991); Eijffinger and Schaling (1992, 1993a)) based on the prevailing central laws. Finally, regressions of the average inflation and economic growth rate on our empirical index of central bank independence confirm that having an independent central bank will lead to lower inflation rates without being accompanied by a reduction of economic growth.

In the present study, one reaction function is estimated for all countries using paneldata. This can be done by identifying an individual country-specific /effect which, of course, does differ among the countries. In section 1 we discuss indices of legal central bank independence. In section 2 the estimation technique is discussed. The results for the so-called empirical index of central bank independence are given in section 3. In section 4 we investigate these results in more detail to see whether significant changes in empirical independence can be detected between the first and second half of our sample period. Also, in this section the numerical values of empirical independence are confronted with the indices of legal independence. In section 5 a short evaluation is given of what has been done so far. Hereafter, in section 6 the relation between economic performance and the several indices of central bank independence (legal as well as empirical) is analyzed.

## 1. THEORETICAL CENTRAL BANK INDICES[1]

In recent years some central bank indices have been developed. Basically, these indices are based on charters of central banks. Therefore, these indices constitute a measure of legal central bank independence. Eijffinger and Schaling (1992) compare the major indices. These are the indices of Bade and Parkin (1988), Alesina (1988, 1989) and Grilli, Masciandaro and Tabellini (1991). From now, these indices will be referred to by, respectively, the BP index, the AL index and the GMT index. After reviewing these indices Eijffinger and Schaling construct their own index (the ES index[2]). We will now briefly discuss the aforementioned theoretical indices of central bank independence[3].

---

1 This section is based on Eijffinger and Schaling (1992) and on Eijffinger and Schaling (1993a) which is a more compact version of the former.

2 In fact, the ES index is more than a purely legal index of central bank independence. The central bank laws are examined against the background of monetary policy-making. See Eijffinger and Schaling (1993a), p. 51. This implies that the ES index tries to grab some of the actual independence. This is in contrast with the other - purely legal - indices of central bank independence.

3 The numerical values for all these indices and some variants are given in table 1.

**Table 1**

**Indices of legal central bank independence.**

| Country | ES | BP | AL | GMT Policy | GMT Political | GMT Economic |
|---|---|---|---|---|---|---|
| Australia | 1 | 1 | 1 | 1 | 3 | 6 |
| Canada | 1 | 2 | 2 | 1 | 4 | 7 |
| France | 2 | 2 | 2 | 1 | 2 | 5 |
| Germany | 5 | 4 | 4 | 3 | 6 | 7 |
| Italy | 2 | 2 | 1.5 | 3 | 4 | 1 |
| Japan | 3 | 3 | 3 | 1 | 1 | 5 |
| Netherlands | 4 | 2 | 2 | 3 | 6 | 4 |
| Switzerland | 5 | 4 | 4 | 3 | 5 | 7 |
| United Kingdom | 2 | 2 | 2 | 2 | 1 | 5 |
| United States | 3 | 3 | 3 | 3 | 5 | 7 |
| Sweden | 2 | 2 | 2 | NA | NA | NA |

ES : Eijffinger-Schaling index;
BP : Bade-Parkin index;
AL : Alesina index;
GMT : Grilli-Masciandaro-Tabellini index;
NA : Not Available;

Bade and Parkin created an index for policy independence based on three criteria[4]:

1. Is the bank the final policy authority?
2. Is there no government official (with or without voting power) on the bank board?

---

[4] Bade and Parkin also constructed a measure for financial independence of central banks from their governments. However, they did not find a relation between this measure and the average rate of inflation or the variability of inflation. (They used the same countries as we did plus Belgium.) Because they did conclude that there is a relation between central bank policy independence and the average inflation rate we only focus on this measure here. See Eijffinger and Schaling (1992), pp. 21-24.

3. Are more than half of the board appointments made independent of the government?[5]

On basis of these three criteria the BP index is constructed which ranges from 1 (least independent) to 4 (most independent)[6]. The construction is designed as follows: positive answers to these questions indicate more independence and every positive answer means that the central bank is ranked one step higher with only negative answers resulting in an index of 1[7]. It is important to note here that all three criteria are weighted equally by Bade and Parkin.

Alesina criticizes Bade and Parkin by noting that they disregarded institutional changes within the sample period[8]. He argues that because of the divorce of the Treasury and the Italian central bank in 1981 the latter became more independent. This is caused by the fact that the Banca d'Italia was no longer obliged to absorb all excess supply of short-term Treasury bills. Consequently, the central bank of Italy was no longer obliged to accommodate monetary policy by monetary financing of government deficits. This implied that the freedom for monetary policy became higher. Therefore, the Banca d'Italia became more independent.

Eijffinger and Schaling (1993a, p. 58) state that Alesina implicitly is extending the work of Bade and Parkin by introducing a fourth criterium:

4. Is the central bank not required to absorb excess supply of short-term Treasury bills?

This question has a negative answer for all countries except for Italy (after 1981). Eijffinger and Schaling argue that this should have led to an upgrading of the independence of the central bank of Italy. Strange enough, Italy is downgraded from a BP index of 2 to an AL index of 1.5 while all other countries maintain the same index. According

---

5 This question was answered yes if the proportion of members which is not directly nor indirectly appointed by the government is greater than or equal to 11/21.

6 Table 1 gives the indices for our sample countries.

7 In fact only four different cases exist within the sample. The most differing cases are the one with only positive and the one with only negative answers. Furthermore, we have countries in which question 1 and 2 are positively answered and countries in which only question 2 can be answered yes.

8 The period Bade and Parkin considered is 1972 till 1986.

to Eijffinger and Schaling this makes the AL index internally inconsistent[9] and, therefore, the AL index cannot be qualified as a proper index of central bank independence[10].

Grilli, Masciandaro and Tabellini designed an index of political independence as well as an index of economic independence. They defined political independence as the capacity to choose the final goal of monetary policy, such as the rate of inflation and the level of economic activity. The GMT Political index is based on the following eight criteria:

1. Is the governor not appointed by the government?
2. Is the governor appointed for more than five years?
3. Are all board members not appointed by the government?
4. Is the board appointed for more than five years?
5. Is there no mandatory participation of a government representative in the board?
6. Is there no government approval of monetary policy required?
7. Are there statutory requirements that the bank pursues monetary stability among its goals?
8. Are there legal provisions that strengthen the bank's position in case of conflicts with the government?

The overall political index is determined by counting all the positive answers. This implies that all criteria are weighted equally.

Note that criteria 5 and 6 are identical to criteria 2 and 1 from the BP index. GMT's criterion 3 is a more strict version of BP's criterion 3. These three criteria of the GMT index (3, 5 and 6) are used by Eijffinger and Schaling to create a GMT Policy index that is comparable with the BP index[11]. Differences between the BP index and the GMT Policy index exist for two reasons. Firstly, because of possible differences in

---

9 They mean by internally inconsistent that not all relevant criteria have been used to determine the independence of each central bank.

10 The reason for this is that the numerical values of the Alesina index in table 4.1 cannot be compared with each other. See also Eijffinger and Schaling (1993a), p. 59.

11 Naturally, this GMT policy index is aggregated in the same manner as the BP index. The basic difference between the way the BP index and the original GMT political index are aggregated is that the bottom value of the BP index is one while the GMT political index can take a zero value.

the interpretation of central bank laws GMT's criteria 5 and 6 (or BP's criteria 1 and 2) are possibly different answered. Secondly, the fact that GMT's criterion 3 is more strict than BP's criterion 3 can lead to differences in the BP index versus the GMT Policy index. Eijffinger and Schaling call this respectively the interpretation and the criterion effect[12].

Eijffinger and Schaling criticize the GMT Policy index for two reasons. Firstly, they argue that by using a very strict criterion concerning the appointments of directors the ranking of the Bundesbank, the Swiss National Bank and Banca d'Italia is severely biased compared with the ranking of the BP index[13]. To clarify the second point of criticism they consider GMT's criteria 6 and 7 in combination with the equal weighting. Eijffinger and Schaling (1993a, p. 66) then note that "*restricting attention to GMT 6 and 7, a subservient central bank with provisions for monetary stability is as independent as an autonomous central bank without these provisions*". This implies that the contents of final goals in charters (criterion 7) are judged without regarding the capacity to choose final goals (criterion 6). For Eijffinger and Schaling this is an argument against equal weighting because it is obvious that whether a central bank has monetary stability among its goals is not relevant when it cannot choose its final goals.

Grilli, Masciandaro and Tabellini define economic independence as the capacity to choose the instruments of monetary policy. To measure this economic independence they use the following seven criteria:

1. Is the direct credit facility of the government non-automatic?
2. Is it at market interest rates?
3. Is it explicitly temporary?
4. Is it of limited amount?
5. Does the central bank not participate in the primary market for government debt?
6. Is the discount rate set by the central bank?

---

12 See Eijffinger and Schaling (1993a), p. 63, table 6. This table gives a decomposition of the differences between the BP index and the GMT policy index in the interpretation and the criterion effect.

13 From table 1 appears that Germany and Switzerland are downgraded and Italy is upgraded versus the BP index. According to the GMT policy index these countries are equally independent. This is counter-intuitive.

7. Is banking supervision not entrusted to the central bank or not entrusted to the central bank alone?

Unlike in constructing previous indices these criteria are not weighted equally. The first six have weight 1/8. Criterion 7, however, has weight 2/8. If central bank supervision is totally entrusted to the central bank this counts for two positive answers and when it is only partly entrusted to the central bank criterion 7 counts for one positive answer. Recognizing this, the positive answers can be aggregated till the measure of economic independence which, theoretically, can range from zero to eight.

After Eijffinger and Schaling gave an overview of the previous indices, they constructed a new index of political independence[14]. Their index is based on three criteria:

1. Is the bank the sole final authority (b), is this authority not entrusted to the central bank alone (b/g), or is it entrusted completely to the government (g).
2. Is there no government official (with or without voting power) on the bank board? (BP's criterion 2)
3. Are more than half of the board appointments made independent of the government? (BP's criterion 3)

As with the index of Bade and Parkin the minimal value of the index is 1. A positive answer to criterion 2 raises the index by one. The same applies to criterion 3. Criterion 1, however, has double weight. A bank of type b means the index of political independence is increased by two while the index is raised by one for a type (b/g) bank. This implies that the numerical values of the index range from 1 to 5. Differences between the ES index, on the one hand, and the BP index or the GMT Policy index, on the other hand, can be decomposed again in an interpretation and a criterion effect[15].

All aforementioned legal indices of central bank independence have some features in common. Firstly, there is no non-arbitrary way of weighting the several criteria. Though, it seems intuitive that some criteria should be weighted more than others it is not clear how large the relative weights should be. Even the choice and the exact formulation of the criteria is - to some extent - arbitrary. If one bases an index of central bank independence on a few criteria there is a danger of omitting important determinants of

---

14 They use the same definition for political independence as Grilli, Masciandaro and Tabellini did, i.e. as the capacity of central banks to choose the final goal of monetary policy.

15 See Eijffinger and Schaling (1993a), p. 67 and p. 69, tables 8 and 9.

central bank independence. On the other hand, basing an index for central bank independence on a lot of criteria leads to a 'watering down' of the real important determinants of central bank independence when equal weighting is used.

Secondly, even the interpretation of central bank charters appears to be subjective to some extent. This causes differences between the several indices as a result of the interpretation effect.

Thirdly, as noted by Cukierman[16], these legal indices only measure one aspect of actual central bank independence. Other aspects of central bank independence are, for instance, informal arrangements, tradition and culture of monetary stability, the quality of the bank's research department and personalities of important persons in the bank or political authorities that try to influence the monetary policy[17].

## 2. THE PANELDATA ESTIMATION TECHNIQUE

As Cukierman (1992, p. 369) notes legal independence is not the same as actual independence. Cukierman argues that there are at least two reasons for this divergence. Firstly, central bank laws are incomplete. It is impossible to specify the limits of the authority of the central bank and the political authorities in all situations. These limits are, among others, determined by informal arrangements, traditions and personalities of persons that are confronted with these unspecified situations. Secondly, even if the scope of authority, procedures, objectives, etc. are described explicitly in the law, actual practice may be different[18].

Because actual independence is determined by many factors from which a lot are

---

16 See Cukierman (1992), p. 369 and section 19.7, pp. 393-395.

17 This may be criticized if one conceives central bank independence structurally. Grilli, Masciandaro and Tabellini (1991, p. 366), for example, acknowledge that "*the independence of the Bundesbank is the result of specific central bank laws but also of its reputation and a tradition of monetary discipline. Hence, by neglecting behaviourial indicators we miss an important dimension of monetary regimes*". Nevertheless, they confine themselves to a purely legal - structural - index of central bank independence because: "*behaviourial indicators have often varied over time (e.g. with personalities in charge of monetary policy) whereas monetary institutions have generally been more invariant and, to the extent that there have been institutional reforms, they are more clearly identifiable*".

18 In this respect it is interesting that Cukierman (1992, p. 421) finds results indicating that the divergence between the law and actual practice in developing countries is substantially higher than in developed countries.

hardly or not quantifiable we will now assume that actual independence cannot be measured directly[19]. We assume that the reaction of central banks to inflation and economic growth data not only depends on these variables but also on an individual unknown country-specific effect. We will interpret this country-specific effect as the actual independence of central banks. This means that the symmetrical reaction function which was taken from Koskela and Virén (1991) takes the following form[20]:

$$\Delta MMR_{i,t} = \beta_0 + \beta_1 P_{i,t} + \beta_2 P_{i,t-1} + \beta_3 Y_{i,t} + \beta_4 Y_{i,t-1} + CBI_i + \eta_{i,t} \qquad (1)$$

with i=1..N, t=1..T and

| | | |
|---|---|---|
| $\Delta MMR_{i,t}$ | := | change in money market rate of country i in period t, |
| $P_{i,t}$ | := | inflation rate of country i in period t, |
| $Y_{i,t}$ | := | real economic growth rate of country i in period t, |
| $CBI_i$ | := | actual central bank independence of country i, |
| $\eta_{i,t}$ | := | the error term for country i in period t.[21] |

The subscript i represents the countries in our sample and t is the time subscript.[22]

Because we would like to infer conclusions about a country-specific effect which cannot be observed directly we resort to the use of paneldata. Furthermore, we assume this central bank independence not to change a lot over the sample period in a particular

---

19 This does not mean, though, that legal independence (and perhaps other factors) can not be used as a proxy for actual independence. Later in this chapter we will try to find empirical measures of actual independence, and, using this measure of actual independence we will test whether actual independence can be approximated by legal independence.

20 Actually we should write $\beta_5 CBI_i$, but this term can only be estimated in a composite form. We are not able to disentangle the constant coefficient $\beta_5$ and the country-specific effect $CBI_i$. So, without loss of generality $\beta_5$ can be normalized at one.

21 We assume the error term $\eta_{i,t}$ to be an independently, identically distributed random variable with mean zero and variance $\sigma_\eta^2$. Furthermore, we assume that the error term is independent of the regressors. Moreover, when we use F-statistics or t-statistics we, implicitly, make the assumption that the error term is normally distributed.

22 We will consider the following ten countries (N=10): Australia, Canada, France, Germany, Italy, Japan, the Netherlands, Switzerland, the United Kingdom and the United States. This means - in comparison to our previous analyses - that we excluded Sweden. This is because of the fact that we were faced with a trade-off between the number of countries to include and the number of observations per country that could be included. Because we are using paneldata we need data for all countries for the whole sample period. This means that the countries with little observations determine the length of the sample period. By excluding Sweden, our sample period ranges from the third quarter of 1977 (t=1) to the last quarter of 1990 (t=T=54).

country[23]. Therefore, the unobservable individual country-specific effect is fixed and this brings us to the fixed-effects models within the paneldata approach.

We will now describe the estimation technique for fixed-effects models using paneldata[24]. For convenience we introduce the following notation:

$$\beta := (\beta_1, \beta_2, \beta_3, \beta_4)',$$
$$x_{i,t} := (P_{i,t}, P_{i,t-1}, Y_{i,t}, Y_{i,t-1})', \; i=1..N, \; t=1..T,$$
$$EMP_i := \beta_0 + CBI_i, \; i=1..N.$$

Now one is able to rewrite (1) as:

$$\Delta MMR_{i,t} = EMP_i + \beta' x_{i,t} + \eta_{i,t} \quad with \; i=1..N, \; t=1..T \tag{2}$$

Note that we have comprised the common intercept $\beta_0$ and the country-specific effect $CBI_i$ together to $EMP_i$. The reason for this is that because both terms are fixed constants we cannot identify or estimate them separately[25]. We will refer to $EMP_i$ as the generalized individual effect or the empirical independence of central banks to distinguish it from the country-specific effect or the actual independence of central banks ($CBI_i$). To continue our exposure we also need the following notations:

$$\Delta MMR_i := (\Delta MMR_{i,1}, \ldots, \Delta MMR_{i,T})', \; i=1..N,$$
$$e := (1, \ldots, 1)',$$
$$X_i := (x_{i,1}', \ldots, x_{i,T}')', \; i=1..N,$$
$$\eta_i := (\eta_{i,1}, \ldots, \eta_{i,T})', \; i=1..N.$$

Now equation (2) can be written as[26]:

---

23 We expect legal independence to constitute the normal (mean) level of central bank independence and changes over time are due to gradual changes in the tradition and culture of monetary stability and because of different personalities in policy boards of central banks and in institutions that try to influence the actions of the central banks. However, for the time being, we assume these changes to be marginal and neglect them.
Concerning the importance of different persons in the policy board of a central bank it is illustrative to quote Friedman (1962, p. 234). He states that a "*defect of the conduct of monetary policy through an independent central bank that has a good deal of leeway and power is the extent to which policy is thereby made highly dependent on personalities*". Referring to Friedman's article Bade and Parkin (1988, p. 21) state that there is a "*large potential for individual Governor/Director preferences and for personal strengths and weaknesses to influence policy in a genuinely independent central bank*".

24 The fixed-effects model approach is described in Hsiao (1986), pp. 29-32.

25 Unless, we have additional restrictions. If we, for example, introduce the restriction that the sum of all $CBI_i$'s must be zero then it is possible to identify both $\beta_0$ as well as all $CBI_i$'s. The individual effects then can be interpreted as the deviation of the individual country from the common mean $\beta_0$. See Hsiao (1986, p. 32).

26 The conditions for $\eta_{i,t}$ mentioned in footnote 21 imply for $\eta_i$:

$$\Delta MMR_i = EMP_i e + X_i\beta + \eta_i \quad (i=1..N) \tag{3}$$

Define matrix Q as Q:=$I_T$-ee'/T. $I_T$ denotes the identity matrix with dimensions T by T. Pre-multiplying equation (3) with Q has the effect of transforming all observations into deviations of their individual means. Performing this transformation on equation (3) gives:

$$Q\Delta MMR_i = QX_i\beta + Q\eta_i \quad (i=1..N) \tag{4}$$

Note that transforming a constant into a deviation of its individual mean gives zero. Therefore, the term $EMP_i e$ disappears in (4). Applying OLS to (4) gives the following within-group estimator[27]:

$$\hat{\beta}_{WG} = (\sum_{i=1}^{N} X_i' Q X_i)^{-1} (\sum_{i=1}^{N} X_i' Q \Delta MMR_i) \tag{5}$$

Now we can estimate $EMP_i$ by:

$$\hat{EMP}_{i,WG} = \overline{\Delta MMR_i} - \bar{x}_i' \hat{\beta}_{WG} \tag{6}$$

$$with\ \overline{\Delta MMR_i} := \frac{1}{T}\sum_{t=1}^{T} \Delta MMR_{i,t},\ \bar{x}_i := \frac{1}{T}\sum_{t=1}^{T} x_{i,t}$$

Furthermore, it is possible to derive that the covariance matrix of the within-group estimator and the variance of the estimator for $EMP_i$ can be estimated by:

$$\hat{V}(\hat{\beta}_{WG}) = \hat{\sigma}_\eta^2 (\sum_{i=1}^{N} X_i' Q X_i)^{-1} \tag{7}$$

with

$$\hat{\sigma}_\eta^2 = \frac{1}{NT-(N+k)} \sum_{i=1}^{N} (\Delta MMR_i - \hat{EMP}_{i,WG} e - X_i \hat{\beta}_{WG})' (\Delta MMR_i - \hat{EMP}_{i,WG} e - X_i \hat{\beta}_{WG}) \tag{8}$$

and

---

$$(i)\ E(\eta_i) = 0 \qquad for\ i = 1..N$$
$$(ii)\ E(\eta_i \eta_i') = \sigma_\eta^2 I_T \qquad for\ i = 1..N$$
$$(iii)\ E(\eta_i \eta_j') = 0 \quad for\ i, j = 1..N \wedge i \neq j$$

with $I_T$ denoting the T by T identity matrix.

27 This estimator is called this way because only the variation within each group (country) is used. Other names which sometimes are used for this estimator are covariance estimator or least-squares dummy-variable (LSDV) estimator. The first name stems from the fact that models like equation (4.2) are also called analysis-of-covariance models. The name LSDV estimator finds its origin in the fact that we also can estimate this model using dummies, as we will see later on.

$$\hat{V}(\hat{EMP}_{i,WG}) = \bar{x}_i' \hat{V}(\hat{\beta}_{WG}) \bar{x}_i + \frac{\hat{\sigma}_\eta^2}{T} \qquad (9)$$

The parameter k denotes the number of regressors. So, k=4 in our case. In general, this analysis can be done for any fixed cross-sectional unit-specific effect. We assumed, however, that the individual country-specific effect can be contributed to the independence of central banks. Therefore, we labelled this country-specific effect $CBI_i$.

Basically, the just discussed approach implies that all countries have the same coefficients in front of the exogenous variables but that the intercepts are different among the several countries. Two remarks can be made here. Firstly, because of equation (2) this approach is also called a variable-intercept model. Secondly, we also could have estimated the model by introducing ten dummies - for each country one - that take over the role of the variable intercepts. The fixed effects method - although being equivalent to the variable intercept method - is discussed above because, in my opinion, the interpretation of the country-specific effects now comes forward in a more natural way.

Furthermore, we can see from this equivalence as well as from the fact that we can apply OLS to equation (4) that under the proper conditions for the error term[28] the within-group estimator is BLUE (Best Linear Unbiased Estimator).

## 3. THE RESULTS AND INTERPRETATION

In the previous section we have seen that we can estimate actual central bank independence using paneldata. We only have to accept the identification of the country-specific effect with the degree of independence of central banks. This seems plausible because, on the one hand, we already mentioned that the money market rate is - almost completely - determined by the instruments of the central bank. And, on the other hand, because we defined central bank independence as the ability and willingness of the central bank to conduct monetary policy which is directed to price stability as the single policy objective. This definition of central bank independence implies that the same degree of independence should lead to the same response to data for economic growth and inflation rate.[29] A central bank that is less independent will be tempted to lower the money

---

[28] See footnote 21 for these conditions.

[29] Though, the response also depends on the way the economy is organized. A different structure of the economy implies somewhat different reactions to actions of central banks and, therefore, somewhat

market rate to stimulate economic growth and, thereby, employment. This implies that this sort of central bank will tend to have a relatively lower money market rate than more independent central banks. Relatively means here regarding the inflation and economic growth data.[30] So, we expect less independent central banks to show a lower individual effect (CBI) and, consequently, a lower generalized individual effect (EMP) in reaction function (2)[31]. Therefore, the degree of central bank independence may be identified with a country-specific effect in the determination of the money market rate. This was already stated in reaction function (1). When we refer to empirical independence of central banks, we mean the estimated generalized country-specific effects (EMP). We are not referring to the country-specific effects (CBI), because we are only able to estimate these in a composite form. This is no problem because our main interest is not the exact value of these effects but their ranking. From former discussion it will be clear that this empirical independence will be used as a proxy for actual independence.

The estimation results of reaction function (2) using paneldata are given in table 2 and the following equation:

$$\Delta MMR_{i,t} = EMP_i + \underset{[1.901]}{0.136}P_{i,t} + \underset{[1.730]}{0.125}P_{i,t-1} + \underset{[6.776]}{0.393}Y_{i,t} + \underset{[2.513]}{0.145}Y_{i,t-1} + \eta_{i,t} \qquad (10)$$

and $\sigma_\eta^2 = 1.691$.

Absolute t-values for estimated coefficients are given between brackets. These results are conform our intuition. Judging the signs of the coefficients we see that the

---

different constraints on the behaviour of central banks.

30 In general, countries with an independent central bank will have lower mean inflation rates than countries with more dependent central banks. See, for instance, Eijffinger and Schaling (1993b) or Cukierman (1992), chapter 18 and 20, for theory and empirical evidence confirming this statement. This implies that, notwithstanding the fact that the money market rate in latter countries will be relatively lower, they actually may have a higher money market rate. According to theory and empirical evidence the degree of independence does not influence the mean level of economic growth. See Eijffinger and Schaling (1993b). These relations between central bank independence and the mean (and variance) of the inflation rate, the rate of economic growth and the money market rate are investigated in section 6.

31 Note that $EMP_i = \beta_0 + CBI_i$. Because $\beta_0$ is equal for all central banks and because the individual effect $CBI_i$ is expected to be lower for more dependent central banks the composite coefficient $EMP_i$ is also expected to be lower for more dependent central banks.

common reaction to inflation and economic growth is a higher money market rate which is the result of a more restrictive monetary policy. On the other hand, the response to economic growth is stronger than the response to inflation which is not conform our expectations. If independent central banks will fight inflation and if they have perfect control over the money market rate, we expect the response to inflation to be more pronounced than to economic growth[32]. The response to current as well as lagged economic growth is strongly significant on a 5% level, while the same response to both inflation variables is significant only on a 10% level, not on a 5% level. The coefficients of our prime interest are the coefficients which measure the differences between the countries. For ease of comparison, we have ranked the generalized individual effect - i.e. the empirical independence - in table 2 from high to low.

These coefficients coincide remarkably well with our prior convictions. Among the ten countries is a first group of three countries (the Netherlands, Switzerland and Germany) which, obviously, have more independent central banks than the second group of countries (we will call these central banks strongly independent from now on)[33]. On the other hand, there is one country (Italy) that has by far the least independent central bank (so, from now on we will classify this central bank as dependent). The other six countries have an intermediate independent central bank[34]. Furthermore, we see that all generalized individual coefficients (EMP) are significantly different from zero[35]. This, however, can also be contributed to the common constant ($\beta_0$) to be significantly different from zero. It does not mean that all individual effects (CBI) have significant effects on the determination of the money market rate. More important is, however, that the differences between the three groups of countries are obvious. These differences cannot be contrib-

---

32 At second thought this may be not so remarkable. We are investigating the common behaviour towards economic growth and inflation of ten countries among which some have independent central banks and some have more dependent ones. So, it is well possible that the common reaction is dominated by economic growth data. After all, the different inflation-aversion between the countries comes forward in the proxy for actual independence.

33 These three central banks are exactly the central banks that are ranked in the ES-index as having the sole final authority. See Eijffinger and Schaling (1993a), p. 65 and p. 67.

34 In table 2 the three types of central banks (strongly independent, intermediate independent and dependent) are separated by double lines.

35 For the Netherlands this is only true for a 10% significance level. For Switzerland and Germany this is true on a 5% level. In the other seven countries the intercept term is even significant on a 1% level.

uted to the common intercept term ($\beta_0$) but must be due to the actual independence of central banks (what we labelled CBI). Though, the point estimations for the generalized individual effects give an obvious ranking, it is important to note that only a few countries have statistically significant different intercepts[36]. Within the class of strongly independent central banks each central bank has a significantly higher level of empirical independence than the Banca d'Italia. The Nederlandsche Bank has also a significantly higher level of empirical independence than the Reserve Bank of Australia[37].

**Table 2**

**Paneldata estimation results for empirical independence of central banks.**
Sample period: 1977 III - 1990 IV.

| Countries | Empirical independence[a] (EMP) | 95%-confidence intervals |
|---|---|---|
| Netherlands | -0.331 [1.725] | (-0.707, +0.045) |
| Switzerland | -0.404 [2.085] | (-0.784, -0.024) |
| Germany | -0.431 [2.224] | (-0.810, -0.051) |
| United States | -0.684 [3.147] | (-1.111, -0.258) |
| United Kingdom | -0.704 [2.987] | (-1.165, -0.242) |
| Japan | -0.718 [3.445] | (-1.126, -0.309) |
| Canada | -0.728 [3.220] | (-1.171, -0.285) |
| France | -0.772 [3.369] | (-1.221, -0.323) |
| Australia | -0.867 [3.569] | (-1.343, -0.391) |
| Italy | -1.155 [4.249] | (-1.687, -0.622) |

[a] Absolute t-values between brackets;

36 Of course, it would be too much to expect the generalized individual effect (EMP) for each country to differ significantly from all other countries. Ten countries imply ten confidence intervals and these are likely to show - at least - some overlap.

37 These comparisons have been made using a 5% significance level.

Summarizing, we have found a clear ranking of central banks and, furthermore, for the most extreme cases (the group of strongly independent central banks versus the group of one dependent central bank) these differences are statistically significant.

## 4. FURTHER REFINING AND INTERPRETATION OF THE RESULTS

We made two important assumptions in section 2. Firstly, that the country-specific effect could be attributed to the degree of actual independence of central banks and, secondly, that this effect was fixed over time. Because of this latter assumption we used the estimation technique for fixed-effects models. An alternative assumption could have been that the country-specific effect has a constant mean but that the actual country-specific effect will vary around this mean (so, it will equal its mean plus a stochastic error term). This could be due to, for instance, changing personalities in the policy board of the central bank and in political authorities that try to influence the central bank. Because, in general, persons come and go gradually over time[38] the actual value of the central bank independence will also change gradually over time. This means that current values of actual independence are not independent of past values. Therefore, we can perform a simple test for this type of time-varying central bank independence[39]. We split up the sample in two sub-samples and we will judge whether the differences between the two sub-periods are significant or not. The results for the first and the second sub-period

---

38 In the United States, for instance, the Board of Governors consists of seven members which all are appointed for fourteen years by the president. Every two years one Governor is replaced. It should be noted, though, that this is the most extreme case of gradually replacing members of the policy board of a central bank. See Bade and Parkin (1988), pp. 10-15.

39 A way to model the alternative behaviour could be:

$$CBI_{i,t} = \mu_i + \nu_{i,t} \quad with \quad \nu_{i,t} = \rho \nu_{i,t-1} + \lambda_{i,t}$$

and

$$\lambda_{i,t} \; i.i.d. \; N(0,\sigma_\lambda^2), \; 0<\rho<1$$

Here i.i.d. denotes independently, identically distributed. A test whether the individual effects are fixed ($H_0$) or not against this alternative would amount to testing:

$$H_0 : \sigma_{\nu_i}^2 = 0 \; versus \; H_1 : \sigma_{\nu_i}^2 > 0$$

Note that we did not test our null hypothesis with respect to this particular alternative. It is mentioned here to get insight in the actual process by looking at an attempt to formalize this process. Note further that Cukierman (1992, p. 165) also uses the same specification for his parameter A - i.e. the relative emphasis on employment versus price stability - when he is modelling shifts in this relative concern as well as the persistence in these shifts. In Eijffinger and Schaling (1993b, p. 6) the parameter 1/A is identified with the degree of central bank independence.

are given in table 3 and the following two equations[40]:

40 The first sub-period ranges from 1977 III - 1984 I and the second from 1984 II - 1990 IV.

$$\Delta MMR_{i,t} = EMP_i + \underset{[1.603]}{0.185P_{i,t}} + \underset{[2.109]}{0.253P_{i,t-1}} + \underset{[5.732]}{0.480Y_{i,t}} + \underset{[1.846]}{0.153Y_{i,t-1}} + \eta_{i,t} \qquad (11)$$

and $\sigma_\eta^2 = 2.386$,

$$\Delta MMR_{i,t} = EMP_i + \underset{[1.866]}{0.199P_{i,t}} + \underset{[0.778]}{0.081P_{i,t-1}} + \underset{[2.924]}{0.241Y_{i,t}} + \underset{[1.710]}{0.143Y_{i,t-1}} + \eta_{i,t} \qquad (12)$$

and $\sigma_\eta^2 = 1.032$.

Absolute t-values for estimated coefficients are given between brackets. The first equation is reaction function (2) again but now estimated for the first half of the sample period. The second equation is the equivalent of the first equation but now for the second half of the sample period. For both sub-periods the signs of the coefficients do not differ from the whole sample period. However, the estimates in the second equation are less accurate than the estimates of the first equation. The overall contribution of the variables to the explanation of the variation in ΔMMR even appears to be insignificant on a 20% level. This may give rise to doubt the robustness of the regression results over time. On the other hand, in the first sub-period the joint contribution of the regressors in equation (2) is significant on a 1% level[41]. So, our model (equation (2)) does give a good fit for the data in the first sub-period but not for data in the second sub-period. A closer look at the determination of central bank independence tells us that these results may be not so remarkable after all. Within the second sub-period the intention of the EMS countries (in our sample: France, Germany, Italy, the Netherlands and partly the United Kingdom) was - more and more - to have converging monetary policies. This implied more weight to the exchange rate target and, therefore, that monetary policy became more and more endogenous[42]. Now factors like the exchange rate vis-à-vis other EMS countries (especially

---

41 Also for the whole sample period the overall contribution of the regressors to the explanation of the variation in ΔMMR is significant on a 1% level.

42 See, for instance, Eijffinger and Schaling (1993b), p. 14. Ungerer (1990) divides the development of the EMS in three phases. The first phase (1979-1982/1983) was a period of orientation. After 1982/1983 up to 1987 there was a period of consolidation. This marks the second phase and according to Ungerer (1990, p. 338) this period "*was characterized 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*". The third phase from 1987 till the present was a period of re-examination in the light of uneasiness about the "asymmetry" of the system. See, for example, Giavazzi and Pagano (1988) for an interesting paper about the advantages of being tied to an exchange rate within the EMS. In Von Hagen (1993) the development of the EMS and

Germany) and the money market rates in these countries are important for the determination of the money market rate. Hence, the fact that our model does not represent the actual process in the second sub-period is explained.

**Table 3**

**Empirical central bank independence in the whole sample period and sub-periods.**

| Country | Whole sample period | First sub-period | Second sub-period |
|---|---|---|---|
| Netherlands | -0.33 (1) | -0.59 (1) | -0.22 (1) |
| Switzerland | -0.40 (2) | -0.65 (2) | -0.27 (2) |
| Germany | -0.43 (3) | -0.69 (3) | -0.29 (3) |
| United States | -0.68 (4) | -1.06 (5) | -0.65 (8) |
| United Kingdom | -0.70 (5) | -1.31 (8) | -0.50 (5) |
| Japan | -0.72 (6) | -1.05 (4) | -0.50 (4) |
| Canada | -0.73 (7) | -1.25 (6) | -0.57 (6) |
| France | -0.77 (8) | -1.38 (9) | -0.61 (7) |
| Australia | -0.87 (9) | -1.26 (7) | -0.86 (10) |
| Italy | -1.16 (10) | -2.10 (10) | -0.86 (9) |

Whole sample period : 1977 III - 1990 IV;
First sub-period : 1977 III - 1984 I;
Second sub-period : 1984 II - 1990 IV;
Rankings in the different periods are given in parentheses;

In table 3 we have included the generalized individual effects - i.e. the empirical independence of central banks - for the two sub-periods as well as for the whole sample period[43]. The generalized effects for the entire sample period are ranked, again, from high to low. For the whole sample period and sub-periods the rankings are given in

its economic performance is reviewed.

43 In table 3 the three types of central banks are again separated by double lines.

parentheses. From this table it appears that the overall ranking does not change a lot. The class of strongly independent central banks is still the same. One noticeable result is that in the second sub-period Australia joined Italy in the group of dependent central banks. We cannot draw conclusions from this because we already saw that the F-statistic to test the model was insignificant. Considering this, it is noticeable that the point estimations, though not being very precise, give roughly the same pattern as in the first sub-period and the whole sample period. Furthermore, the ranking of intermediate independent central banks has slightly changed between the two sub-periods. This is not surprising, because the differences within this class are small. It is interesting to note, though, that the differences between the three groups have become smaller from the first to the second sub-period in the sense that the extreme values for the individual generalized effects (EMP) lie closer together. This may point to a convergence of independence of central banks. On the other hand, it may point to a slightly different value for $\beta_5$[44]. Furthermore, according to table 3, there is no evidence of big changes in the ranking of central banks with respect to each other. Therefore, we conclude that there is no evidence of significant changes over time in the country-specific effects (CBI)[45].

We now have proxies for actual independence of central banks which, approximately, appear to be constant over time. In section 1 we also discussed some indices of legal independence[46]. It is interesting to confront these measures with each other. In

---

[44] To see that this is more likely we consider the generalized individual effect again. $EMP_i = \beta_0 + \beta_5 CBI_i$. For ease of notation we normalized $\beta_5$ to one. Now, we abandon this normalization for a moment. In fact, there exist three different effects which cannot be disentangled. In estimating reaction function (2) the $EMP_i$'s are chosen in a way that gives the best fit. This means that we implicitly estimated $\beta_0$, $\beta_5$ and the $CBI_i$'s. We only can guess after the underlying causes of different estimated values for the $EMP_i$'s. A lower value for $\beta_0$ in the first sub-period may have caused the more negative values for $EMP_i$ in this sub-period. In the same way, a value of $\beta_5$ closer to zero may have caused the values for $EMP_i$ to converge from the first to the second sub-period. Note that the values of $\beta_0$ and $\beta_5$ do not have to be changed significantly to cause the differences between the $EMP_i$ values in both sub-periods. Only the point estimations may be somewhat different. In other words, the country-specific effects ($CBI_i$) do not have to be changed significantly. Because the ranking does not change a lot between the two sub-periods it is even likely that the independence of central banks in particular countries did not change much.

[45] This is confirmed by applying the Chow stability test. Computing this test statistic for the paneldata estimations - i.e. equations (10), (11) and (12) - gives 0.598 which does not exceed 1.70 which is the 5% significance level of the F-distribution with 14 degrees of freedom in the numerator and 512 in the denominator.

[46] Of course, also legal dependence may change when central bank laws are adjusted. At this point it is interesting that recently an independent panel proposed a change in the law of the United Kingdom. See

table 4 we repeat table 1 but we insert our measure of actual central bank independence and we order the countries - according to our measure of actual independence - from the country with the most independent central bank to the country with the least independent central bank[47].

---

Roll (1993). The intention of this proposal is to make the central bank more independent. At this moment the government has responsibility over the monetary policy. The major change due to this proposal would be that the central bank will take over the responsibility for monetary policy. The government, though, may override the central bank's objective of price stability in extreme situations and only by Parliamentary approval and for a finite fixed time. Following this proposal the independence of the central bank will certainly increase relative to the present situation. To which extent, though, is not clear yet. The Bank of England now has an ES-index of 2. Implementing this proposal - i.e. changing the statutes - would raise this index to 3 or 4. This depends on the actual practice of monetary policy. If the actual execution of the law would be that the right of overriding in practice does not appear then the central bank is - de facto - responsible for monetary policy and should aim at price stability. Other procedures being equal the ES-index would then be 4. This may be compared to the situation of the Netherlands where the Minister of Finance has the right to give directions to the central bank. This right to give directions has never been exercised till now. See Eijffinger and Schaling (1993a, p. 75). However, if the practice appears to be that the right of overriding is used at some occasions the final authority will lie in hands of both government and cental bank and the ES-index would only increase to 3. If actual policy amounts to frequently using the right of overriding then the government will maintain its final authority for monetary policy and the ES-index would not change.

47 Of course, we will not include Sweden in this table because we also excluded Sweden when determining the empirical independence of central banks. Note further that the three groups of central banks (strongly independent, intermediate independent and dependent) are separated in the table 4 by a double line.

**Table 4**

**Empirical and legal indices of central bank independence.**

| Country | EMP | ES | BP | AL | GMT Policy | GMT Political | GMT Economic |
|---|---|---|---|---|---|---|---|
| Netherlands | -0.33 | 4 | 2 | 2 | 3 | 6 | 4 |
| Switzerland | -0.40 | 5 | 4 | 4 | 3 | 5 | 7 |
| Germany | -0.43 | 5 | 4 | 4 | 3 | 6 | 7 |
| United States | -0.68 | 3 | 3 | 3 | 3 | 5 | 7 |
| United Kingdom | -0.70 | 2 | 2 | 2 | 2 | 1 | 5 |
| Japan | -0.72 | 3 | 3 | 3 | 1 | 1 | 5 |
| Canada | -0.73 | 1 | 2 | 2 | 1 | 4 | 7 |
| France | -0.77 | 2 | 2 | 2 | 1 | 2 | 5 |
| Australia | -0.87 | 1 | 1 | 1 | 1 | 3 | 6 |
| Italy | -1.16 | 2 | 2 | 1.5 | 3 | 4 | 1 |

EMP : Empirical independence;
ES : Eijffinger-Schaling index;
BP : Bade-Parkin index;
AL : Alesina index;
GMT : Grilli-Masciandaro-Tabellini index;

From table 4 we see that most measures of legal independence coincide rather well with actual independence[48]. The correlation between our measure of actual independence and the indices of legal independence from table 1 (or table 4) are given in table 5. We also tested whether these Pearson correlation coefficients are significantly positive[49]. The values for this Pearson correlation statistic are also given in table 5[50].

---

[48] This is consistent with the observation of Cukierman (1992, p. 419) that legal independence is a good measure for actual independence in developed countries. He found evidence, however, that legal independence and actual independence are two different things in lower developed countries. He suggests the turnover of central bank governors as a measure of actual independence of central banks in this latter group of countries.

[49] Notice that this is a one-sided test. The null hypothesis is no - or negative - correlation and the alternative hypothesis is positive correlation.

**Table 5**

**Pearson correlation test for positive correlation between empirical and legal central bank independence.**

| Correlation of empirical independence with the: | Pearson correlationcoefficient | Pearson test statistic: $t_\rho$ |
|---|---|---|
| ES index | 0.762** | 3.323 |
| BP index | 0.560* | 1.912 |
| AL index | 0.645* | 2.386 |
| GMT Policy index | 0.349 | 1.052 |
| GMT Political index | 0.490 | 1.208 |
| GMT Economic index | 0.555* | 1.886 |

* : significant for $\alpha=0.05$;

** : significant for $\alpha=0.01$;

From table 5 appears that our judgement is confirmed by the correlations. All indices show a positive relationship with actual independence. The ES index has the highest coefficient of correlation with the measure of actual independence. Moreover, the ES index is the only index that shows a significantly positive relation with actual independence on a level of 1%. So, the ES index of legal independence is the best proxy for the measure of actual independence that we estimated[51]. The BP, AL and GMT Economic

---

50 The Pearson correlation test statistic is defined by

$$t_\rho := \frac{\sqrt{n-2}}{\sqrt{1-\rho^2}}\rho, \text{ with}$$

$\rho$: = Pearson correlation coefficient,

n: = number of observations.

We have 10 countries in our sample. So, n=10. Under the assumption that the numerical values for empirical independence and the legal index of central bank independence are drawn from a bivariate normal distribution the Pearson correlation test statistic follows a t-distribution with n-2 degrees of freedom. In our case the critical values for the Pearson test statistic are 1.860 on a 5% level and 2.896 on a 1% level. This corresponds to critical levels for the correlation coefficient of 0.549 respectively 0.715.

51 This is not remarkable in the light of the fact that the ES-index is the only index that tries to grab some of the actual implementation of central bank laws. Also our empirical index is based on actual behaviour of central banks. So, apparently, Eijffinger and Schaling succeeded in creating an index that

index show a positive relation on a level of 5%. So, these legal indices are also relatively good indicators for actual independence[52]. Finally, for the GMT Policy index and the GMT Political index we did not find a significant positive correlation.

## 5. EVALUATION

At this point it is worthwhile to summarize what we have done so far. The intentions of this research were twofold. Firstly, are we able to measure actual independence of central banks and, secondly, can we tell something about the trade-off between inflation and economic growth given this degree of central bank independence? After trying to deduce both intentions at the same time with the use of symmetrical and asymmetrical reaction functions per country, we felt strongly that this approach did not bring us far. Within this chapter we decided to use a paneldata analysis. Doing this, results were obtained for actual independence of central banks which were intuitively appealing. So, we reached our first goal. This, however, was at the expense of the second goal of this research. The use of paneldata restricted the response to inflation and economic growth data for all countries to be the same, apart from the fixed individual effect. Therefore, we will investigate the effects of central bank independence on the mean (and variance) of the rate of inflation, the economic growth rate and the money market rate in the following section.

## 6. CENTRAL BANK INDEPENDENCE AND ECONOMIC PERFORMANCE

Why is the concept of central bank independence so important? The answer lies, basically, in the ongoing 'rules versus discretion' debate. Monetary policy-makers are

---

comprises legal independence as well as the actual implementation of the law. It should be noted, however, that legal indices only change when central bank laws are changing and that these changes are easily to identify. The ES-index, though, is somewhat more difficult to construct and is likely to change more frequently while these changes are more difficult to identify.

52 At first sight, it may look strange that the AL index performs better as a proxy for actual independence than, for instance, the BP index. Is this a contradiction of the fact that the AL index is internally inconsistent? This is not the case. The Al index is internally inconsistent because Italy is downgraded for the wrong reasons. The fact that Italy is downgraded was expected to correspond more to reality. This is confirmed by the results.

confronted with a time-consistency problem[53]. The optimal policy (zero inflation) is time-inconsistent, because a policy-maker - which values surprise inflation positively - is always tempted to create surprise inflation[54]. The time-consistent discretionary policy, however, is sub-optimal. Kydland and Prescott (1977, p. 475) show that: "*Doing what is best, given the current situation, results in an excessive level of inflation, but unemployment is no lower than it would be if inflation (possibly deflation or price stability) were at the socially optimal rate*". Therefore, they advocate the use of rules instead of policy by discretion. In words of Sijben (1992, p. 236): "*Kydland and Prescott point out that a credible and steady preannounced monetary policy rule always generates a better pay-off in terms of inflation and employment than a discretionary policy, when the macroeconomic outcomes are dependent on the expectations with regard to future monetary policy*". This conclusion is based on the fact that submitting to the temptation of organizing surprise inflation will induce higher inflationary expectations and, thereby, costs for the long term. These costs consist of either accommodating the inflationary expectations[55], or not accommodating which results in an unemployment rate above the natural level. So, the policy-maker has to weight the short term benefits of organizing surprise

---

53 Especially, when the government is designing monetary policy there is a time-consistency problem. Governments are short-sighted, like to be reelected and will, therefore, sacrifice long term benefits from price stability for short term gains from surprise inflation.

54 This temptation is not necessarily the result of the employment motive. The employment motive is based on the negative relation between deviations of the natural level of unemployment and unexpected inflation. This in turn is based on the short term Phillips-curve or on the supply function in the context of the contract theory with price and wage rigidity. See Sijben (1992), p. 237. Surprise inflation can also be attractive because of the nominal debt motive. This amounts to the fact that inflation diminishes real government debt when government debt is nominated in nominal terms. Yet another motive is the one of financial stability. Cukierman (1992, pp. 117-118) states that central banks may compromise on their objective of price stability to smooth interest rates and to reduce the likelihood of financial instability. Yet another motive to inflate may be to finance budget deficits through monetary financing.

55 Accommodating inflationary expectations makes these expectations self-fulfilling. This raises the question: What are the costs of inflation? This is somewhat unclear. Barro and Gordon (1983a, p. 104) state that "*although people generally regard inflation as very costly, economists have not presented very convincing arguments to explain these costs*". Rogoff (1985, p. 1174) notes that "*the costs of inflation include the administrative costs of posting new prices and the costs of adjusting the tax system to be fully neutral with respect to inflation*". Furthermore, there are also the so-called 'shoe-leather costs' of inflation, i.e. high inflation forces agents to economize on their holdings of non-interest bearing money. Also, inflation distorts the information content of prices and undermines an efficient allocation of resources. Finally, Roll (1993, p. 5) remarks "*High inflation is also inevitably uncertain inflation. Uncertainty erodes confidence, foreshortens the time horizon for investment decisions, obscures the information in prices as a signal to change behaviour, and allows substantial but unforeseen redistribution of income and wealth*" and concludes that "*inflation damages the real economy*". For a recent article on theory and evidence of the costs of inflation see Driffill, Mizon and Ulph (1990).

inflation against the long term costs.

Of course, the optimal solution - i.e. zero inflation - may be achieved by a binding commitment to a zero-inflation rule. This, however, is either impossible or undesirable[56]. After recognizing this, Barro and Gordon (1983a, 1983b) show that there may exist a reputational equilibrium with a low but sustainable rate of inflation. They argue that although a monetary policy-maker is always tempted to organize surprise inflation, he also has to recognize the costs induced by the translation of this surprise inflation into higher inflationary expectations. As long as this enforcement is larger than the temptation the announced policy will be credible. This means that a zero inflation rate is unrealistic because, in general, the temptation to cheat - i.e. to create surprise inflation - will offset the enforcement. So, a zero inflation policy is not credible and an inflationary bias is inevitable. The question is then which inflation rates are credible? By behaving as a strong policy-maker - i.e. by not giving in to short term gains of surprise inflation - the policy-maker is able to built up a good reputation[57]. A reputation as strong policy-maker that gives no room for inflationary processes will lead to corresponding inflationary expectations. The installation of an independent institute will enlarge the reputation of this policy. Therefore, an independent central bank will contribute to the mitigation of the inflationary bias induced by the time-consistency problem[58].

Summarizing, governments always face a trade-off between surprise inflation and unemployment. In the short run, surprise inflation will lead to lower unemployment but in

---

56 This is undesirable because in case of a binding commitment to a zero inflation rate there is no room at all to respond to supply shocks. See Rogoff (1985).

57 See also Backus and Driffill (1985) who are explicitly modelling reputation by a learning mechanism. This amounts to the public thinking in terms of probabilities for the policy-maker being 'weak' or 'strong'. They also conclude that "*the analysis suggests that governments may try to appoint central bankers with reputations for fighting inflation, even if their own preferences place positive weight on employment*" (p. 537).

58 We already mentioned that especially governments are confronted by a time-consistency problem. In general, there is a time-consistency problem when the policy-maker who designs monetary policy benefits from surprise inflation. Strictly speaking also the most independent central banks are not completely independent and they too are confronted with a time-consistency problem. The public knows, however, that they are more inflation-averse than the government and that they have a lot of independence such that they will not easy give in substantially to inflationary pressures. The fact that also the most independent central banks will not be completely independent is put into words in Roll (1993, p. 36) who states that "*complete independence could never be achieved because it is always open to Parliament to repeal the legislation that initially confers that independence*" and "*a second reason why independence necessarily is limited: in practice no government is ever willing to cede all control over exchange rate policy*".

the long run the policy-maker will end up with high inflation and unemployment at its natural level[59]. This situation is not optimal because the same level of employment can be reached with zero inflation. To convince the public that the government is well-meaning in restraining inflation it is beneficial to establish an independent central bank which takes care of the anti-inflation policy. However, Rogoff (1985, p. 1169) notes, that - although it is indeed beneficial to have an independent central bank which is more inflation-averse than the public - an infinite weight to the price stability objective is also sub-optimal because of the high variance in employment when supply shocks are large.

Grilli, Masciandaro and Tabellini (1991, p. 375) state that having a central bank is like having a 'free lunch'. They introduce this term to denote that the greater the independence of the central bank the lower the average inflation rate will be, but without implications for the average economic growth rate. So, there are obvious benefits of having an independent central bank but there are no apparent costs. This will be examined in this section.

What other relations are indicated by the theory. Eijffinger and Schaling (1993b) derive some propositions on basis of a single-stage Phillips-curve monetary policy game with supply shocks. They claim that central bank independence is negatively related with the mean and variance of inflation, not related to the mean economic growth rate and positively related with respect to the variance of economic growth. This is intuitive because the more independent a central bank the more credible - and effective - its policy directed at a low and stable inflation rate. Moreover, on basis of the Phillips-curve analysis, it is clear that in the long run the mean level of economic growth will equal its natural rate no matter how dependent or independent the central bank is. Supply shocks, however, are absorbed by the rate of economic growth and not by the inflation rate such that the variance of economic growth is likely to be positively related to central bank independence.

Eijffinger and Schaling (1993b) test these propositions by regressing the average inflation rate, the variance of the inflation rate, the average economic growth rate and the variance of the economic growth rate on the Bade-Parkin index, the Alesina index, the

---

59 Behind this is the Phillips-curve analysis. On the short term there is a trade-off between surprise inflation and unemployment but in the long run the employment is at its natural rate despite of the inflation rate.

GMT Political index and their own index of central bank independence[60]. They find that the theoretical relation between central bank independence and the average inflation and economic growth rate is confirmed by the empirical results, while the variability in inflation and economic growth do not give significant relationships with central bank independence[61]. We will estimate the same regressions for a somewhat different sample period and we also use the empirical index of central bank independence, and the other two Grilli, Masciandaro and Tabellini indices (i.e. the GMT Policy and the GMT Economic index). Our hypothesis is that the empirical index is a better approximation of actual central bank independence than any of the other indices that measure legal independence of central banks. Therefore, using our measure of actual independence will give more meaningful and - we expect - more pronounced results.

We just mentioned that the statement 'having a central bank is like having a free lunch' will be examined in this section. Furthermore, it is interesting to test whether central bank independence has any effect on the mean and variance of the money market rate. Especially, the relation between the empirical index and the average money market rate is interesting in light of the meaning of this empirical index. The empirical index actually measures the tendency of keeping the money market rate high (relative to the inflation and economic growth data). This upward pressure on the money market rate does not mean that it is higher in absolute value. We just mentioned the negative relationship between central bank independence and average inflation. So, although, there is a greater upward pressure on the money market rate because of the independence there is less upward pressure on behalf of the inflation data. So, it is not clear a priori which countries will show the highest money market rates. Those with independent central banks or those with more dependent central banks. From a theoretical point of view there are two possible visions on whether a more independent central bank will lead to higher or lower interest rates. Nominal interest rates may be lower because of less inflation uncertainty and a lower expected rate of inflation or higher to keep the inflation rate low. This question is important because of the relation between the level of interest rates and

---

60 See section 1 for a discussion of these indices.

61 De Haan and Sturm (1992), however, did find a negative significant relationship between central bank independence and the variability of inflation for the period reaching from 1961 till 1987.

the level of investments (and consumption)[62]. Therefore, we investigate whether higher central bank independence will lead to higher or lower money market rates[63]. The money market rate is not the rate against which loans are made for investment plans but the preferred habitat theory of the term structure states that long term interest rates can be seen as consisting of expected short term interest rates over the same period plus a term premium that responds to demand and supply conditions[64]. Through this mechanism the money market rate - which is a short term interest rate - is linked to long term interest rates.

Summarizing, we tested the relation between the mean and the variability of the inflation rate, the rate of economic growth and the money market rate, on the one hand, and all indices (legal and actual) from table 4, on the other hand[65]. The results are given below in table 6. These results are in line with the results of Eijffinger and Schaling (1993b)[66]. Obviously, the results confirm the inverse relationship between central bank independence and the inflation rate[67]. The higher central bank independence the lower

---

62 It should be noted, though, that it is not clear what determines investments. It is likely that the real interest rate is more important in determining investments than the nominal interest rate. This implies that if central bank independence leads to lower inflation and concomitant inflationary expectations as well as to a lower nominal money market rate the total effect of central bank independence on the real interest rate still is undetermined.

63 At the same time we also analyze whether central bank independence has any effect on the variability of the money market rate. This is investigated because a lower variability in the money market rate contributes to more financial stability.

64 See Mishkin (1992), p. 146.

65 In appendix A the data that were used for the mean and variance of the inflation rate, the economic growth rate and the money market rate are given. Also is described how these averages and variances have been computed.

66 Eijffinger and Schaling (1993b) estimated a subset of the regressions given in table 6. They did not use the mean and variance of the money market rate as dependent variable. Furthermore, they did not use the GMT Policy index, the GMT Economic index and, of course, they did not use the empirical index as independent variable. They also considered a slightly different sample period: namely from 1972 till 1990 or 1991 and sub-samples reaching till and from 1982.

67 The GMT indices, however, do not give a significant relationship. This is equally true for the relation between the other dependent variables and these three indices except for a significant relationship on a 5% level between the GMT Economic index and the variability of inflation. So, we may conclude that these GMT indices do not explain the mean and variance of inflation, economic growth and the money market rate. Therefore, they are not discussed extensively. It should be noted, though, that the signs of the coefficients for the GMT indices do also indicate a negative relationship between average inflation and central bank independence.

the mean inflation rate. The empirical index gives the most strong and significant relationship[68]. Also the coefficient of determination is higher for the empirical index than for other indices. Approximately 72% of the sample variation in the mean inflation rate is explained by the empirical index of actual independence. This implies that the index of actual independence alone explains almost completely the average inflation rate among the sample countries. Considering the variance of the inflation rate all signs indicate an inverse relationship too[69] - except for the GMT Policy index - but only the GMT Economic index gives a significant relationship. So, the overall picture is that there is no significant relation between central bank independence and the variability of inflation[70].

---

68 Notice that the constant is insignificant and negative for the empirical index, where the intercept for all other indices is significant and positive. This is not remarkable because the empirical index takes negative values, while all other indices only take positive values.

69 This is not remarkable in the light of the fact that low inflation and low inflation variability, in general, appear together. See, for instance, De Haan and Sturm (1992), p. 311.

70 The empirical index, though, does give a significant inverse relationship on a 10% level.

**Table 6**

**Economic performance and the indices of independence: 1977-1990.**

| Explanatory Variables | Average Inflation Rate | Variance Inflation Rate | Average Output Growth Rate | Variance Output Growth Rate | Average Money Market Rate | Variance Money Market Rate |
|---|---|---|---|---|---|---|
| Constant | 10.483** | 1.367* | 2.742** | 1.548 | 15.348** | 9.423** |
| | [5.399] | [2.636] | [4.323] | [2.163] | [9.641] | [5.906] |
| BP | -1.877* | -0.193 | -0.044 | -0.223 | -2.499** | -1.075 |
| | [2.576] | [0.991] | [0.186] | [0.829] | [4.182] | [1.796] |
| Adj. $R^2$ | 0.385 | -0.002 | -0.120 | -0.036 | 0.647 | 0.198 |
| SE | 2.125 | 0.568 | 0.694 | 0.783 | 1.742 | 1.746 |
| Constant | 10.658** | 1.449* | 2.751** | 1.438 | 15.225** | 9.537** |
| | [6.390] | [3.050] | [4.579] | [2.096] | [11.195] | [6.615] |
| AL | -1.987* | -0.230 | -0.049 | -0.183 | -2.499** | -1.144 |
| | [3.135] | [1.276] | [0.214] | [0.700] | [4.836] | [2.087] |
| Adj. $R^2$ | 0.495 | 0.065 | -0.119 | -0.060 | 0.713 | 0.272 |
| SE | 1.925 | 0.548 | 0.693 | 0.792 | 1.570 | 1.664 |
| Constant | 6.872* | 0.805 | 3.413** | 0.524 | 11.549** | 7.108** |
| | [3.156] | [1.739] | [7.704] | [0.869] | [5.240] | [4.472] |
| GMT Policy | -0.515 | 0.038 | -0.372 | 0.222 | -1.165 | -0.178 |
| | [0.545] | [0.188] | [1.934] | [0.848] | [1.217] | [0.257] |
| Adj. $R^2$ | -0.085 | -0.120 | 0.234 | -0.032 | 0.051 | -0.116 |
| SE | 2.822 | 0.600 | 0.574 | 0.782 | 2.856 | 2.060 |
| Constant | 7.580** | 1.436** | 3.303** | 0.299 | 11.320** | 6.540** |
| | [3.861] | [3.792] | [7.676] | [0.568] | [5.440] | [4.364] |
| GMT Political | -0.484 | -0.149 | -0.181 | 0.187 | -0.600 | 0.053 |
| | [1.013] | [1.618] | [1.734] | [1.462] | [1.184] | [0.144] |
| Adj. $R^2$ | 0.003 | 0.152 | 0.182 | 0.112 | 0.043 | -0.122 |
| SE | 2.706 | 0.522 | 0.593 | 0.725 | 2.870 | 2.065 |
| Constant | 9.596** | 1.938** | 2.842** | 1.186 | 12.529** | 7.980** |
| | [3.839] | [4.253] | [4.113] | [1.459] | [4.420] | [3.960] |
| GMT Economic | -0.705 | -0.195* | -0.039 | -0.036 | -0.635 | -0.231 |
| | [1.605] | [2.436] | [0.321] | [0.252] | [1.274] | [0.651] |
| Adj. $R^2$ | 0.149 | 0.354 | -0.111 | -0.116 | 0.065 | -0.069 |
| SE | 2.499 | 0.456 | 0.691 | 0.813 | 2.835 | 2.015 |
| Constant | 9.750** | 1.316** | 2.986** | 0.783 | 14.083** | 8.974** |
| | [7.526] | [3.379] | [6.333] | [1.372] | [14.398] | [7.708] |
| ES | -1.414** | -0.154 | -0.127 | 0.074 | -1.779** | -0.800 |
| | [3.418] | [1.238] | [0.840] | [0.407] | [5.694] | [2.150] |
| Adj. $R^2$ | 0.543 | 0.056 | -0.034 | -0.102 | 0.777 | 0.287 |
| SE | 1.832 | 0.551 | 0.667 | 0.808 | 1.383 | 1.646 |
| Constant | -0.710 | -0.094 | 1.903* | 1.932* | 2.489 | 3.290 |
| | [0.510] | [0.205] | [3.065] | [2.709] | [1.420] | [2.122] |
| EMP | -9.573** | -1.441 | -1.073 | 1.386 | -9.740** | -5.074* |
| | [4.931] | [2.259] | [1.241] | [1.395] | [3.989] | [2.349] |
| Adj. $R^2$ | 0.722 | 0.313 | 0.057 | 0.095 | 0.624 | 0.334 |
| SE | 1.430 | 0.470 | 0.637 | 0.732 | 1.799 | 1.591 |

absolute t-values between brackets;
* : significant for $\alpha=5\%$;
** : significant for $\alpha=1\%$;

Adj. $R^2$ : Adjusted coefficient of determination;
SE : Standard Error of the regression.

There is no significant relationship either between central bank independence and average economic growth. This is in line with the statement that having an independent central bank is like having a free lunch. It should be noticed, though, that all signs are negative. Considering the variance of output growth the signs are different over the indices and there is no significant relationship. The empirical index, though, gives a positive sign. This positive sign is in line with the theory. A stable inflation rate can only be achieved if shocks are transmitted to the rate of economic growth.

The average money market rate is obviously negatively related to central bank independence (legal as well as actual), although the GMT indices do not show a significant relationship. So, one may conclude that having an independent central bank also results in having a lower money market rate on average. This relationship is strongest for the empirical index[71] and considered in the light of representing the upward pressure on the money market rate of independent central banks it highlights that these banks are successful in significantly lowering the average inflation rate. The variability of the money market rate also seems to give a negative relation with central bank independence. Although, this relation is only significant for the empirical measure of central bank independence. This implies that an independent central bank contributes to a stable financial system and mitigates uncertainty concerning the money market rate.

The fact that the empirical index gives the most or one of the most strong relationships when theory indicates there exists a relationship is reason for us to conclude that the legal indices do attempt to measure independence but that actual independence is best approximated by our measure of empirical independence[72]. Summarizing, an indepen-

---

71 Notice that the intercept in the regression of average as well as variance of the money market rate on the empirical index is insignificant contrary to the other cases. This difference is caused by the fact that the empirical index is negative and all other indices are positive.

72 One might criticize the regression analyses in this section by stating that we are closing the circle. First, we estimated empirical independence on basis of data for inflation and economic growth and then we related this measure to - averages and variances of - the same data. It should be noted, though, that the

dent central bank will contribute to lower inflation without effects on the economic growth rate. So the statement of Grilli, Masciandaro and Tabellini that having an independent central bank is like having a free lunch is confirmed. An independent central bank will also contribute - on average - to a lower money market rate and lower variability in the money market rate[73].

---

empirical index measures the upward pressure of the money market rate after movements in the money market rate on behalf of the inflation rate and the rate of economic growth have been removed. So, the relation we found between empirical independence and economic performance is not pre-imposed by the method of research. This is confirmed by the fact that - although less pronounced - the indices of legal central bank independence indicate the same relations.

73 See appendix B for a graphic illustration of the discussed relations between the mean and variance of the inflation rate, the rate of economic growth and the money market rate, on the one hand, and actual independence (measured by our empirical index), on the other hand.

APPENDIX A: MEASURES OF ECONOMIC PERFORMANCE (1977-1990)

| COUNTRY | Average Inflation Rate | Variance Inflation Rate | Average Output Growth | Variance Output Growth | Average Money Market Rate | Variance Money Market Rate |
|---|---|---|---|---|---|---|
| Australia | 8.0689 | 0.5157 | 2.9653 | 1.2521 | 12.5022 | 9.1473 |
| Canada | 6.5291 | 0.5765 | 2.8036 | 0.9433 | 11.1037 | 8.3870 |
| France | 7.1328 | 1.0494 | 2.3522 | 0.3171 | 10.5000 | 7.0110 |
| Germany | 2.8855 | 0.3855 | 2.4330 | 1.2700 | 6.5783 | 6.3981 |
| Italy | 10.5334 | 1.8515 | 2.7807 | 0.5747 | 12.7391 | 9.5540 |
| Japan | 2.7192 | 0.7046 | 4.2737 | 0.4015 | 6.3876 | 3.1252 |
| Netherlands | 2.9712 | 0.4911 | 2.0183 | 2.8862 | 6.9587 | 4.9255 |
| Switzerland | 3.3057 | 0.4844 | 2.1238 | 0.2212 | 4.2826 | 5.8134 |
| United Kingdom | 7.7945 | 1.9347 | 2.2037 | 1.1139 | 11.3017 | 6.8556 |
| United States | 5.9584 | 0.8551 | 2.3577 | 0.9309 | 8.6637 | 6.1349 |

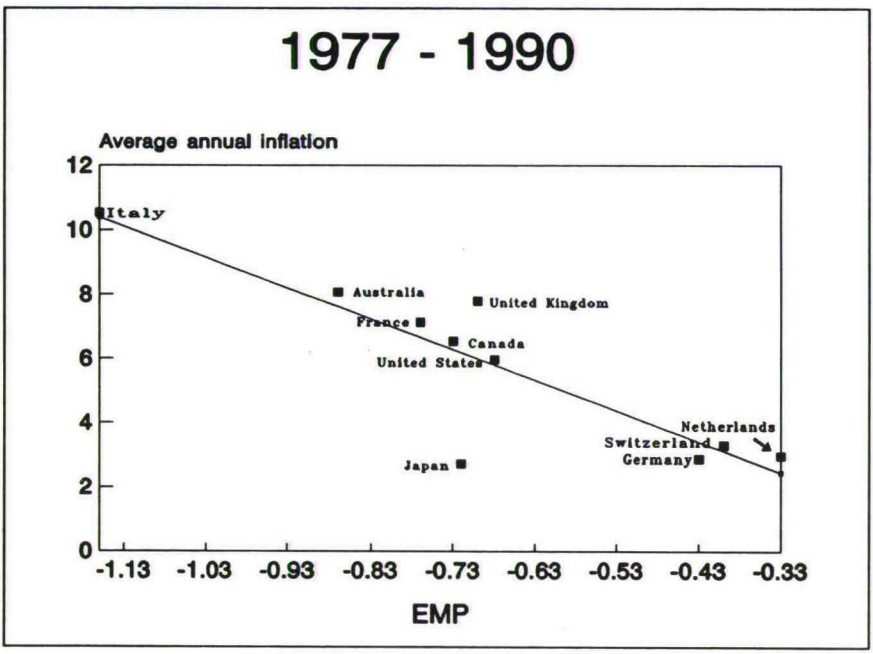
The data for economic performance which have been used for the regressions reported in table 6 are given above. These averages and variances are calculated from quarterly data reaching from the third quarter of 1977 till the last quarter of 1990. So, they are based on 54 observations. This particular period has been chosen because it coincides with the sample period used in the paneldata estimations. This because of the conviction that the interpretations in section 7 are most meaningful when the analyses of the behaviour of central banks - given by reaction function (10) and table 2 - are as comparable as possible with the data for economic performance. Consequently, the rate of inflation and the rate of economic growth are calculated from quarter to quarter. These data, however, are represented on annual basis and, therefore, the quarterly averages have been multiplied by four. Note that this means a slight underestimation compared with the more usual way of calculating the annual rate of inflation and the annual rate of economic growth. In calculating these rates one takes the change in percentages of the present level compared to the level one year before. The fact that quarterly data have been used in the paneldata estimations and the knowledge that all ten countries are treated in the same manner convinced us to use these data here too. Of course, the averages of the money market rate do not need to be multiplied. The variances of the rate of inflation, the rate of economic growth and the money market rate are based on their quarterly observations and not adjusted to represent them on annual basis. This again has been done

because the assumption implicit in reaction function (10) that central banks also calculate the inflation rate and the rate of economic growth on a quarterly basis and act according to these quarterly data.

APPENDIX B: CENTRAL BANK INDEPENDENCE AND ECONOMIC PERFORMANCE: A GRAPHICAL REPRESENTATION

**Figure 1**

**Actual central bank independence and the level of inflation**



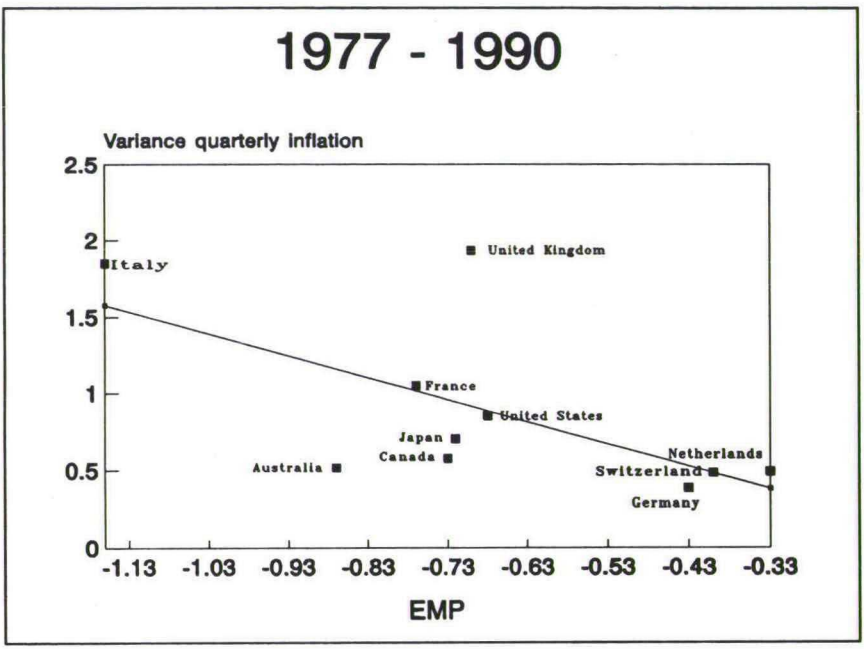

Average inflation = -0.710 - 9.573 * EMP
[0.510] [4.931]

Dependent Mean: 5.790

Adjusted $R^2$: 0.722

**Figure 2**

**Actual central bank independence and the variability of inflation**



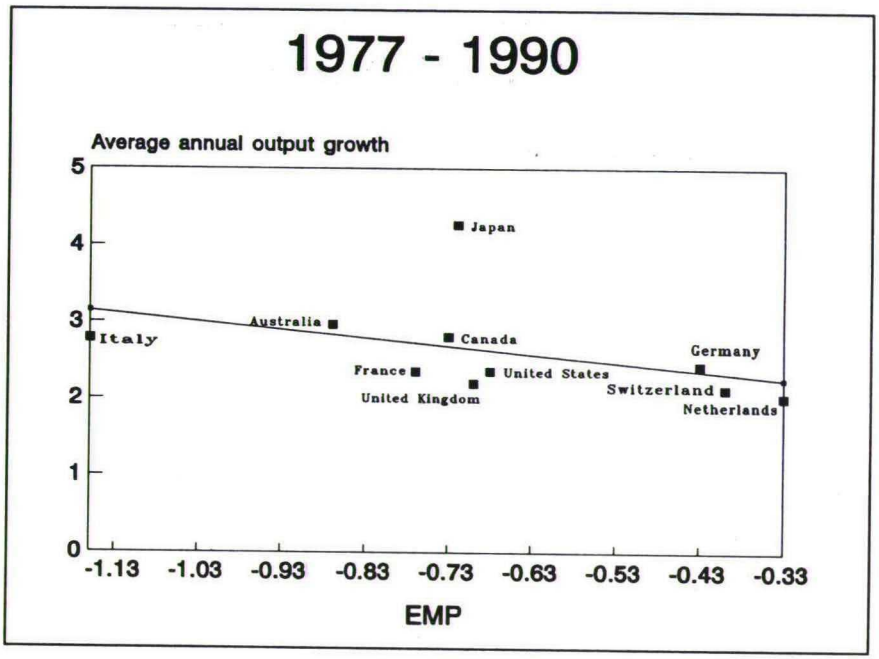

Variance inflation = -0.094 - 1.441 * EMP
[0.205] [2.259]

Dependent Mean: 0.885

Adjusted $R^2$: 0.313

**Figure 3**

**Actual central bank independence and the level of economic growth**



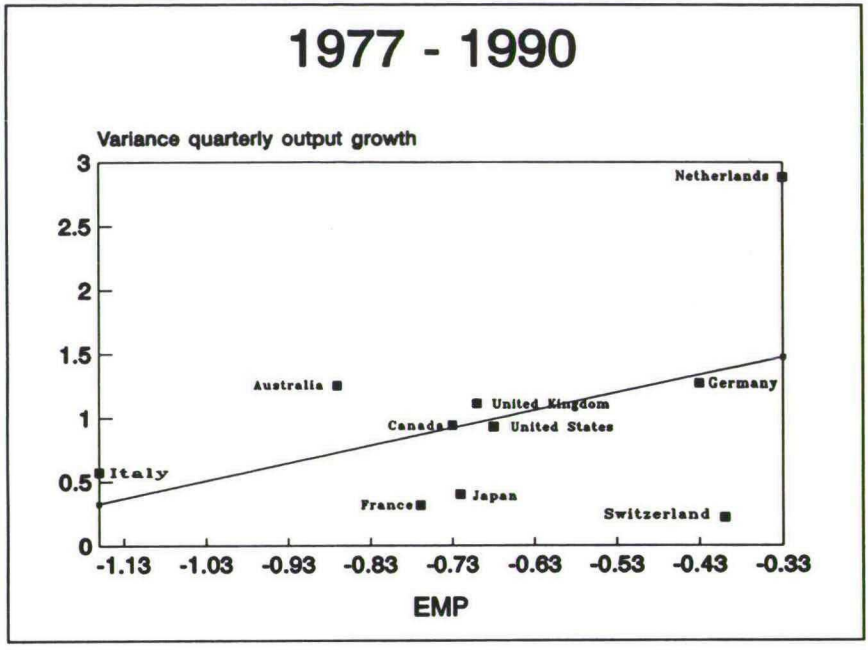

Average output growth = 1.903 - 1.073 * EMP
[3.065] [1.241]

Dependent Mean: 2.631

Adjusted $R^2$: 0.057

**Figure 4**

**Actual central bank independence and the variability of economic growth**



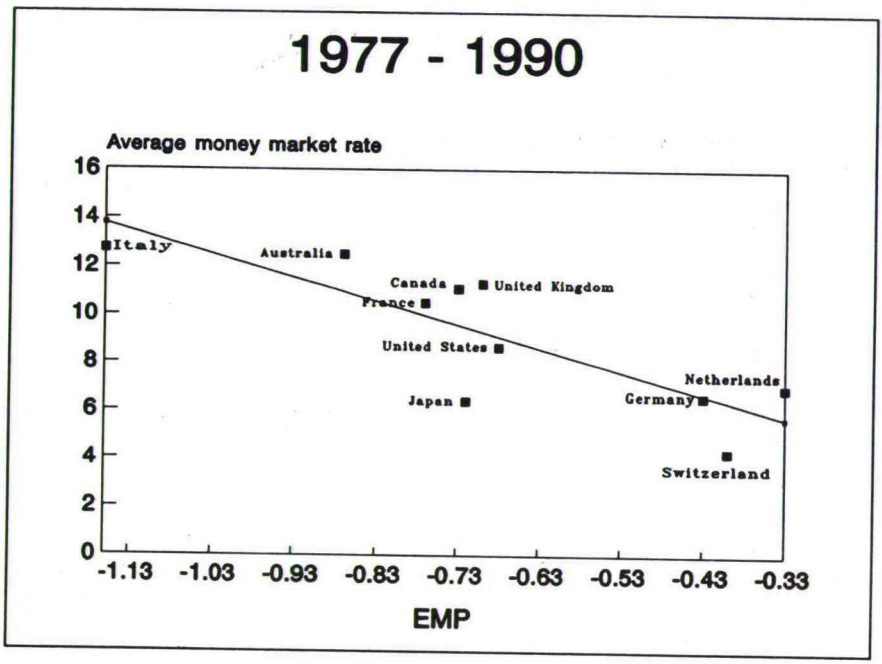

Variance output growth = 1.932 + 1.386 * EMP
[2.709] [1.395]

Dependent Mean: 0.991

Adjusted $R^2$: 0.095

**Figure 5**

**Actual central bank independence and the level of the money market rate**



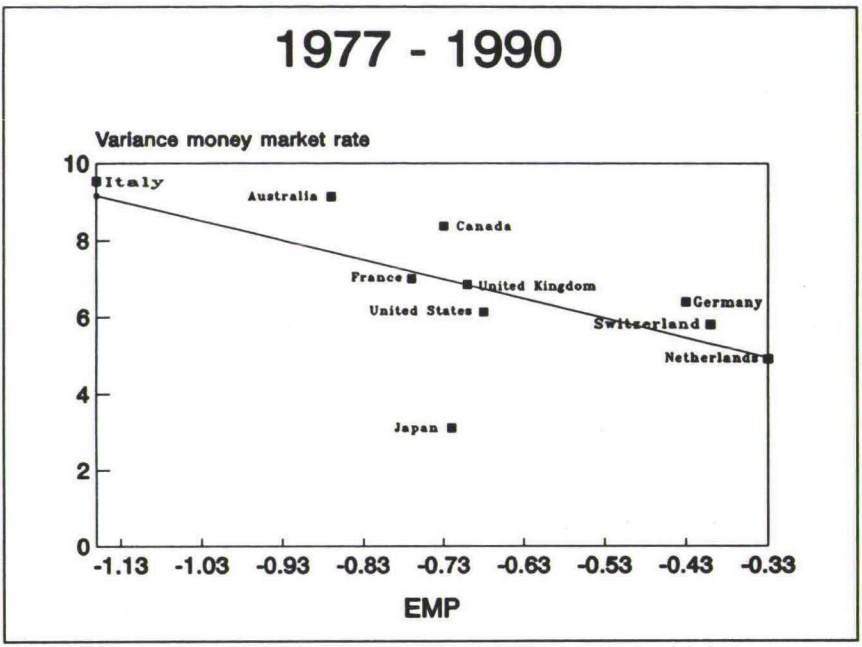

Average money market rate = 2.489 - 9.740 * EMP
[1.420] [3.989]

Dependent Mean: 9.102

Adjusted $R^2$: 0.624

**Figure 6**

**Actual central bank independence and the variability of the money market rate**




Variance money market rate = 3.290 - 5.074 * EMP
[2.122] [2.349]

Dependent Mean: 6.735

Adjusted $R^2$: 0.334

# REFERENCES

Alesina, Alberto (1988), "Macroeconomics and Politics". In: Stanley Fischer (ed.), NBER Macroeconomics Annual 1988, Cambridge, MIT Press, pp. 13-61.

Alesina, Alberto (1989), "Politics and Business Cycles in Industrial Democracies", Economic Policy: A European Forum, vol. 4, pp. 55-98.

Backus, David and John Driffill (1985), "Inflation and Reputation", The American Economic Review, vol. 75, pp. 530-538.

Bade, Robin and Michael Parkin (1988), "Central Bank Laws and Monetary Policy", Working Paper Department of Economics University of Western Ontario.

Barro, Robert J. and David B. Gordon (1983a), "Rules, Discretion and Reputation in a Model of Monetary Policy", Journal of Monetary Economics, vol. 12, pp. 101-121.

Barro, Robert J. and David B. Gordon (1983b), "A Positive Theory of Monetary Policy in a Natural Rate Model", Journal of Political Economy, vol. 91, pp. 589-610.

Chow, Gregory C. (1960), Tests of Equality Between Sets of Coefficients in Two Linear Regressions", Econometrica, vol. 28, pp. 591-605.

Cukierman, Alex (1992), Central Bank Strategy, Credibility and Independence: Theory and Evidence, Cambridge, MIT Press.

De Haan, J. and J.E. Sturm (1992), "The Case for Central Bank Independence", Banca Nazionale del Lavoro Quarterly Review, vol. 45, pp. 305-327.

Driffill, John, Grayham E. Mizon and Alistair Ulph (1990), "Costs of Inflation". In: Benjamin M. Friedman and Frank H. Hahn (ed.), Handbook of Monetary Economics, Volume II, Amsterdam, North-Holland Publishing Company, pp. 1013-1066.

Eijffinger, Sylvester (1993), "Convergence of Monetary Policies in Europe - Concepts, Targets and Instruments". In: Klaus Gretschmann (ed.), Economic and Monetary Union: Implications for National Policy-Makers, Dordrecht, Martinus Nijhoff Publishers, pp. 169-193.

Eijffinger, Sylvester and Eric Schaling (1992), "Central Bank Independence: Criteria and Indices", Research Memorandum Department of Economics Tilburg University, No. 548.

Eijffinger, Sylvester and Eric Schaling (1993a), "Central Bank Independence in Twelve Industrial Countries", Banca Nazionale del Lavoro Quarterly Review, vol. 46, No. 184, pp. 49-89.

Eijffinger, Sylvester and Eric Schaling (1993b), "Central Bank Independence: Theory and Evidence", Discussion Paper CentER for Economic Research, No. 9325.

Friedman, Milton (1962), "Should There Be an Independent Monetary Authority". In: L.B. Yeager (ed.), In Search of a Monetary Constitution, Cambridge, Harvard University Press, pp. 219-243.

Giavazzi, Francesco and Marco Pagano (1988), "The Advantage of Tying One's Hands", European Economic Review, vol. 32, pp. 1055-1082.

Grilli, Vittorio, Donato Masciandaro and Guido Tabellini (1991), "Political and Monetary Institutions and Public Financial Policies in the Industrial Countries", Economic Policy, vol. 6, pp. 342-392.

Hsiao, Cheng (1986), Analysis of Panel Data, Cambridge, Cambridge University Press.

Koskela, Erkki and Matti Virén (1991), "Monetary Policy Reaction Functions and Saving-Investment Correlations: Some Cross-Country Evidence", Weltwirtschaftliches Archiv, vol. 127, pp. 452-471.

Kydland, Finn E. and Edward C. Prescott (1977), "Rules Rather than Discretion: The Inconsistency of Optimal Plans", Journal of Political Economy, vol. 85, pp. 473-491.

Mishkin, Frederic S. (1992), The Economics of Money, Banking and Financial Markets, third edition (first edition: 1986), New York, HarperCollins Publishers.

Rogoff, Kenneth (1985), "The Optimal Degree of Commitment To an Intermediary Monetary Target", Quarterly Journal of Economics, vol. 100, pp. 1169-1189.

Roll, Eric (1993), "Independent and Accountable: A New Mandate for the Bank of England", Centre for Economic Policy Research.

Schaling, Eric and David Smyth (1994), "The Effects of Inflation on Growth and Fluctuations in Dynamic Macroeconomic Models", Discussion Paper CentER for Economic Research, No. 9439.

Sijben, Jac. J. (1992), "Monetary Policy in a Game-Theoretic Framework", Jahrbücher für Nationalökonomie und Statistik, vol. 210, pp. 233-253.

Ungerer, Horst (1990), "The EMS, 1979-1990, Policies-Evolution-Outlook", Konjunkturpolitik, vol. 36, pp. 329-362.

Von Hagen, Jürgen (1993), "Monetary Policy Coordination in the European Monetary System". In: Michele U. Frattianni and Dominick Salvatore (ed.), Studies in Comparative Economic Policies, vol. 3, Amsterdam, North-Holland Publishing Company, pp. 509-

560.

**Discussion Paper Series, CentER, Tilburg University, The Netherlands:**

(For previous papers please consult previous discussion papers.)

| No. | Author(s) | Title |
|---|---|---|
| 9409 | P. Smit | Arnoldi Type Methods for Eigenvalue Calculation: Theory and Experiments |
| 9410 | J. Eichberger and D. Kelsey | Non-additive Beliefs and Game Theory |
| 9411 | N. Dagan, R. Serrano and O. Volij | A Non-cooperative View of Consistent Bankruptcy Rules |
| 9412 | H. Bester and E. Petrakis | Coupons and Oligopolistic Price Discrimination |
| 9413 | G. Koop, J. Osiewalski and M.F.J. Steel | Bayesian Efficiency Analysis with a Flexible Form: The AIM Cost Function |
| 9414 | C. Kilby | World Bank-Borrower Relations and Project Supervision |
| 9415 | H. Bester | A Bargaining Model of Financial Intermediation |
| 9416 | J.J.G. Lemmen and S.C.W. Eijffinger | The Price Approach to Financial Integration: Decomposing European Money Market Interest Rate Differentials |
| 9417 | J. de la Horra and C. Fernandez | Sensitivity to Prior Independence via Farlie-Gumbel -Morgenstern Model |
| 9418 | D. Talman and Z. Yang | A Simplicial Algorithm for Computing Proper Nash Equilibria of Finite Games |
| 9419 | H.J. Bierens | Nonparametric Cointegration Tests |
| 9420 | G. van der Laan, D. Talman and Z. Yang | Intersection Theorems on Polytopes |
| 9421 | R. van den Brink and R.P. Gilles | Ranking the Nodes in Directed and Weighted Directed Graphs |
| 9422 | A. van Soest | Youth Minimum Wage Rates: The Dutch Experience |
| 9423 | N. Dagan and O. Volij | Bilateral Comparisons and Consistent Fair Division Rules in the Context of Bankruptcy Problems |
| 9424 | R. van den Brink and P. Borm | Digraph Competitions and Cooperative Games |
| 9425 | P.H.M. Ruys and R.P. Gilles | The Interdependence between Production and Allocation |
| 9426 | T. Callan and A. van Soest | Family Labour Supply and Taxes in Ireland |

| No. | Author(s) | Title |
|---|---|---|
| 9427 | R.M.W.J. Beetsma and F. van der Ploeg | Macroeconomic Stabilisation and Intervention Policy under an Exchange Rate Band |
| 9428 | J.P.C. Kleijnen and W. van Groenendaal | Two-stage versus Sequential Sample-size Determination in Regression Analysis of Simulation Experiments |
| 9429 | M. Pradhan and A. van Soest | Household Labour Supply in Urban Areas of a Developing Country |
| 9430 | P.J.J. Herings | Endogenously Determined Price Rigidities |
| 9431 | H.A. Keuzenkamp and J.R. Magnus | On Tests and Significance in Econometrics |
| 9432 | C. Dang, D. Talman and Z. Wang | A Homotopy Approach to the Computation of Economic Equilibria on the Unit Simplex |
| 9433 | R. van den Brink | An Axiomatization of the Disjunctive Permission Value for Games with a Permission Structure |
| 9434 | C. Veld | Warrant Pricing: A Review of Empirical Research |
| 9435 | V. Feltkamp, S. Tijs and S. Muto | Bird's Tree Allocations Revisited |
| 9436 | G.-J. Otten, P. Borm, B. Peleg and S. Tijs | The MC-value for Monotonic NTU-Games |
| 9437 | S. Hurkens | Learning by Forgetful Players: From Primitive Formations to Persistent Retracts |
| 9438 | J.-J. Herings, D. Talman, and Z. Yang | The Computation of a Continuum of Constrained Equilibria |
| 9439 | E. Schaling and D. Smyth | The Effects of Inflation on Growth and Fluctuations in Dynamic Macroeconomic Models |
| 9440 | J. Arin and V. Feltkamp | The Nucleolus and Kernel of Veto-rich Transferable Utility Games |
| 9441 | P.-J. Jost | On the Role of Commitment in a Class of Signalling Problems |
| 9442 | J. Bendor, D. Mookherjee, and D. Ray | Aspirations, Adaptive Learning and Cooperation in Repeated Games |
| 9443 | G. van der Laan, D. Talman and Z. Yang | Modelling Cooperative Games in Permutational Structure |
| 9444 | G.J. Almekinders and S.C.W. Eijffinger | Accounting for Daily Bundesbank and Federal Reserve Intervention: A Friction Model with a GARCH Application |
| 9445 | A. De Waegenaere | Equilibria in Incomplete Financial Markets with Portfolio Constraints and Transaction Costs |

| No. | Author(s) | Title |
|---|---|---|
| 9446 | E. Schaling and D. Smyth | The Effects of Inflation on Growth and Fluctuations in Dynamic Macroeconomic Models |
| 9447 | G. Koop, J. Osiewalski and M.F.J. Steel | Hospital Efficiency Analysis Through Individual Effects: A Bayesian Approach |
| 9448 | H. Hamers, J. Suijs, S. Tijs and P. Borm | The Split Core for Sequencing Games |
| 9449 | G.-J. Otten, H. Peters, and O. Volij | Two Characterizations of the Uniform Rule for Division Problems with Single-Peaked Preferences |
| 9450 | A.L. Bovenberg and S.A. Smulders | Transitional Impacts of Environmental Policy in an Endogenous Growth Model |
| 9451 | F. Verboven | International Price Discrimination in the European Car Market: An Econometric Model of Oligopoly Behavior with Product Differentiation |
| 9452 | P.J.-J. Herings | A Globally and Universally Stable Price Adjustment Process |
| 9453 | D. Diamantaras, R.P. Gilles and S. Scotchmer | A Note on the Decentralization of Pareto Optima in Economies with Public Projects and Nonessential Private Goods |
| 9454 | F. de Jong, T. Nijman and A. Röell | Price Effects of Trading and Components of the Bid-ask Spread on the Paris Bourse |
| 9455 | F. Vella and M. Verbeek | Two-Step Estimation of Simultaneous Equation Panel Data Models with Censored Endogenous Variables |
| 9456 | H.A. Keuzenkamp and M. McAleer | Simplicity, Scientific Inference and Econometric Modelling |
| 9457 | K. Chatterjee and B. Dutta | Rubinstein Auctions: On Competition for Bargaining Partners |
| 9458 | A. van den Nouweland, B. Peleg and S. Tijs | Axiomatic Characterizations of the Walras Correspondence for Generalized Economies |
| 9459 | T. ten Raa and E.N. Wolff | Outsourcing of Services and Productivity Growth in Goods Industries |
| 9460 | G.J. Almekinders | A Positive Theory of Central Bank Intervention |
| 9461 | J.P. Choi | Standardization and Experimentation: Ex Ante Versus Ex Post Standardization |
| 9462 | J.P. Choi | Herd Behavior, the "Penguin Effect", and the Suppression of Informational Diffusion: An Analysis of Informational Externalities and Payoff Interdependency |
| 9463 | R.H. Gordon and A.L. Bovenberg | Why is Capital so Immobile Internationally?: Possible Explanations and Implications for Capital Income Taxation |

| No. | Author(s) | Title |
|---|---|---|
| 9464 | E. van Damme and S. Hurkens | Games with Imperfectly Observable Commitment |
| 9465 | W. Güth and E. van Damme | Information, Strategic Behavior and Fairness in Ultimatum Bargaining - An Experimental Study - |
| 9466 | S.C.W. Eijffinger and J.J.G. Lemmen | The Catching Up of European Money Markets: The Degree Versus the Speed of Integration |
| 9467 | W.B. van den Hout and J.P.C. Blanc | The Power-Series Algorithm for Markovian Queueing Networks |
| 9468 | H. Webers | The Location Model with Two Periods of Price Competition |
| 9469 | P.W.J. De Bijl | Delegation of Responsibility in Organizations |
| 9470 | T. van de Klundert and S. Smulders | North-South Knowledge Spillovers and Competition. Convergence Versus Divergence |
| 9471 | A. Mountford | Trade Dynamics and Endogenous Growth - An Overlapping Generations Model |
| 9472 | A. Mountford | Growth, History and International Capital Flows |
| 9473 | L. Meijdam and M. Verhoeven | Comparative Dynamics in Perfect-Foresight Models |
| 9474 | L. Meijdam and M. Verhoeven | Constraints in Perfect-Foresight Models: The Case of Old-Age Savings and Public Pension |
| 9475 | Z. Yang | A Simplicial Algorithm for Testing the Integral Property of a Polytope |
| 9476 | H. Hamers, P. Borm, R. van de Leensel and S. Tijs | The Chinese Postman and Delivery Games |
| 9477 | R.M.W.J. Beetsma | Servicing the Public Debt: Comment |
| 9478 | R.M.W.J. Beetsma | Inflation Versus Taxation: Representative Democracy and Party Nominations |
| 9479 | J.-J. Herings and D. Talman | Intersection Theorems with a Continuum of Intersection Points |
| 9480 | K. Aardal | Capacitated Facility Location: Separation Algorithms and Computational Experience |
| 9481 | G.W.P. Charlier | A Smoothed Maximum Score Estimator for the Binary Choice Panel Data Model with Individual Fixed Effects and Application to Labour Force Participation |
| 9482 | J. Bouckaert and H. Degryse | Phonebanking |

| No. | Author(s) | Title |
|---|---|---|
| 9483 | B. Allen, R. Deneckere, T. Faith and D. Kovenock | Capacity Precommitment as a Barrier to Entry: A Bertrand -Edgeworth Approach |
| 9484 | J.-J. Herings, G. van der Laan, D. Talman, and R. Venniker | Equilibrium Adjustment of Disequilibrium Prices |
| 9485 | V. Bhaskar | Informational Constraints and the Overlapping Generations Model: Folk and Anti-Folk Theorems |
| 9486 | K. Aardal, M. Labbé, J. Leung, and M. Queyranne | On the Two-level Uncapacitated Facility Location Problem |
| 9487 | W.B. van den Hout and J.P.C. Blanc | The Power-Series Algorithm for a Wide Class of Markov Processes |
| 9488 | F.C. Drost, C.A.J. Klaassen and B.J.M. Werker | Adaptive Estimation in Time-Series Models |
| 9489 | Z. Yang | A Simplicial Algorithm for Testing the Integral Property of Polytopes: A Revision |
| 9490 | H. Huizinga | Real Exchange Rate Misalignment and Redistribution |
| 9491 | A. Blume, D.V. DeJong, Y.-G. Kim, and G.B. Sprinkle | Evolution of the Meaning of Messages in Sender-Receiver Games: An Experiment |
| 9492 | R.-A. Dana, C. Le Van, and F. Magnien | General Equilibrium in Asset Markets with or without Short-Selling |
| 9493 | S. Eijffinger, M. van Rooij, and E. Schaling | Central Bank Independence: A Paneldata Approach |