STUDIES ON INSTITUTIONS AND CENTRAL BANK INDEPENDENCE

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Finis coronat opus says the Latin sententia displayed at many graduation ceremonies around the world. Although we celebrate the final outcome, one should never forget that who we are is, to a large extent, the result of people we meet and work with.

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I dedicate this dissertation in memoriam to my grandfather Jan Łosinski, PhD in Biology, and to my Family. With Love.

Turku, December 2011
Aleksandra Masłowska

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Summary

The failure of institutions designed to safeguard price stability, the Bretton Woods system and the European Monetary System (EMS), was an impetus for scientists and countries to search for an alternative design of central banks and monetary policy. Encouraged by the positive example of the German Bundesbank and a history of low inflation in this country, economists and political scientists concentrated their work on solving credibility and flexibility problems, suggesting an increase in the central bank's autonomy, for example. Differences in institutional structures and policy design affect the incentives faced by central bankers in various countries. These are all likely to influence the macroeconomic outcomes. Specifically, the degree of central bank independence (CBI) from political influence seems to be, at least in developed economies, negatively correlated with average rates of inflation. This study focuses on the phenomenon of the 1990s–the worldwide spread of central bank autonomy and its effect on economies. The approach taken here is different from the standard analysis found in the literature To our knowledge, there is no other comprehensive study like ours that describes the CBI measurement problem in such detail.

For the past 30 years, researchers have analyzed if CBI really matters. Recent monetary policy decisions by two major central banks in the world, the Federal Reserve System and the European Central Bank indicate that this question still initiates discussion. This debate is about deciding what is the right institutional design of central banks. Several studies points toward the choice of an independent central bank. Subsequent research questions the optimal definition of CBI and how to quantify its effect on the economy.

The first chapter addresses these questions. We reveal what are the literature's findings on the importance of different institutional designs of central banks, in particular the importance of its autonomy. An example of two strong central banks, the Federal Reserve System and the Bundesbank clarifies that two banks can be considered highly independent, and yet differ significantly in the way autonomy is

represented. This brief illustration indicates that definitions of CBI are not unified. Before explaining how CBI is categorized, we familiarize the reader with the types of choices a monetary policy maker has. The central banker faces a social welfare function, which describes her policy objectives. At the same time, however, the central banker faces incentives to deviate from these objectives, and the time-inconsistency problem arises. Policymakers usually inflate to obtain short-terms goals, which carries the cost of lost credibility. One solutions to time-inconsistency and to a threat of higher uncertainty coupled with lost credibility, is delegating responsibilities to an independent and conservative central bank.

The more central banks decide to implement the solution of autonomy, the more questions arise about its potential benefits for the economy. To be able to answer these questions means to be certain about what the independence of central banks really is. Does the current state of literature in this area clarify a definition of CBI? Are we able to determine the degree of independence of banks around the world and rank them according to their legal autonomy? We search for answers to these questions in chapter 2. The quantity of CBI definitions is truly overwhelming. A few exist that define central bank autonomy in general terms of few characteristics, others compose a definition of CBI with more than fifteen attributes, specifying a relationship between a central bank and its government. The level of economic development matters for the CBI definition as well. This is why many studies attempt to compose a CBI definition taking under consideration country-specific peculiarities. The reader will find numerous CBI definitions in this chapter. The growing number of CBI measures provokes accusations of their imprecision, subjective researchers' opinions affecting final degrees of independence and coincidental sets of attributes distorting the general idea of central bank autonomy. In Chapter 2, we also focus on the above problems and perform simple comparison among CBI measures.

Chapter 3 consists of an exhaustive empirical analysis of CBI measurement. Having time-series cross-section data, instead of only cross-sectional structure, and updated CBI values for the 1990s and 2000s we ask whether CBI measures were able to explain changes in inflation. The selection of seventeen original measures of CB autonomy gives a unique opportunity to compare if all of them have the same explanatory power. Can we use these CBI definition interchangeably? The outcome is as expected: We find a statistically significant negative relationship between levels of inflation rate and degree of CBI. However, this outcome depends on the definition of the CBI we use and methods of estimations.

The diversity of CBI measures and uncertainty about what is the right definition of central bank autonomy to be used in empirical analysis initiates the need for another type of study of the relationship between the degree of CBI and the economic situation. What if we abandon the traditional analysis that assumes applying proxies of CBI, and instead choose a policy rule to detect if CBI really matters? We decide to proceed with this idea by estimating the Taylor rule for two European countries, Sweden and the United Kingdom, and we choose the United States for our robustness test. The central banks of both European countries have modified their legal statuses, and so have significantly increased degrees of autonomy. We positively answer the question that CBI really does matter by comparing estimated coefficients of the Taylor rule for two sub-periods before and after the institutional change.

Chapter 1

Theoretical Introduction to Institutions of Central Banks

1.1 Modern Design of Central Banks

The failure of institutions designed to safeguard price stability, the Bretton Woods system and the European Monetary System (EMS), was an impetus for scientists and countries to search for an alternative design of central banks and monetary policy. Encouraged by the positive example of the German Bundesbank and a history of low inflation in this country, economists and political scientists concentrated their work on solving credibility and flexibility problems, suggesting for example an increase in the central bank's autonomy. Cukierman (1995) lists a few more reasons why a number of countries have increased the independence of their central banks since 1989. First, the Treaty on European Union requires a country to have an independent central bank in order to become a member of the European Monetary Union (EMU). Second, a history of high and persistent inflation encouraged Latin American countries to look for new institutional arrangements. Inspired by these events, analysing the impact of increased level of central bank autonomy has become the centre of interest for many.

Apart from a bright example of the Bundesbank, one should also notice the general monetary situation in the world in the 20th century. Neither a gold standard, nor the Bretton Woods system guarantied a fully autonomous monetary policy for countries. Autonomy in an economic policy means the possibility of choosing your own economic goals, fulfilling these goals with independently chosen instruments and within the environment free from any pressure towards economic institutions

in pursuing both actions. Under both[1] monetary regimes full monetary policy independence did not exist.

The history of the Federal Reserve System in the United States (the Fed) recalls when monetary administration claimed its right to an autonomous monetary policy. The Fed started to be more autonomous in the early days under the control of the Treasury Department. This trend continued under the strong philosophy of the president of the New York Reserve Bank, Benjamin Strong, who initiated the Reserve Banks to start their coordination of open-market transactions and the formation of the predecessor to the Federal Open Market Committee (the FOMC). Finally, the Fed was managing the U.S. economy (Bremner 2004, 83).

Several milestones can be distinguished in the split of political power from monetary power. The first example goes back to the U.S. policy under President Truman's administration and to the beginning of the tenure of William McChesney Martin, one of the longest serving chairman of the Fed. With the signing of the Treasury-Federal Reserve Accord in May 1951, the Treasury agreed that the Federal Reserve would no longer be committed to supporting the price of U.S. government securities (Brimmer 1998). This accord and the strong Fed leadership by Martin marked the future stance of the Fed towards the U.S. economy and the relation in the Fed-Congress-President tripartite. The Fed itself explained its independent position saying "The independence of the Federal Reserve does not mean independence from the government, but independence within the government" (Bremner 2004, 90).

Many other situations, however indicate that the Federal Reserve has never really been an independent institution, and it has never taken sole responsibility for the U.S. monetary policy or has it been accountable for it. Perhaps due to the political system in the United States, historical transformations of a country or a long aversion to centralising monetary power, the strong political influence remained within the monetary "temple". An activist economic policy of the 1970s, an experiment that led to high inflation, had many supporters among political circles, as well as within the Fed, including the chairman Arthur Burns. Hetzel (1998, 22) draws a political and economic picture of these years describing the role that was played by Burns: "Burns was a part of a political, intellectual, and popular environment that expected the government to control the economy". Despite setting the natural rate of unemployment at 4% level, facing the 6% level Burns believed that "the country needed a combination of policies that would simultaneously restore

[1] Gold standard and the Bretton Woods system

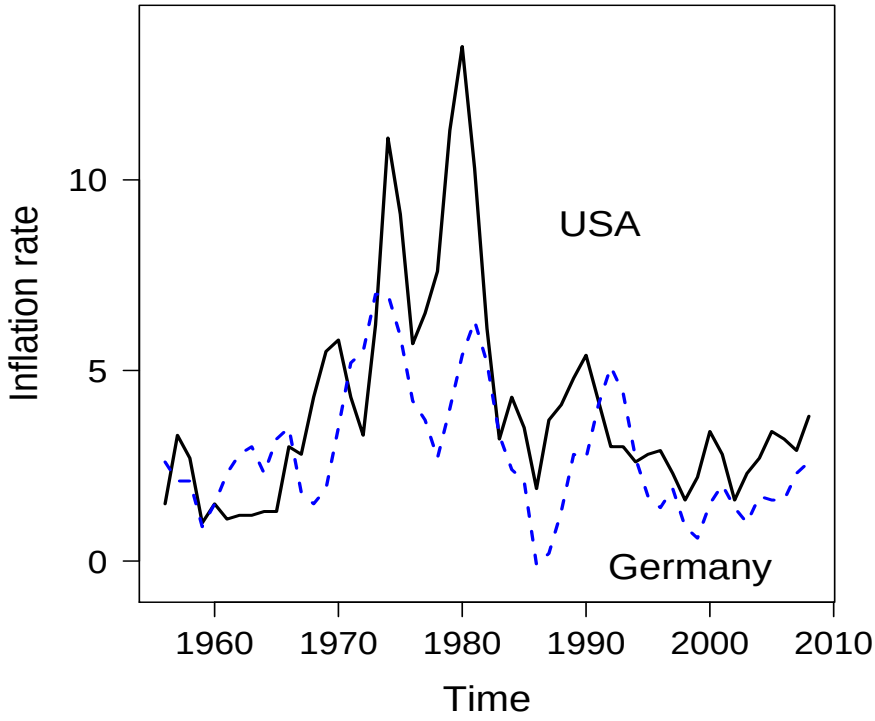

Figure 1.1: USA-Germany inflation rate
Notes: Annual Inflation Rate corresponds to the annual percentage change in the consumer price index reported in the OECD.Stat.org

price stability and full employment".

The case of the Bundesbank shows that a central bank can become an institution, which makes its decisions autonomously, if it earns to do so by gaining credibility and reputation. Even though the Bundesbank was legally dependent on the Allied Banking Commission between 1948 and 1951, as Berger (1997) explains, the bank had relatively large autonomy in its decisions. Its unification with the German legal system, however, threatened the bank losing this "actual autonomy". In order to prevent this the monetary authorities engaged themselves in promoting its anti-inflationary policy and forming a reputation for being conservative and independent. Figure 1.1 presents the history of the inflation rate in the U.S. and Germany. Should we describe more of the bank-government relations, the priori-

ties of economic policies in these countries and a few major economic indicators, we would see why the time-series of inflation in Germany has smaller fluctuation extremes, and why the U.S. suffered a relatively high level of inflation from the 1970s to the mid 1980s.

Though the idea of central bank independence has grown in importance since the end of the 1980s, most authors provide no clear definition of this phenomenon. Beginnings of the debate can be found already in the works of Keynes (1932), who defined CBI by stressing the elimination of any direct control that could come from a parliament and result in interference of the banking policy. He favoured the solution of a monetary policy which aimed primarily at stability of value in terms of wholesale prices rather than in terms of an international standard such as gold. He was also strongly against the idea presented by the Labour Party in 1932, in which the party suggested the nationalization of the Bank of England, as well as giving to the Government the right of choosing the governor of the central bank (Keynes [1932] 1982, 130). According to Friedman, however, "Money is too important to be left to the central bankers" (Friedman [1962] in Leube1987, 429), hence he politically rejected the concentration of vast powers in an institution free from any kind of direct and effective political control. Friedman's definition of central bank independence refers to a relation between the central bank and the government that is comparable to the relation between the judiciary and the government. Judiciary's rule is dependent on the legislature, and hence the change of law can also change the judiciary's actions.

It is common, nowadays, to define CBI according to the definition prepared by Cukierman, Webb and Neyapti (1992). It includes the largest group of CBI determinants and relates central bank autonomy to three areas. First, personnel independence describes ways of the appointment of a bank's governor, the bank's board, and a monetary policy committee. Second, financial independence refers to the government's ability to finance its expenditure with the use of direct or indirect central bank credits. Policy independence, finally, covers the area connected to a bank's choice of conducting its monetary policy. This type of independence has been additionally distinguished with respect to goals (the bank can freely choose its final goals) and instruments (the bank freely choose instruments to reach the goal) of the central bank (Debelle and Fischer 1995).

Determinants of central bank independence, as well as other institutions that help to achieve price stability, originate from general political, economic and cultural conditions. The following paragraphs present a few of those that are found

important while discussing the idea of CBI. First, a central bank creates its own social welfare function based on its legal mandate, its own public preferences, so-called "median-voter" preferences, for, for example, based on the contract made with the principal. Additionally, a bank considers various kinds of uncertainty, in which it is going to operate, i.e. economic conditions, its monetary policy model, or the way it measures major economic indicators. Another key component in the discussion of central bank independence is the idea of time-inconsistency; a central bank's temptation to deviate from the promise and consequences it brings.

Defining a central bank's objective function depends on the bank's as well as the public's preferences relating to their objectives. The bank may wish to place more stress on price stability, or choose economic growth as its major target. According to literature on monetary policy games, one may find two competing interpretations to the objective function of monetary policymakers (Cukierman 1992, 43). One part of the literature regards this function as a social welfare function, with the central bank that behaves as a benevolent social planner (Kydland and Prescott 1977; Barro and Gordon 1983; Backus and Driffill 1985). The rationale for such an approach rests on the notion that due to distortionary taxes or union power, or both, employment is lower than its socially optimal level and on the social costs of inflation (Cukierman 1992, 43). Inflation has a negative effect on social welfare, which results from the loss of consumer surplus that inflation produces through the decrease in the public's real money balances. The competitive view of the central bank regards the bank as a mediator between different interest groups that try to push monetary policy in various, not necessarily consistent, directions. Hence, the bank's objective function reflects a distributionally motivated political compromise reached through the central bank between supporters of employment stimulation and those of price stability (Cukierman and Meltzer 1986, Havrilesky 1987, Willet 1988). Since political authorities rarely give any explicit instructions to their central banks, Blinder (1999, 6) explains, monetary authorities have to create their own social welfare function based on their legal mandate and value judgments. The advantage of this approach is that there is more than one possible type of central banker, and the public does not know what is the type is currently in the office (Cukierman 1992, 45).

1.1.1 Social Welfare and Central Bank's Objective Functions

The social welfare approach seems best suited to describe how a central bank should behave while all individuals in the economy are identical (Cukierman 1992,

43). A truly complete description of the policymaker's problem, as Cecchetti (1997) explains, starts with an intertemporal general equilibrium model based on social welfare function, production functions and market imperfections that cause nominal shocks. These three elements relate to public tastes, available technology and nominal rigidities present in the market and lead to welfare maximization.

Following this approach, one may assume that the central bank seeks to minimize the expected value (E_t) of the objective function (Wickens 2008, 371- 374):

$$E_t \sum_{i=0}^{\infty} \beta^i [(\pi_{t+i} - \pi^*)^2 + \alpha(y_t - y_t^*)^2], \tag{1.1}$$

that depends on the target level of inflation (π^*), future values of inflation (π_{t+i}), as well as of output (y_t) and its target level (y_t^*). Additionally, β is the discount factor and α is the weight attached to the output objective relative to that for the inflation objective. The aim of the policymaker is to minimize the present value of deviations of inflation and output from their target levels.

Suppose that the social welfare function for the representative household in period t is

$$U_t = lnc_t - \gamma lny_t(z), \tag{1.2}$$

where c_t is the index of total household consumption and $y_t(z)$ is production, and ln represent natural logarithms of these variables. The index of total household consumption is given by the constant elasticity of substitution (CES) function

$$c_t = \left[\int_0^1 c_t(z)^{(\sigma-1)/\sigma} \right]^{\sigma/(\sigma-1)} \quad \sigma > 1, \tag{1.3}$$

where the last term reflects utility from leisure inversely related to the work required to produce $y_t(z)$, and the parameter $\sigma > 1$ denotes elasticity of substitution. The higher value of σ implies greater substitutability. Consumption and work, or in other example goods and services, are imperfect substitutes if σ is finite. The P_t, the general price index, is given by

$$P_t = \left[\int_0^1 p_t(z)^{1-\sigma} \right]^{1/(1-\sigma)}. \tag{1.4}$$

The budget constraint for the representative household is given by

$$P_t c_t = p_t(z) y_t(z) \tag{1.5}$$

Given the CES consumption index and the utility function, the domestic household demand for good z is defined by

$$c_t(z) = \left[\frac{p_t(z)}{P_t} \right]^{-\sigma} c_t. \tag{1.6}$$

With the social welfare function and following assumptions, it is possible to represent the central bank's objective function, given in (1.1), as an approximation to the intertemporal utility function defined by equation (1.2).

In the model, market clearing in the goods market requires that consumption equals production thus $c_t(z) = y_t(z)$ and $c_t = y_t$ thus we can rewrite equation (1.6) as

$$y_t(z) = \left[\frac{p_t(z)}{P_t}\right]^{-\sigma} y_t. \tag{1.7}$$

One element of a central bank's objective function, the variance of total output about the steady state, can be derived by using second-order approximation to the utility function taken about the steady-state values of c_t and $y_t(z)$, denoted by c_t^* and $y_t^*(z)$.

A second-order approximation of utility is derived around a steady state allocation. Frequent use is made of the following second-order approximation of relative deviations in terms of log deviations (after Galí 2008, 86)

$$\frac{Z_t - Z}{Z} \simeq \hat{z}_t + \frac{1}{2}\hat{z}_t^2, \tag{1.8}$$

where $\hat{z}_t \equiv z_t - z$ is the log deviation from the steady state for a generic variable z_t. Next, consider a second-order approximation to the utility function (1.2) taken about the steady-state values of c_t and $y_t(z)$, which can be denoted as c_t^* and $y_t^*(z)$ (Wickens 2008, 373).

$$\begin{aligned} E_t U_t \simeq lnc_t^* - \gamma lny_t^*(z) - \frac{1}{2}E_t\left[\frac{c_t - c_t^*}{c_t^*}\right]^2 - \frac{1}{2}\gamma E_t\left[\frac{y_t(z) - y_t^*(z)}{y_t^*(z)}\right]^2 \\ = U_t^* - \frac{1}{2}V_t(lnc_t) - \frac{1}{2}\gamma V_t[lny_t(z)] \\ = U_t^* - \frac{1}{2}V_t(lny_t) - \frac{1}{2}\gamma V_t[lny_t(z)], \end{aligned}$$

where $V_t(lny_t)$ can be interpreted as the variance of total output about the steady state $V_t(lny_t) \simeq E_t(y_t - y_t^*)^2$, and $V_t[lny_t(z)]$ can be defined as the variance of output across households/firms from steady state. Hence, the dispersion of output across firms is assumed to cause a real welfare loss.

An important feature of the price adjustment mechanism is the assumption that the general price level is made up of the prices of many individual items, and that the prices of these components adjust at different speeds (Wickens 2008, 217). Calvo (1983) assumed that firms adjust their prices infrequently and that opportunities to adjust appear randomly. Moreover, at each period, there is a constant probability ρ that the firm can adjust its price and $(1-\rho)$ is the probability that the

price remains the same; because these adjustment possibilities occur randomly, the interval between price changes for an individual firm is a random variable. When allowed to change the price, the firms choose a price to minimize a discounted sum of the squared deviations of the actual price and the flex price.

Suppose a representative firm sets its price to minimize a quadratic loss function that depends on the difference between the firm's actual price in period t and its optimal price, p_t^*. Thus the aim is to choose p_t to minimize

$$\frac{1}{2}\sum_{s=0}^{\infty}\beta(1-\rho)E_t(p_t-p_{t+s}^*)^2 \tag{1.9}$$

The first order condition for the optimal choice of p_t requires that

$$\sum_{s=0}^{\infty}\beta(1-\rho)E_t(p_t-p_{t+s}^*)=0$$

which, after rearrangement, letting x_t denote the optimal price set at t and introducing a new notation $\gamma=\beta(1-\rho)$, leaves us with the new price

$$x_t=(1-\gamma)\sum_{s=0}^{\infty}\gamma E_t p_{t+s}^*.$$

With a large number of firms, a fraction ρ will actually adjust their price each period, and the aggregate price level can be expressed as

$$p_t=\rho x_t+(1-\rho)p_{t-1}. \tag{1.10}$$

The above equation, along with the one describing inflation in the model, that is $\pi_t=\rho(1-\gamma)(p_t^*-p_{t-1})+\gamma E_t\pi_{t+1}$ describe the evolution of the optimal price set and an aggregate price level. They describe that at time t the actual change in the price is related to the desired change in the price and to the expected future change in the price (Wickens 2008, 221). Walsh (2003, 227) comments that one attractive aspect of the Calvo model is that it shows how the output movements have a smaller impact on current inflation, holding the expected future inflation constant. The current demand condition becomes less important when the opportunities to adjust prices occur less often.

In terms of the previous social welfare analysis, the Calvo aggregate price level can be written as a weighted average of $lnP_t=\rho lnX_t+(1-\rho)lnp_{t-1}(z)$. Consequently, the second element of central bank's loss function can be derived based on the social welfare function, which takes the following form in the final stage

$$\begin{aligned}E_tU_t &\simeq U_t^*-\frac{1}{2}V_t(lny_t)-\frac{1}{2}\gamma\left(\frac{\sigma\rho\delta}{1-\delta}\right)^2[E_t\pi_{t+1}(z)-\pi]^2\\ &\simeq U_t^*-\frac{1}{2}E_t(y_t-y_t^*)^2-\frac{1}{2}\alpha[E_t\pi_{t+1}-\pi]^2\end{aligned}$$

Thus, a central bank's commonly accepted quadratic objective function, as presented above, can be regarded as an approximation to the intertemporal utility function based on a utility function.

The political approach to central bank behaviour suggests there may be more than one possible type of central banker, and hence more than one possible social welfare functions that characterise the economy (Cukierman 1992, 45). Moreover, the political approach emphasises alternative objectives of central banks, as well as facts that the public may not be fully informed about the current central bank's preferences about inflation and economic activity. The following paragraphs focus on such situations, when a policy-maker introduces new institutional mechanisms in order to achieve credibility and reputation.

1.1.2 Why do Government Inflate - the Time-Inconistency Problem

Governments normally inflates to achieve real objectives (Cukierman 1992, 17). For years, it has been important to analyse what incentives policy-makers face, when actually setting their policy instruments (Walsh 2003, 363). Following the seminal contribution of Kydland and Prescott (1977) and Barro and Gordon (1983) attention has been directed to problems of central bank credibility, incentives and ability to precommit to chosen policies and concentrated on a general idea of time (in)consistency.

The time-inconsistency problem describes one of those situations. Policymakers have incentives to announce low inflation policies, and then deviate from that promise in order to achieve short-term improvements in real economic outcomes. This inflationary bias creates the need for credible commitment mechanism, leading many countries to choose independent central banks. The justification of these actions is described below.

Defining Time Inconsistency

The simple definition explains that a policy is *time consistent* if an action planned at time t for time $t+i$ remains optimal to implement when time $t+i$ actually arrives. A policy is *time inconsistent* if at time $t+i$ it will not be optimal to respond as originally planned.

Suppose that a policymaker is responsible for choosing a policy starting at time t for several periods in the future and designs an optimal policy rule or a plan for future policy. In doing so, the policymaker maximizes some objective function subject to the requirement of private sector economic equilibrium. Based

on a similar example presented in Drazen (2000, 101-102) one may consider the policymaker's choice of inflation for time $t+i$, where we denote by $\pi_{t+i}(t+j)$ the policy chosen at time $t+j$ for $t+i$, $0 \leq j \leq i$. A forward-looking policymaker can wait until $t+i$ to choose the inflation rate for that date, or they can choose the $t+i$ inflation rate at time t. If there are no changes in their preferences or technology, nor any unanticipated shocks between the two considered periods, one would expect that the level of inflation rate chosen in these periods should be the same. Time inconsistency is said to arise when, though nothing has changed, these choices are not equal, that is if

$$\pi_{t+i}(t+i) \neq \pi_{t+i}(t). \tag{1.11}$$

The phenomenon of time-inconsistency becomes interesting when one realizes that it occurs in cases where the time-inconsistent policy is chosen to *maximize the welfare of those who are misled* (Drazen 2000, 102, italics in original). Furthermore, the fundamental characteristics of this phenomenon is that the policymaking environment has not changed, for example there is no exogenous shock, which would justify the change in optimal policy.

A policymaker faces different constraints ex post than they did ex ante and this makes them prefer a different policy: the original plan is said to be time-inconsistent (Persson et al. 1994, 3). However, a necessary condition is that the policy-maker faces the second-best solution: there would be no point in deviating from the ex ante optimal plan once the best solution has been achieved at time t. Finally, whether time inconsistency matters or not depends on the policymaking design. The policymaking framework could help the central bank to make a binding commitment at date t to pursue a particular policy at date $t+i$ and thus make time inconsistency irrelevant.

The time-inconsistency problem can also be presented in the frame of the prisoner's dilemma based on three key relationships (Cukierman 1992, 17- 18). First, one needs to assume that, in an economy, deviations of employment from its natural level are positively related to unanticipated inflation. Consequently the demand for labour is the binding constraint on employment, so any increase of inflation that was not anticipated at contracting time reduce the real wage rate and temporarily increase employment. Second, the relationship assumes that policymakers have an objective function that gives a positive weight to the stimulation of employment, that goes even beyond the natural rate and a negative weight to inflation. Finally, the public fully knowledgeable of the policymakers' objectives understands their mode of behaviour.

Employers and workers bargain over nominal wages at the beginning of each contracting period and set a nominal wage rate. In the absence of inflationary pressures the nominal wage rate will also be the actual real wage rate. The corresponding demand for labour determines natural employment. During each period the government decides on a rate of inflation through its monetary expansion rate in order to maximizes its objectives. The optimal rate of inflation is determined so as to minimize the combined costs of inflation and of low employment.

A zero rate of inflation could have been achieved if, prior to the signing a nominal contracts, government would have credibly committed itself to a zero inflation rate. If the commitment is credible, nominal contracts are settled with such an assumption and the actual inflation rate is in fact zero. The problem arises when government has the discretion to choose inflation after the contracts have been made. In such a case an excessively high positive inflation arises. However, the presence of precommitments eliminates this bias. This fact constitutes a basic argument in favour of fixed rules rather than discretion (Cukierman 1992, 18).

Maintaining Reputation in Monetary Policy

The policymaker is repeatedly involved in interactions with the private sector and other policymakers. These interactions link current and expected future policy; private agents are assumed to be able to form expectations about the future based on the current and past policy development. The policymaker faces a trade-off: continuing the ex post optimal policy today not only includes current benefits but also future costs. These future costs help the policymaker relax the incentive constraints and achieve credibility (Persson et al. 1994, 8).

The reputation in a monetary policy problem can be explained with the Barro and Gordon model (1983), where the policymaker has an explicit intertemporal objective: an attempt to minimize the present discounted value of a one-period loss function over the entire horizon. The analysis in this model can proceed along the same lines as in the literature on repeated games: whenever private agents observe inflation different from the one they expected, they anticipate the policymaker to act only in accordance with his short-run incentives for some time in the future. This creates a trade-off for the policymaker: he can get a current benefit by setting the current inflation rate above the expected value, which is balanced with the cost of higher expected, and actual inflation in the future.

The monetary policy instrument is denoted by z, and it could be the official interest rate, R, or the rate of growth of money supply, Δm. A simplifying assumption

is that the effect of a monetary instrument on the inflation rate is stochastic and can be captured with the stylized transmission mechanism

$$\pi = z + v, \tag{1.12}$$

where v is a shock not observable by the central bank and has a zero mean, $E(v) = 0$. Another simplifying assumption is that the transmission mechanism is instantaneous and involves no lags. At present, an additional assumption is of a discretionary type monetary policy rather than a rule. Thus, the rational expectations of inflation is

$$E\pi = \pi^e = z. \tag{1.13}$$

Barro and Gordon specify the central bank's objective function as

$$U = \lambda(y - y_n) - \frac{1}{2}(\pi - \pi^*)^2, \tag{1.14}$$

where π^* is the target rate of inflation. The implication of equation (1.14) is that the central bank prefers output (y) to be above its natural level (y_n) but dislikes inflation (π) deviating from target.

The central bank's problem is to choose z to maximize U subject to the constraints provided by the economy. One of the constraints is a supply function being a form of the stylized version of the Phillips equation

$$y = y_n + \alpha(\pi - \pi^e) + \varepsilon, \tag{1.15}$$

where y_n is equilibrium output, π^e is the economy's rational expectation of inflation, and ε is an output shock. The second constraint for a central bank's objective function is the stylized transmission mechanism, represented by equation (1.12). Substituting these two constraints, the objective function (1.14) takes the form of

$$\begin{aligned} U &= \lambda[\alpha(\pi - \pi^e) + \varepsilon] - \frac{1}{2}(\pi - \pi^*)^2 \\ &= \lambda[\alpha(z + v - \pi^e) + \varepsilon] - \frac{1}{2}(z + v - \pi^*)^2. \end{aligned}$$

The first order condition is

$$\frac{\partial U}{\partial z} = \alpha\lambda - (z + v - \pi^*) = 0,$$

and the solution for the policy instrument z is

$$z = \alpha\lambda + \pi^* - v.$$

The central bank does not know v and by using its best guess, namely that $E(v) = 0$ the optimal setting of z is

$$z = \alpha\lambda + \pi^*,$$

and this implies the actual inflation rate

$$\pi = \alpha\lambda + \pi^* + v$$

and so the public's rational expectation of inflation is

$$\pi^e = E\pi = \alpha\lambda + \pi^* > \pi^* \tag{1.16}$$

Equation (1.16) shows that the expected inflation is greater than its target level. This phenomenon is called *inflation bias*. The existence of inflation bias is dependent on the policymaker's preferences between output and inflation levels. Consequently, if $\lambda = 0$, which means that a central banker acts like a strict inflation targeter, inflation would be lower and the inflation bias would be zero. Using a quadratic loss function would lead to a similar solution that an inflation bias appears whenever $1 > \lambda > 0$. Furthermore, welfare costs are minimized by setting $\lambda = 0$. Thus, a central bank following a policy of discretion may be as well a strict inflation targeter as there is no advantage to having $\lambda > 0$ and this solution is not affected by the choice of the objective function (Wickens 2008, 374-78)[2].

On Reputation and Credibility

Credibility problems in macroeconomics arise from situations described above, that is from two-period games between a policy-maker and the public, from the timing of occurrence of the first and second best solutions for the policy-maker, and from policy-maker's incentives and constraints, which are a public knowledge.

When a perfect information is available to everyone and no commitments to policy are present, a policy announced today for some point of time in the future can be either credible or non-credible at all. It gains credibility if it is dynamically consistent and not credible otherwise. The full information available to the public makes it possible to calculate in advance the dynamically consistent policies.

The absence of perfect information makes the public diverge between what the public believes the rate of monetary expansion will be and the one planned by the

[2]In his description of central banking in theory and practice, Blinder (1998) argues that the description of policymaking in the Barro-Gordon model bears little resemblance to the process of conducting monetary policy in the United States and many other countries.

monetary authorities. The absolute value of this divergence becomes the measure of policy-maker credibility. Cukierman (1992, 206) points out how measures of credibility in the presence and in the absence of asymmetric information differ between each other. In the presence of asymmetry information, credibility is no longer full or nonexistent. In this environment it becomes a measure that is inversely related to the absolute value of the divergence between the policy-maker's plans and public beliefs.

Credibility can be gained by choosing and following a rule or delegating the policy to a chosen agent with a specified by the "median voter theorem" preferences. In the absence of commitment, however, a policy to be credible must simultaneously fulfil two conditions (Persson et al. 2002, 402): the policy is ex post optimal and expectations are optimal. In game-theoretic terms, those conditions are required for the Nash equilibrium in a game with many atomistic private wage setters moving before the policy-maker. Moreover, in a game-theoretic setting, credibility is identified with either dynamic consistency or incentive compatibility (Blinder 1999, 64).

One should notice that a desirable policy rule does not become credible just by being announced; on the other hand, why would a policy-maker recommend a non-credible policy rule. Simply speaking, credibility could be identified as a situation when the public believes what the policy-maker announces to do. A central bank will earn credibility with its consistency between actions and announcements.

Concerns about credibility usually appear during periods of sustained changes in the objectives of the central bank (Cukierman 1992, 191). How soon the public recognizes these sustained changes depends on certain determinants. The process of learning leads to a higher degree of reputation. One can name a disinflationary policy as an example of a public's learning process and an action leading to higher reputation for the policy-maker. Once a policy is announced and inflation rate is maintained at a lower level for a sufficient length of time, the public formulates its expectations and finds a central bank's policy credible. Volcker's disinflation in the United States or the disinflation process in certain transition economies in the 1990s are examples of this general regularity.

Finally, one should keep in mind that, according to Drazen (2000, 166), credibility of the policy-maker and the credibility of the policy itself should not be viewed as synonymous. Credibility of the policy means that having certain institutional constraints, policy is credible, independent of whom the current policy-maker is. Moreover, policy is credible when it is *expected* to be carried out.

Gaining Credibility in Uncertainty

Gaining credibility and reputation could be relatively straightforward for policy-makers in the presence of full certainty. These conditions are not, however, available to central banks. Due to uncertainty's pervasive nature, Greenspan (2003) calls it an important feature of the monetary policy that in fact is the defining characteristic of this landscape. Walsh (2000) adds that uncertainty, due to its constant presence, has an impact on promoting economic stability and low inflation.

How does uncertainty affect monetary policy is dependent on the particular form of uncertainty. The literature specifies uncertainty about current economic conditions with unobservable supply and demand shocks; uncertainty about the parameters of the model, where the slope of the aggregate supply function cannot be measured accurately and uncertainty about the model itself (Cecchetti 2000). Practitioners add to this list uncertainty about how the policy instruments affect inflation and economic activity - the monetary transmission mechanism. Three other specific sources of uncertainty are mentioned in the literature and among central bankers – data uncertainty in measuring the output gap, uncertainty about the persistence of inflation shock, and uncertainty about the inflation process itself.

Uncertainty about economic conditions - the data - describes a situation when a policy maker needs to filter from observable data the level of latent variables, i.e. output gap, equilibrium real interest rates, or various measures of excess liquidity, and to identify and interpret the nature of the shocks driving observed economic developments (Issing 2003). A good example is the concept of the natural rate of unemployment - the level that is associated with a balance between supply and demand in labour markets with steady inflation.

Data limitations about economic conditions relates to, for example, imperfect measurement and data lags. These limitations led to the focus on real-time data, another source of imperfect information. One solution to data uncertainties would be the alteration of the set of variables the policy maker reacts to.

The situation when the model's parameters are uncertain allows error terms to be entered multiplicatively (Walsh 2003, 534). This *parameter* or *multiplicative uncertainty* is defined as imperfect knowledge of the parameters, which characterise elasticities and functional dependencies within any particular model (Issing 2003). It has been analyzed by Brainard (1967), who showed that the presence of uncertainty which impact policy instruments have on the economy forces a central bank to respond more cautiously than it would be in the absence of uncertainty.

Brainard's uncertainty reduces the reaction to any shock. Cecchetti (2000, 25)

explained: “The bigger the uncertainty about the reaction of output to an interest-rate change, the less sensitive the policy will be to a given size shock”. Thus, uncertainty makes a central banker being conservative, and gives rationale for a prudent, gradualist approach to monetary policy-making. Blinder (1998) has argued that Brainard’s result goes along with what Blinder felt was a reasonable approach to policy - the Fed (or a central bank in general) should calculate the best change in the federal fund target as if one faced no uncertainty, and then change the funds rate a little less.

The cautiousness about interest rate adjustments is generally referred to as “interest rate smoothing” (Clarida et al. 1999). It can be captured with a monetary policy rule:

$$i_t = (1-\rho)[\alpha+\beta\pi_t+\gamma x_t]+\rho i_{t-1}+\varepsilon_t \tag{1.17}$$

where α is a constant interpretable as the steady state nominal interest rate, and a parameter $\rho\in[0, 1]$ reflects the degree of lagged dependence in interest rate, i_t is the interest rate, π_t and x_t represents deviations of inflation from its target level and output gap respectively, while ε_t is the error term. The reasoning behind choosing this cautionary smoothing lays, for example, in the fact that certainty equivalence models may not properly capture the constraints that policy-makers face in practice. Another explanation for policy cautiousness includes the fear of disrupting financial markets

Monetary theorists speak about another type of uncertainty, model uncertainty, when assumptions do not hold that the model of the economy is linear, shocks are additive and the policy-maker preferences are quadratic, and certainty equivalence relies on perfect knowledge about the true model of the economy. The problem of model uncertainty, as Cecchetti (2000) says, is “quite serious”. However, with some formal literature on this problem, Blinder (1999, 12) explains that “it is safe to say that central bankers neither know nor care much about this literature”. Blinder’s solution is to use a wide variety of models and never trust any of them too much, though. McCallum’s (1999) remedy is to model a policy rule, which would be robust to the possibility that numerous models are correct. Finally, Levin and Williams (2003) warn from drawing conclusions on monetary policy based on a single model. They show that policies, which may be optimal in one model may perform poorly in another one.

Every model, remains a simplified representation of the world no matter how detailed or how well designed conceptually and empirically it is. Consequently, as Greenspan (2003) explains, “even with large advances in computational capabili-

ties and greater comprehension of economic linkages, our knowledge base is barely able to keep pace with the ever-increasing complexity of our global economy".

The analysis of agents' behaviour caused by central banker's policy decisions and announcements does not lead only from the central bank towards economic agents. There is not only uncertainty about the economy or the impact on the economy of policy actions but also policy decisions themselves may affect economic uncertainty. Economic agents may also be unsure about the true motivations of monetary authorities, as well as other economic agents.

When public expectations about inflation remain above the inflation rates announced by central banks, it makes it more difficult to reduce the real inflation. Uncertainty about policy-makers' commitment to the inflation target leads the public to continue to expect inflation, and to raise the unemployment costs of bringing inflation rates down. The solution to endogenous expectations of uncertainty lays in the degree of a central bank's credibility, which in turn, can be obtained introducing institutional arrangements like independence or/and monetary policy announcements.

Nowadays, central banks generally stabilize a combination of inflation, output and interest rates. However, one should notice the special care placed by central banks on the inflation rate. The primary objective of many monetary authorities is to stabilize prices. The reasons for such interest laid in costs of inflation, have been defined by e.g. Cecchetti (2000) as (1) the tax on the money that the public holds; (2) the cost related to the tax system, which not properly indexed, may lead to welfare losses associated with inflation; (3) inflation-created noise in the price system; (4) high levels of inflation forcing people to find ways to reduce its costs; (5) finally, there is the empirical fact that high inflation is uncertain inflation leading to raised uncertainty in general economy.

The last problem of the high variability of inflation and uncertainty unites central bankers who agree that inflation leads to significant losses. Money holdings yield direct utility and higher inflation reduces real money balances, hence inflation generates a welfare loss (Walsh 2003, 59). This raises a question: how large is the welfare cost of inflation[3]? This problem has been quantified from the perspective of the money demand curve (showing money demand as a function of the nominal rate of interest) starting with Bailey (1956). Lucas (1994) proposes to estimate the welfare costs of inflation using the instantaneous utility function and by calculating the percentage increase in steady-state consumption necessary to make

[3]Gillman (1995) provides a survey of different estimates of the welfare cost of inflation.

the household indifferent between a nominal interest rate and a nominal rate of 0 (Walsh 2003, 62).

Uncertainty about inflation has (at least) two types of economic effect, so-called *ex ante* and *ex post*, explains Golob (1994). First, it leads to uncertainty among business and consumers, who make economic decisions that may differ from the ones made in the full certainty situation. It takes place with the use of channels, through which uncertainty about inflation spreads among the public. For example, inflation uncertainty affects financial markets by raising long-term interest rates; it may encourage businesses to spend resources avoiding the associated risks, and it may also reduce economic activity.

The *ex post effect* of inflation uncertainty deals with the situation after the decisions have been made. This occurs when inflation differs from what had been expected. Unexpected inflation leads to a transfer of wealth, which, if large enough, can affect the whole economy. A problem with balancing savings and loans provides an example of an inflation-induced wealth transfer.

Measuring inflation becomes another problem in the literature and real economics. Which price index would be the most appropriate? The most simple and perhaps the easiest to understand for the public, the Consumer Price Index (CPI), is interpreted as a cost-of-living index for the average consumer. Its advantage lays in easyly understandable, frequent publications by many statistical offices and relatively rare revisions. However, as Svensson (2000) explains, CPI carries elements of interest-related costs, which central banks prefer to avoid. Thus, central banks eliminate components over which monetary policy has little or no influence and introduce inflation measures defined, for example, as the CPI less interest-rate costs (CPIX in New Zealand, RPIX in Great Britain). The Eurosystem, on the other hand, has defined price stability in terms of the Harmonized Index of Consumer Prices, HICP, which also excludes interest costs.

Imperfect knowledge about inflation, policy makers' changing beliefs about the natural rate hypothesis, and so-called "adaptive monetary policy" are the reasons which could explain why the level of inflation remained high in United States for many decades after World War II[4]. Moreover, some economists (Golob 1994) believe inflation uncertainty had a great impact on keeping the long-term interest rates high in the 1980s and 1990s.

[4]Other reasons mentioned in the literature are, for example: the motives of behaviour of Arthur Burns; expectations trap; slow process of the Fed adaptations to productivity slowdown and the rise in the natural rate of unemployment.

1.1.3 Solutions to Time-Inconsistency Problem

If a potential time-consistency problem occurs in an environment with no uncertainty, or in one where all contingencies can be fully specified ex ante, committing the policymaker to a sequence of action may be optimal. In the real world, however, such *inflexibility* is inconvenient due to unforeseen and unforecastable events that may occur (Drazen 2000, 126).

Studies on time consistency presented by Barro and Gordon (1983) have become an influential contribution in this area and have been followed by large literature that aim to examine alternative solutions to the inflationary bias under discretion. These solutions concentrate on how the policymaking environment can make policy credible, that is, how institutions or the creation of external circumstances can lead to the expectation that announced policies will be carried out, and thus credible. One class of solutions, represented by Barro and Gordon (1983), incorporates notions of reputation into a repeated-game framework. By following its desire to inflate today, the central bank worsens its situation tomorrow and consequently the loss of reputation raises the marginal cost of inflation.

The second class of solutions considers the case when the central bank has preferences that differ from those of society at large so that the marginal cost of inflation as perceived by the central banker is higher (see e.g. Rogoff 1985). One option is to choose the central banker who places a greater importance on achieving low inflation and then gives that individual the independence to conduct a monetary policy. Finally, the third class of solutions suggests imposing constraints on the central bank's flexibility, for example by specifying a targeting rule that requires the central bank to achieve a present rate of inflation or imposes some cost-related to deviations from this target (on central bank targeting, especially inflation targeting see Svensson 1999 a and b).

Law, Constitution and Social Contracts

In considering institutions that enhance the credibility of a monetary policy and policy in general, one should mention their legal constraints which try to "bind" the policymaker. It can be embodied in a country's basic laws, like constitution, and institutions specific law, like act of the central bank. There are important differences between promises which have no legal backing and laws in analyzing solutions to the time inconsistency problem (Drazen 2000, 133). Laws have penalties, so that there are explicit costs of breaking them. Moreover, laws or widely recognized social norms make noncompliance more visible and hence more costly.

The legislative structure of central bank's fundaments can be affected by various factors. The history of inflation performance is one of those. Countries with poor inflation history might be more willing to entrench their central bank's authority with constitutional paragraphs. King (2004) suggests that countries without experienced hyperinflation may be less willing to strengthen monetary arrangements with constitutional paragraphs. A central bank law is therefore subjected to the monetary authorities' inflation-aversion and can result in a legislated inflation target as the anchor for price stability. Poole (2002) argues that an inflation target can be beneficial whether or not it is legislated if only it is accepted by the public. Thus it is not essential to have a legislated inflation target but its framework needs to be seen by the public as having constitutional force, that is that "a law or practice cannot be changed without resort to lengthy discussion and, in the case of a law, by a super majority or its equivalent" (Poole 2002, 2). Whether legislated or not, it is crucial for central bankers to constantly explain the reasons for inflation targeting.

Discussions over a central bank's legislation are often accompanied by disputes on the topic of its legal relations within the state and with the government. Solving potential conflicts between monetary authorities and the government in industrial countries is currently regulated in three ways. An example of the United States shows that there is no explicit recognition of the possibility of emerging such a situation (Siklos 2002, 2005). Necessity for this kind of legal recognition has not been noticed since the Fed emerged originally as an institution with a limited mandate in the country.

The next example of legal recognition of potential conflicts has some minimal identification in the central bank statutes. Its role is to enhance some autonomy of the central bank and usually allows the dismissal of central bankers only in the case of extreme misconduct. This type of legislation can be found e.g. in Japan or the European Central Bank. Finally, the third solution mentioned by Siklos includes the explicit recognition in statutes of possibility that a disagreement over monetary policy and the legislation may also indicate how conflicts should be solved. In this case, the directive is used to deal with policy conflicts. Siklos (2004) points out that 'custom' is important in every economy; this termdescribes the role played by a free market, a developed financial system or the presence of stable and respected institutions. Thus it is also wise to connect efficiency of monetary authority to the length of its presence in the market. The longer it exists and operates in the market, the longer it learns about the economy, possible crises, and the different level of inflation and the more successful it can be in conducting a monetary policy.

Targets and Contracts

Targeting rules are regulations on the basis of which the central bank aims to achieve an earlier specified value for some macro variables and which can play the role for the future judgment of the central bank's performance. Svensson (2005) defines that a targeting rule "specifies a condition to be fulfilled by the central bank's target variables". The central bank is assigned a loss function, which can feature only one target variable, for instance inflation, or some additional variables like income.

'Target variables' are endogenous variables introduced in a loss function; 'targeting' is minimizing such a loss function (Svensson and Woodford 2005). Targeting is a situation when "monetary policy is represented in terms of targeting rules which are based on the first-order conditions from the central bank's policy decision problem" (Walsh 2005). Inflation targeting and exchange rate pegs with a low inflation country are examples of targeting rules. Targeting rules depend on the nature of the central bank's objectives as well as the constraints imposed by the economy's structure. A broad study on this topic can be found in e.g. Svensson (1998, 2005), whereas McCallum and Nelson (2004) present some critical views on this matter.

Inflation targeting is perhaps the most widely discussed targeting regime in the literature and it has been characterized in various ways in the theoretical studies (see e.g. Bernanke and Mishkin 1997 or Svensson and Woodford 1999). It has also been implemented in different ways in the countries that have chosen this monetary policy framework. Other targeting regimes that are analyzed in the literature are for instance price level targeting (see e.g. Dittmar, Gavin, and Kydland 1999), hybrid price level-inflation targeting (Batini and Yates 2000), average inflation targeting (Nessén and Vestin 2000), and regimes based on the change in the output gap or its quasi-difference (Jensen and McCallum 2002)[5]

A performance contract is a situation, when a central banker is oferred a performance contract, which ties the central banker's salary or the bank's budget to the macroeconomic performance for example the degree inflation rate. Walsh (1995) explains this with a presentation as a *principal-agent problem*. A principal (an individual or a group) delegates control of a policy to an agent (another individual or a group), conditioned on a contract as an incentive, for instance a stage-contingent wage contract. This contract is set to prevent an agent from choosing differently

[5]For a detailed description of targeting rules, see e.g. Walsh, 2003, chapter 8, Woodford 2003, chapter 8.

from the principal's desired objectives and from introducing a policy that is different from the principal's most desired outcome.

With the principal-agent solution, Walsh concentrates on the source of the problem - a situation when the central banker confronts a set of preferences that do not yield the outcome that society desires (Waller 1995). Hence, instead of appointing conservative central bankers or opting for reputation strategies, the solution may be found in creating certain incentives to maximize the society's well-being. This approach, on contrary to other solutions to the time-inconsistency problem, involves the society to pursuit the self-interest by choosing the central bank that aims to achieve the socially desirable outcome. With the performance contract, the central bank becomes accountable for its actions.

Preferences and Independence

An alternative solution to solving the inflationary bias of discretion focuses on the preferences of the central bank, and considers a special case when these preferences are different from those of the public. This branch of literature focuses on the case when the central bank gives more weight to achieving the inflation objective than does the public, or the central bank has a lower target level of inflation π^* than the public. In other words, the central bank is more conservative about the inflation than the public.

Furthermore, in the vast majority of countries, the most prominent example of delegation of macroeconomic policymaking to a conservative central banker is at the same time accompanied with equipping a central bank with varying degrees of independence from other policy authorities in the conduct of a monetary policy. The extensive empirical work in this area has found, at least for the industrialized economies, that countries' average inflation rates are negatively correlated with measures of the degree to which a central bank is independent of the political authorities[6].

Rogoff (1985) was the first to analyze the effect of appointing a monetary authority that places a greater weight than the social planner on the losses from deviations of inflation from its optimal rate.[7] Since the central bank is free to choose the inflation rate according to its own objective function, some argue that, in this framework, it has both a goal and instrument independence (Drazen 2000, 144). This is challenged with another view that it is society or a social planner who

[6]This empirical work will be discussed in chapter 2.

[7]Nowadays the European Central Bank can be called a 'typical' Rogoff type bank.

chooses an inflation target and only then appoints an inflation-averse agent with instrument independence to achieve it. Rogoff's suggestion has been described as *weight conservatism* (Svensson 1997) to underline that there are also other types of conservatism. For example, a central bank might have a target inflation rate that is lower than that of the government (Walsh 2003, 394).

To illustrate the problem of varying preferences, one may consider a welfare function of the central bank of the form (Wickens 2008, 382-84)

$$U^{CB} = \lambda(y - y_n) - \frac{1}{2}(1+\delta)(\pi - \pi^*)^2 \tag{1.18}$$

where δ represents preferences, and other notations are the same as in equation (1.14) . The key idea here is that the central bank's preferences are defined with $\delta > 0$, while the public preferences about the degree of inflation rate are represented by $\delta = 0$. Thus, the central bank gives more weight to the inflation objective than the public. The objective function (1.18) can be rewritten in the following way

$$U^{CB} = (1+\delta)\left\{\frac{\lambda}{1+\delta}(y - y_n) - \frac{1}{2}(\pi - \pi^*)^2\right\}$$

in order to find the optimal setting for policy

$$z^* = \frac{\alpha\lambda}{1+\delta} + \pi^* = \pi^e.$$

The model includes differences in preferences δ, so the effect of introducing preferences, which are positive, is to reduce both z and the inflation bias.[8] Ultimately, the measure of welfare will depend on whose welfare function is being used. The central bank's level of welfare is

$$U^{CB} = \lambda(\alpha v + \varepsilon) - \frac{1}{2}(1+\delta)\left(\frac{\alpha\lambda}{1+\delta} + v\right)^2,$$
$$E(U^{CB}) = -\frac{1}{2}\left[\frac{(\alpha\lambda)^2}{1+\delta} + (1+\delta)\sigma_v^2\right],$$

and the public's welfare function is

$$E(U^P) = E(U^{CB})|_{\delta=0}$$
$$= -\frac{1}{2}[(\alpha\lambda)^2 + \sigma_v^2].$$

These two welfare functions imply that while the public's welfare is not affected by the value of preferences δ because it obtains no benefit from having a central

[8] Setting here is similar to previous analysis on "Maintaining reputation in monetary policy", except for the new element describing preferences δ.

bank more averse to inflation than itself, the welfare cost of the central bank is dependent on the size of δ. Its optimal level, found from partial derivatives of the expected value of the objective function is of the form

$$\delta = \frac{\alpha\delta}{\sigma_v} - 1.$$

Thus, the greater σ_v is and the smaller α is, the smaller δ should be. Rogoff's solution underlines a trade-off: the inflation bias can be reduced under the cost of distorting stabilization policy. The implication of this solution indicate that countries orientated more on inflation objectives should have, on average, lower inflation, but at the same time, they should experience larger output variance.

Although conservativeness is not equivalent to independence, Rogoff's solution is often connected with the appointment of an independent central banker. The policy of greater weight put on the inflation objective may not always be a socially desirable goal. Hence, the concept of independence supports the idea that once appointed, the central bank is able to set a policy of its preference without interference or restrictions. Lohmann (1992) extends Rogoff's study to allow for a better trade-off between credibility and flexibility. Empirical support for central bank independence goes even further when authors (see e.g. Grilli, Masciandaro and Tabellini 1991 or Eijffinger and Schaling 1993) claim that CBI presents a *free lunch*: it reduces average inflation at no real cost. An additional advantage of choosing an independent central bank may be the protection of society from the distortions introduced by the electoral business cycles. This concept is analyzed for instance by Waller (1989), who formulated a model of central bank independence under partisan politics.

The opinion of a positive effect on real economy given by a higher degree of central bank independence is not shared by everyone. From a theoretical point of view, Bibow (2004) points out what he calls "the most serious defect of the time-inconsistency" that is the belief that maximum independence of central banks would necessarily render the maximum welfare contribution. Perhaps the most famous critique of such institutional solutions to the time-inconsistency problem is presented by McCallum (1995, 1997), who underlines that some of solutions do not solve the problem, but merely "relocate" it, in that it is not clear why the institutions are themselves credible.

1.1.4 Central Bank Independence

Many observers believe that the degree of independence of a central bank is an important determinant of policy actions, hence also of inflation. Moreover, it has been observed (see e.g. Eijffinger and de Haan 1996 for an overview) that in countries with a higher degree of a nation's central bank independence, the level of inflation is lower than in countries, where central banks remain under strong influence of the government. Explanations of why central bank independence would be related to a lower inflation rate can be found in the studies on the central bank and potential political pressures to behave according to the government's preferences (e.g. Buchanan and Wagner 1977); in studies on the division of power between fiscal and monetary authorities (Sargent and Wallace 1981); and finally those based on the prominent argument of time-inconsistency problem.

The degree of central bank independence is important when political authorities and a central bank place different emphasis on alternative policy objectives. For various reasons, central banks are normally more conservative and care relatively more about price stability than political authorities (Cukierman 1992, 349). The choice of an apolitical and independent central bank is an act of authority delegation. The higher the independence of a central bank, the stronger a political authority's commitment to such delegation. Determinants of the degree of central bank independence, though seem to be, in general, similar, may vary in countries and time.

Determinants of CBI

In general, the degree of CBI is determined by formal institutional characteristics. It can be affected by the nature of political and legal institutions, as well as by a nation's accepted practice, culture, and personalities (Cukierman 1992, 359). Eijffinger and de Haan (1996) as well as Eijffinger (1997) summarize economic and political determinants of central bank independence: (1) the equilibrium or natural rate of unemployment; (2) the stock of government debt; (3) political instability; (4) supervision of financial institutions; (5) financial opposition to inflation; (6) public opposition to inflation, and (7) other determinants. These determinants are not necessarily mutually exclusive and may partly overlap. Various studies have empirically verified these determinants. Naming a few, it is possible to mention Cukierman 1992 (political instability), Posen 1993 (financial opposition to inflation), or Eijffinger and Schaling 1995 (NAIRU, relative number of years of socialist government, variance of output growth, compensation of employees paid by

resident producers).

The intuition behind the natural rate of unemployment as a CBI determinant is as followed (Eijffinger and Schaling 1998): a higher natural rate of unemployment implies a higher time-consistent rate of inflation. Eijffinger and de Haan (1996) clarifies that, in the case of nominal-wage contracts, unexpected inflation has positive effects on the levels of production and unemployment. This, in turn, means that a higher natural rate of unemployment implies that surprise inflation is more valuable for the government. The government debt, as a CBI potential determinant, matters in terms of the size of debt. Cukierman (1994) claims that the larger the government's debt, the more likely it is that monetary authority will be shifted to an independent agent, and the more independent this institution will be.

Some studies have presented and proven the hypothesis that the type of political system and its structure determines the presence and degree of central bank independence. First, Moser (1999) shows that the legal CBI is significantly higher in those OECD countries, where extensive checks and balances were present. Moreover, countries with checks and balances have recorded a stronger negative relation between legal CBI and average inflation rate. Similarly, Keefer and Stasavage (2001) empirically show that central bank independence will prove more effective as a commitment mechanism in countries with multiple veto players in government.

While the general idea in central bank independence lays in keeping the monetary policy out of political control, its degree, determinant and eventual success of implementation, similarly to many other institutional solutions, as Acemoglu et al. (2008) suggest, depends on politicians and the process of policymaking. The case of Zimbabwe illustrates this problem perfectly. Figure 1.2 plots the inflation rate in Zimbabwe with a vertical line in 1995 when the Central Bank Act was modified in order to grant the Reserve Bank of Zimbabwe greater independence. The Act legislated the key elements of what constitute the definition of central bank independence: (1) after 1995 the bank had its own budget and could decide about its own finance, and (2) the control of inflation became the unique objective of monetary policy. Granting a higher degree of CBI to RBZ was accompanied with raised political instability[9] in the country. Thus, in this case, figure 1.2 suggests that a higher degree of CBI is related to higher inflation rate.

[9]It is generally understood that the origins of increase political instability in the country can be found for example, in land issues that resulted in the transferring the land property rights from the white part of the country's population to the black one.

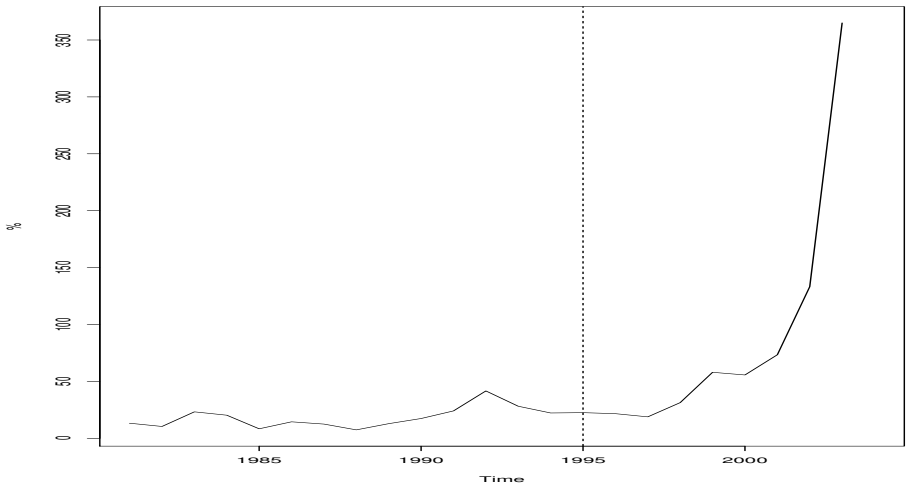

Figure 1.2: The Case of Zimbabwe
Annual Inflation Rate corresponds to the annual percentage change in the consumer price index reported in the International Financial Statistics (IMF)

Whether the supervision of a financial institution is a determinant of central bank independence is not so obvious. Literature and real-economy examples name a few arguments in favour of separation of powers in central banks, some prefer stronger institutions that join monetary and supervision powers in one. Recent financial crisis developments bring new ideas to this discussion voting strongly in favour of the latter. Opponents of separation claim the central bank plays a crucial role in the smoothing of the payment system operations and its associated risks. The bank plays also the role of "lender of last resort" and supplying sufficient liquidity. Separation of powers and creating a new institutions could lead to a conflict of interest between the two. The models of output variability and inflation performance presented by, for example, Barro and Gordon (1983), Rogoff (1985) and Alesina (1988), suggest that countries which have smaller real shocks are more likely to choose to have central bank independence[10]. The optimal choice of institutions is, however, the condition for this relationship.

Finally, one should notice the importance of financial and public opposition to inflation as an important determinant of central bank independence. Posen (1993a, 1993b) concentrates on the importance of financial opposition as a key factor that helps to find a relation between inflation rate and the degree of CBI. The central

[10]For a theoretical review and empirical proves see for example Crosby (1998).

bank is successful in its anti-inflationary policy when there is a coalition of interests, like the financial sector, that can protect this aim. On the other hand, the public's preferences or an accepted practice in a country seems to be as important as previously mentioned determinants of central bank independence. A thorough investigation of the link between societies' aversion to inflation, country's inflation performance and the degree of their central bank independence can be found in Hayo (1998). According to this study, public acceptance of the need for price stability may be as important as having independent monetary authorities.

Central Bank Legal Framework and CBI

The analysis of institutional design of central banks focuses on the investigation of the legal structure of monetary authorities. Legal independence, an essential part of the 'actual' one, suggests the degree of independence that legislators meant to supply the CB. Quantifying CBI implies capturing certain legal factors that may explain the degree of autonomy. Cukierman (1992, 369 - 371) explains that "the use of many proxies to characterize independence is based on the notion that each proxy is a noisy indicator that captures a somewhat different aspect of CB independence". The clusters of CB attributes include the structural organization of a central bank, the ability to formulate a monetary policy as well as its objectives, and restrictions concerning lending to the private sector. It is widely understood that using all of these clusters is desirable because, first, they complement each other, and second, this may reduce the noisiness of the overall measure.

Structural organization The idea of an optimal structural organization of central banks involves several issues. First, the discussion focuses on the number of people responsible for setting a monetary policy. The common solution of a one-person (the governor) decision process was widely changed in the 1990s' by countries into a process based on the group of people highly specialized in area of finance and banking. Central bank's actions are felt to be more transparent and independent when the monetary policy is based on the collective decision of members of the Monetary Policy Committee. Despite CBI being widely accepted, there is still less consensus regarding the structure of the governing bodies of the central bank. Sibert (2006) presents a survey on positive and negative sides of decision-making by committee. Other studies focus on the structure and design of the governing bodies (Lybek and Morris 2004) and characterize differences in the membership size of decision-making bodies around the world (Berger, Nitsch and Lybek 2006).

The impact of structural organization on central banks is measured also by analyzing the legal procedures of appointing and dismissing chief executive officers (sometimes members of the Board as well). Close convergence between the business cycle (parliamentary or presidential elections) and the personal changes in monetary authorities are seen as high dependence of central bank on political structures. Another indication of a central bank's dependence is political parties' or the government's authority to appoint the governor (president) of CB.

Policy formulation Responsibility of a policy formulation determines who has the actual power over the monetary policy. As long as the central bank remains the only legally accepted institution holding, it is seen as independent. By the same logic, it is necessary for CB to resist the executive branch in cases of conflict.

Objectives of central bank This attribute reflects the legal independence of CBI to raise the target of price stability above other objectives rather than the general level of independence from government. Hence, central banks with only or a main objective of price stability are classified as being more independent than those with a number of objectives in addition to price stability. Furthermore, banks with price stability among their several objectives are thought to be more independent than those, whose price stability is not mentioned as an objective at all. In Rogoff's (1985) terminology, this determines the strength of the central bank's 'conservative bias' (Cukierman 1992, 372 - 377).

Lending restrictions Finally, lending restrictions to the public sector constitute an important factor determining the level of legal commitments. Central banks' holding of governments bonds has fiscal effects as long as seigniorage is added to public revenues; hence, the stronger limitations on lending from the CB to the public sector, the greater degree of central bank independence.

CBI and International Solutions for Central Banking

There have been at least two major institutional reforms in the 1990s: a legislative and targeting route. A legislative route is based on the creation of a law that would support the design of an independent central bank. The law gives the right to control of monetary policy instruments as well as guarantees the mandate towards achieving a policy of price stability. The targeting approach of institutional reforms aims to "let the political principals of the central bank impose an explicit inflation target of price for monetary policy on top of the general mandate for price stability, and make the central bank leadership explicitly accountable to its principals for its success in meeting this target" (Persson and Tabellini 1994, 279). Both routes

have their representatives in the 'real world'; the legislative one has been supported by the successful policies of the Bundesbank, whereas changes undertaken in the central banks of New Zealand and Canada can represent the second approach.

Nowadays, there is wide consensus, both in theoretical and empirical studies that the primary responsibility of the central bank is to assure price stability.[11]. The design of a central bank as an autonomous organization in the state has become common since the 1990s. Cukierman (2006) gives several reasons for this worldwide trend: 1) an increased quest for price stability as an opposition to the stagflation of the 1970s and high-inflation situation in some other countries e.g. in Latin America; 2) a globalization and its impact on the development of international capital markets. Maxfield (1997) presents more reasons by arguing that the concern about central banking and the independence of monetary authority has reached the greatest levels due to the end of fixed exchange rate systems devised at Bretton Woods, and next to globalization also European economic transformation, including integration and post-Communist transition. In addition, Maxfield (1997) shows that globalization is the most crucial factor which decides the design of central banks, especially in respect to their independence: "Politicians use central bank independence to try to signal their nation's creditworthiness to potential investors. The more global financial markets become, the more politicians must concern themselves with signalling investors" (Maxfield 1997, 4).

The numerous informal practices among the European Community's member states concerning their mutual relations had been established long before the final Treaty of Maastricht. They included the Economic and Monetary Union (EMU) which had been first formalized with the Report of the Committee for the Study of Economic and Monetary Union by the late 1980s. The final phase of the EMU, introducing a single currency, has become a significant event in the history of world monetary arrangement. Responsibility for a monetary policy in the euro area has been delegated to the European Central Bank (ECB). The ECB's primary objective, as specified in the Maastricht Treaty, is price stability[12].

Developing countries have generally moved towards price stability, as a main monetary goal, following the trend started by industrial economies. Despite an obvious dislike towards inflation and a negative association with growth, the inflation

[11]The European Central Bank is the prime example of promoting price stability. Simultaneously, there is a discussion whether price stability is a sufficient target of monetary policy (see White 2006)

[12]For a recent study on the institutional framework of the ECB see for example Jakob de Haan, Sylvester C.W. Eijffinger and Sandra Waller "The European Central Bank: Credibility, Transparency and Centralization", CESifo Book Series, 2005.

level has differed quite significantly in developing countries. Studies on the development of central banking in developing countries (see for example Fry, Goodhart and Almeida 1996) show that, in terms of government financing, foreign exchange systems and the domestic banking systems, central banks in these countries face environments that differ radically from those faced by central banks in the richer OECD countries. For example, central banks in developing countries tend to dominate their countries' financial sectors to a larger degree than those in the OECD countries.

1.1.5 Central Bank Independence: free lunch?

The promotion of central bank independence, largely in Europe and among world industrial and developing countries, has been a resonance of the "free lunch" hypothesis. Its major idea lays in the belief that the presence of central bank independence has no costs, only benefits. It is hard to decide who should get credit for this term but many quote Grilli, Masciandaro, and Tabellini (1991, 375), who wrote: "Thus having an independent central bank is almost like having a free lunch; there are benefits but no apparent costs in terms of macroeconomic performance". There can be, however, some cost, as Rogoff (1985) explains, in the form of increased output variability.

Despite the lack of consensus on what is the right measure of central bank independence, empirical studies are considered to strengthened the theoretical point and confirm CBI as a primary choice for monetary stability. Most of empirical literature considers central bank independence as an exogenous variable and focuses on explaining some elements of a country's economic performance. For example, cross-country data for developed countries show a negative relation between a degree of central bank independence and inflation, but no correlation with output or employment (see e.g. Bade and Parkin (1998), Grilli et al. (1991), Cukierman (1992, ch. 19), Eijffinger and Schaling (1993), or Alesina and Summers (1993)). In a theoretical analysis, Alesina and Gatti (1995) prove that creating a central bank is not necessarily associated with an increase in real economic variability, but it does relate to a reduced average inflation rate.

The observed relation between the inflation rate and the degree of central bank independence is depicted in the figure 1.3. It shows a case of selected, so-called, transition economies, which, at the beginning of the 1990s, had a similar set of features: relatively high inflation caused by the freeing of prices from the government control, and a constantly unstable political and institutional system with a trans-

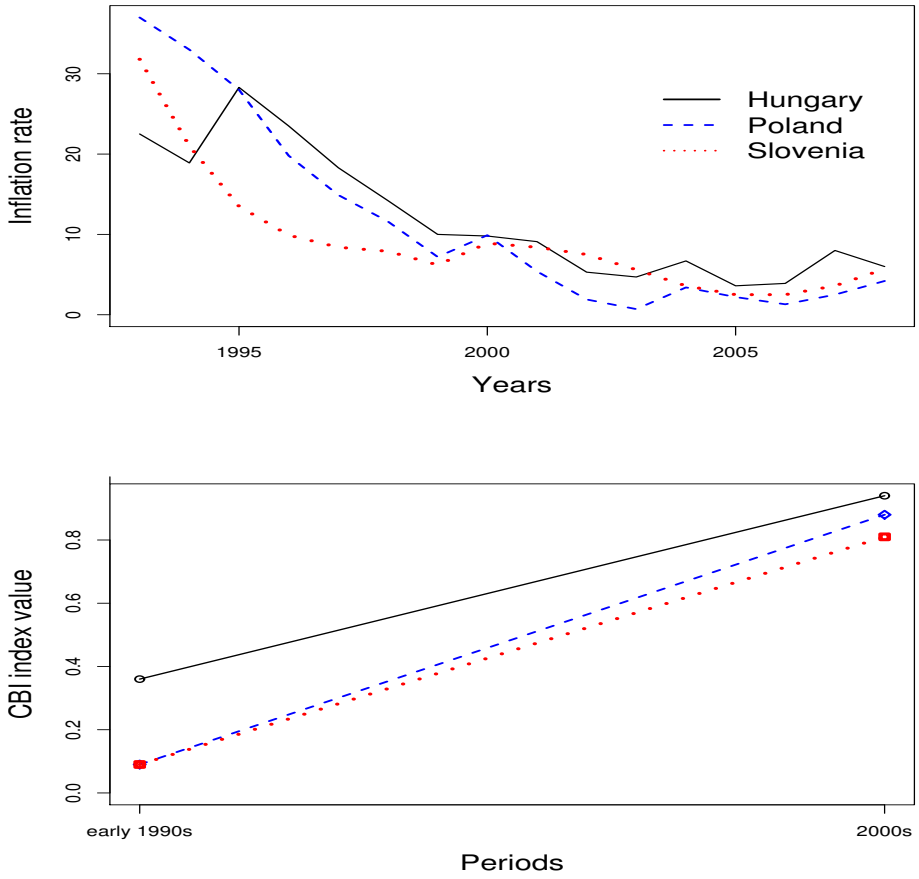

Figure 1.3: Inflation rate and values of CBI in Hungary, Poland and Slovenia
Annual Inflation Rate corresponds to the annual percentage change in the consumer price index reported in the OECD. CBI measure based on Grilli, et al. (1991) and updates Arnone et al. (2007)

forming banking sector and politically dependent central bank. In the 21st century the situation is dramatically different: a low inflation rate comparable to other West European countries and modernized, politically independent institutions of monetary authorities. The lower graph shows that this decrease in the inflation rate has been accompanied by an increase in countries' central bank autonomy. This group of countries is one of many examples confirming that an inverse relation exists between the degree of CBI and inflation rate.

The exogeneity of central bank independence and the "free lunch" hypothesis is challenged by Debelle (1996) who states that the previous study on CBI assumed central bank's actions done in isolation from the actions of other policymakers. This, Debelle continues, is not acceptable because a monetary policy is not the only policy in the economy and therefore CBI is not generally exogenous to other policy institutions. The central bank's preferences are no longer the main determining factor of the state of the economy. They are accompanied by the preferences of the fiscal authority, the nature of the policy game (the Stackelberg equilibria are seen as more proper by the author than commonly examined the Nash equilibrium), and the obligation to repay debts. Having the expected loss function

$$\begin{aligned} E[V_s] = & \quad E\left[\pi_N^2\left(s_\pi + \frac{s_x}{\mu^2} + s_g\left(\frac{\delta_x}{\delta_g \mu}\right)^2\right)\right] \\ = & \quad \left[Var(\pi_N) + (E([\pi_N])^2)\right]\left(s_\pi + \frac{s_x}{\mu^2} + s_g\left(\frac{\delta_x}{\delta_g \mu}\right)^2\right) \end{aligned} \tag{1.19}$$

it is possible to determine the optimal level of central bank inflation aversion μ. Differentiating an equation (1.19) with respect to μ, and setting it equal to zero we can achieve a solution given the Nash framework. A solution in the deterministic version of the model is of a form

$$\mu_N^* = \frac{s_x \delta_g^2 + s_g \delta_x^2}{s_\pi \delta_g (\delta_x + \delta_g)} \tag{1.20}$$

The optimal degree of central bank inflation aversion is: (1) increasing with society's weight on inflation; (2) decreasing with society's weight on output; (3) decreasing with society's weight on government spending (Debelle 1996). One of the conclusions drawn from Debelle analysis may give an answer to a fundamental question concerning differences in central banks design in various countries. The more weight the society places on inflation, the more inflation-averse a central bank will be chosen. Hence, according to this study, the central bank institutional framework depends on decisions made by societies with different objective

functions, and moreover, "the empirical relationship between central bank independence and inflation may simply reflect differences in inflation aversion across countries" (Debelle 1996, 12).

Literature on CBI also represents another view on the necessity of presence and the potential "free lunch" that comes from having an independent central bank. Posen (1993, 1995) argues that the relationship "higher degree of CBI-lower rate of inflation" is not causal and may be caused by society's preferences for low and stable inflation. He considers that countries that are inflation-averse may simply develop institutions to support this aversion. Thus, if this is the case, as Fischer (1995) continues this topic, simply educating the public about the true costs of inflation may be the best way to reduce inflation. Posen was criticized by de Haan and Van 't Hag (1995) who show that Posen's results are confirmed only when the Cukierman's legal indicator is used.

If central bank independence means ensuring an inflation-averse institution that is credible and possesses an adequate reputation, then there are even more arguments proving CBI does not give a "free lunch". Gaining credibility of a low-inflation type, a central bank may hardly ever be costless as shown by Backus and Driffill (1985). In the words of central bank practitioners, credibility is "painstakingly built up by a history of matching deeds and words" (Blinder 1999, 65). The cost of reducing inflation is, as Feldstein (1997, 124) explains, a "one-time" loss of output and employment that eventually brings the benefits of low inflation. Bibow (2004) however wonders, if these costs connected with the short-run of anti-inflationary benefits building ever actually end.

While there are many studies that doubt in costless benefits of CBI, there is also another bulk of research that either try to find an ideal definition of CBI and the way it is measured; or criticise already existing ones. Before we perform a robustness check of several indices of central bank autonomy, chapter 2 presents an exhaustive review of numerous definitions of CBI and their critical analysis.

Chapter 2

Discussion on the Inconsistency of Central Bank Independence Measure

Measures of central bank independence (CBI) have long been of interest to economists because of the debate on whether central bank autonomy is a "free lunch". This term describes a situation when countries with significant monetary independence are able to achieve lower average inflation without any real additional costs. The negative relationship between degrees of CBI and inflation rate have been shown to be robust by many studies. More recent investigation test the robustness of this statistical relationship and cast doubt on its presence if one considers varying sets of countries or CBI measures.

These last studies shed some light, not only on the lack of consensus on a preferred measure of CBI, but also on weaknesses and shortcomings of empirical verification of this statistical relationship. A closer examination of characteristics that define CBI measures reveals wide heterogeneity. Diversity results for multiple reasons. Primarily, there is a general trend in the literature to improve on previous measures by including new CBI attributes. This results in multiple CBI definitions.

Performing empirical analysis on the existence of statistical relationship between degrees of CBI and inflation requires acquainting the reader with a series of central bank autonomy measures. The following section describes a comprehensive set of such indices. We focus on the type of the measure, the number and importance of CBI attributes included, the sample they were designed for and the uniqueness that distinguishes one measure from the other. Subsequent steps

require quoting a few studies, which draw attention to the fact that a growing number of CBI indices results in increased blurriness of the phenomenon's definition. We complement this literature review with our critical analysis of CBI measures, which will be followed by their empirical comparison in the next chapter.

2.1 Measures of Central Bank Independence

Literature on the optimal design of monetary authority presents a number of central bank independence measures. It is difficult to decide which measure gives the most accurate value of a degree of independence. Indices vary in the areas of: central bank attributes they consider; weighting and coding of certain characteristics; and focusing on different central bank activities and responsibilities. There is, however, a common consensus concerning the meaning of certain central bank attributes that constitute measures of independence.

In general, it is possible to distinguish five groups of central bank factors, which are important for the central bank design from the political economy point of view. First, independence of a central bank is related to its governor (otherwise called president or CEO), in particular it is linked with the appointment and dismissal rules, and the length of his stay at the post. It also includes similar rules for members of the board. A second group is related to policy formulation. A central bank is examined on whether it is able to conduct a monetary policy without the government's influence. In particular, it relates to the authority of setting discount rates, of supervision and banking regulation and how the central bank is accountable. Third, independence is related to policy objectives, where it is assumed to be high if price stability is the only, or at least the primary, objective of the central bank. A fourth group concerns the (dis)ability of the government to borrow from the central bank. Finally, external monetary relations are important as well, such as the exchange rate and capital controls. Hence, central banks are classified as the most independent in the following cases:

1. The central bank governor's legal term of office is longer than the political election cycle in the country, and in which the government has little authority in the appointment and dismissal process of both the governor and the board (personnel independence).

2. The central banks possess wider authority in the area of policy making, especially when they become the *final* authority in case of conflicts with the government (policy independence).

3. The central bank chooses price stability as its main objective (policy (goal) independence).

4. The central bank is not allowed to give advances for the government or when advances are the subject to restrictions (financial independence).

Political studies on central bank independence concentrate on analysing the legal framework of monetary authorities. They try to understand, for example, the complexity of central banks' legal framework expressed with constitution paragraphs or statutes. The laws of central banks can differ in their focus, scope and degree of detail; they can rely on social customs and country development.

Another type of independence–actual, as opposed to formal–is not only conferred on the central bank by law, but as Cukierman (1992) explains, it also depends on the "myriad of less structured factors". These can be represented by informal contracts with the government, the quality of the bank's research department or personal features of important representatives of the bank. It is hard to quantify these informal relations, although a few attempts have tried to grasp elements of regulations that have not been included in the legislation, or any informal tradition and practices that deviate from the accepted law. Most work, however, focuses on defining and quantifying CBI measures based on the nation's legislation. Measures constructed this way are able to show the actual degree of independence, which was meant to be granted on central banks by legislators.

The indices mentioned most often in the group of legal measures are those constructed by Alesina (1988, 1989), Grilli, Masciandaro and Tabellini (1991), Cukierman (1992) and Eijffinger and Schaling (1992, 1993). A major assumption behind these measures lies in attaching a numerical value to selected central bank institutional factors, which constitute the power and ability to conduct monetary policy. Despite the same methodology, these indices differ in the choice of central bank attributes, their weighting and sometimes in the final degree of CBI. One of the restrictions in this analysis concerns the accusation of imperfections of this method expressed by imperfect knowledge of the researcher working on the study, as well as excluding several informal factors such as unofficial arrangements with governments or the quality of bank personnel. The other problem concerns narrowing a sample to the industrial countries only. This was a concern in first stages of the analysis; recent studies also include developing countries.

Non-legal measures of independence include those based on a questionnaire (for example, Cukierman 1992; Masciandaro and Spinelli 1994; or Fry, Goodhart, and Almeida 1996) and indices that calculate CBI based on the central bank gov-

ernors' turnover (for example, Cukierman and Webb 1995). The former method formulates an index with the use of central bankers' subjective perception of what central bank independence really is. Rarely used due to its subjectivity problem, this method can point out certain problems in actual CBI. The political vulnerability index is thought to reflect both the frequency of political change and the percentage of political changes that are followed by changes in the governorship in the central bank.

We have tried to collect as many studies that offer a new perspective on measuring CBI as possible. Table 2.1 presents a list of such attempts, specifying authors name, date of construction, type of index, number of countries for which the CBI measure was constructed and whether the index has an update.

Table 2.1: Compendium of central bank independence measures

Authors	Measure	Date	No. of countries	Update
Epstein and Schorr	legal measure	1986	10 industrial	No
Bade and Parkin	legal measure	1988	12 industrial	No
Alesina	legal measure	1988	16 industrial	No
Grilli et al.	legal measure	1991	18 industrial	Yes
	economic and political			Yes
Burdekin and Willett	legal measure	1991	13 industrial	No
Cukierman	legal, and	1992	70 countries	Yes
and Cukierman at el.	actual and		72 countries	Yes
	questionnaire-based			No
De Haan and Sturm	combination of three measures (AL, ES, GMT)	1992	up to 18 industrial countries	No
De Long and Summers	average of previous measures AL and GMT	1992	16 industrial	No
Eijffinger and Schaling	legal measure	1993	12 industrial	No
Alesina and Summers	average of previous measures AL and GMT	1993	16 industrial	No
Siklos	composition of legal and actual measures by Cukierman et al.	1993	4 transition	No
Eijffinger, Van Rooij and Schaling	empirically calculated measure of actual CBI	1994	10 industrial	No
Fratianni and Huang	average of nine indicators	1994	15 industrial	No
Masciandaro and Spinelli	Functional and political CBI	1994	21 industrial	Yes for some countries
Cukierman and Webb	actual measure of political vulnerability	1995	64 countries	No
Debelle and Fischer	GMT and components of thereof	1995	18 industrial	No
De Haan	components of LVAW	1995	21 industrial	No
Banaian et al.		1995	21 industrial	No

Froyen and Waud	Alesina-Summers and	1995	16 OECD and	No
	Cukierman based index	1995	34 other	No
De Haan and Van 't Hag	SUMLV based on Cukierman index	1995	up to 21 OECD countries	No
Fry et al.	Questionnaire-based index	1996	38 of different development	No
Eijffinger et al.	empirical analysis	1996	10 OECD	No
De Haan and Kooi	decomposition of GMT and LVAU	1997	21 OECD	No
Loungani and Sheets	SIB and CBI-DF	1997	12 transition countries	No
Iversen	Based on BP, GMT and LVAU. Hard-currency index	1998	15 OECD	No
Hall and Franzese	Average of LVAU, QVAU, two components of GMT, BP	1998	18 OECD	No
Mangano	Redefined GMT and LVAU	1998	17 OECD	No
Bernhard	Normalized values of GMT, AS and LVAU	1998	18 industrial	No
Fry	CB ability to neutralize G's credit requirement	1998	70 less developed countries	No
Bagheri and Habibi	Average of three components of LVAU	1998	20 industrial and 52 developing	No
Elgie	37 attributes of legal CBI	1998		No
Iversen	Composition of GMT LVAU and AL	1999	13-16 OECD	No
Lybek	Index of CBI and accountability	1999	15 post-soviet republics	No
Oatley	Based on eight indicators	1999	21OECD	No
Kilponen	components of LVAU	1999	17 OECD	No
Maliszewski	GMT with two additional attributes	2000	20 transition	No
Cukierman at el.	LVES	2001	26 former socialist and 21 developed	No
Neyapti	modified LVAW by 3 additional attributes	2001	8 Eastern European	No
Freytag	internal and external independence	2003	11 transition	No
Freytag and Masciandaro	similar to Freytag (2003)	2005	14 CEE and 23 other	No
Jacome and Vasquez	measure of independence and accountability	2005	countries of Latin America	No
Krause et al.	PROB	2007	34 of different development	Yes

We start the encyclopedic summaries of CBI measures with the two most important contributions by Grilli, Masciandaro and Tabellini (1991) and Cukierman, Webb, and Neyapti (1992). The array of CBI measurement contributors in Table

2.1 explicitly portray which definition of independence is considered the most accurate. Aforementioned CBI indicators receive enough attention to be updated with more current information. In fact, values of the turnover rate of governors measure by Cukierman et al. is by far the most often revised CBI index, and thanks to its simple construction, it can be continuously updated. Moreover, the importance of these measures is attested by a long list of new CBI indices, whose construction predominantly relies on work by the above mentioned authors. The work by Bade and Parkin (1998), Alesina (1988, 1989) or Eijffinger and Schaling (1993) is also considered to be an inspiration for further studies. Their measures are not as comprehensive as studies by Grilli et al. and Cukierman et al. However, the depth of CBI definition they consider is significant, and thus these studies are also perceived as a foundation for later approaches.

2.1.1 Index of economic and political independence

A comparison of monetary regimes done by Grilli, Masciandaro and Tabellini (1991, GMT hereafter), focuses on monetary institutional features, disregarding behavioural indicators such as the average rate of growth of the money supply or the level of interest rates. Their explanation is based on greater stability and identification of monetary institutions compared to behavioural indicators, which often vary over time. The biggest contribution of GMT is their introduction to the literature of definitions of *political* and *economic* central bank independence. "Political independence is the capacity to choose the *final goal* of monetary policy, such as inflation or the level of economic activity. Economic independence is the capacity to choose the *instruments* with which to pursue the goals" (italics in original, Grilli et al. 1991, 366).

Three aspects primarily determine *political independence*: (1) the procedure to appoint members of central bank boards; (2) the relationship between monetary authorities and the government; and (3) the formal responsibilities of central banks. Several features are taken to describe economic independence, including the government's ability to influence their amounts of borrowings from the central bank, and the nature of the monetary instruments, which remain under the control of the central bank. All aspects constrain different central bank attributes, which are used to measure CBI, and later to analyze any relationship that occurs between CBI and inflation rate. Using the combination of these attributes, Grilli et al. formulate synthetic indicators of the political and economic independence of the central bank. The studies done by GMT focus on eighteen industrial countries. The index of

economic and political independence describes its level on a range of 1 to 7 or 1 to 8, depending on how many attributes are taken in the description. Zero means total dependency from political authorities.

Grilli et al. find a strong and negative relationship between inflation rate and economic independence, as was expected. Higher sensitivity of relations between the two, exactly during periods of higher inflation, might indicate that in this correlation the presence of influential observations is crucial. The indicator of political independence has a negative sign as well, but it is significant only during the 1970s. The European Monetary System (EMS) dummy, even though it shows strong negative correlation with inflation rate, has appeared to be not significantly different from zero. GMT summarizes their findings as follows: "Monetary institutions matter, indirectly, through their effects on credibility, and directly, by shaping the central bank incentives" (Grilli et al. 1991, 372).

2.1.2 Measures of legal and actual independence

While Grilli et al. (1991) focused on distinguishing between economic and political sides of independence, Cukierman (1992) and Cukierman, Webb and Neyapti (1992) make their seminal contribution by discriminating between legal and actual forms of CBI. The legal measure (LVAU and aggregated version LVAW) includes a wider range of information on CBI compared to previous studies by Bade and Parkin (1988) or Alesina (1988), to name a few. It combines information on personal independence, policy decisions and final central bank objectives, and constraints on central bank lending to the government. This measure, contrary to previous studies, does not assign codes equally. It elevates CBI characteristics importance and assigns the codes accordingly. Moreover, unlike other studies, it is coded within $[0, 1]$ scale, and 0 means complete dependence. Each of four subsections of the measure can be considered a separate index, while the aggregation of these sub-parts results in a single index of legal independence–LVAU, an unweighted index. The aggregation is calculated as a simple average of the codings, while LVAW is a weighted index of the same variables. Cukierman et al. (1992) focus on the sample composed by up to 70 countries, including 49 less developed ones. This is yet another feature differentiating it from other indices, which had been calculated only for OECD countries. Legal independence measure has become popular in subsequent studies thanks to this large cross-country set, but also for values calculated for each decade for the period 1950-89.

The results of the analysis over the period 1950-1989 show the median level

of legal independence similar in both groups of countries (around 0.32), with the higher concentration of developed countries at the top 10%, and developing ones at the bottom 10% of the distribution. Additionally, preliminary observations suggest that "legal central bank independence may be neither necessary nor sufficient for low inflation" (Cukierman 1992, 382). This conclusion has been drawn from Panama, Japan or Belgium, where very low rates of inflation had been observed, but at the same time, the countries were ranked in the lowest quartile of legal CBI. On the other hand, countries with the relatively higher level of inflation, like Argentina, Peru and Nicaragua, have had their rankings of legal independence above the median.

The analysis of legal acts can be difficult in case of developing or transition countries, due to their shorter history of central banking. The laws are incomplete; they are not necessarily able to specify the limits of authority between the central bank and the political authorities. Additionally, the actual practice can deviate from the law. Therefore, legal independence measure, though informative, has been criticised for being helpful only in a limited number of countries. The isolation of actual independence from any features of the legal one creates the opportunity for new measures of CBI.

A new measure, the turnover rate of central bank governors (TOR), proposed by Cukierman, Webb and Neyapti (1992) and Cukierman (1992), captures elements of personal independence with actual practice: higher turnover of central bank governors indicates a lower level of independence. Political authorities often have the power to decide about governor candidates and the final choice. Moreover, they have also an incentive to choose a governor, which will represent their inflation preferences, over the ones with different preferences. Newly elected governors might be discouraged from imposing their longer-term policies in favour of more political cycle orientated ones. Thus, this brings a conclusion that rapid turnover creates, or is an effect of, political dependence of the central bank.

Cukierman et al. (1992), suggest that a long presidency might not necessarily show a high level of independence, but simply indicate the presence of a relatively subservient governor. In a sample of central banks, prepared by Cukierman, Webb, and Neyapti (1992) from 1950 to 1989, Iceland, Netherlands and Denmark had the lowest values of TOR. The authors highlight this exceptionally low turnover rate. For example Iceland's governor changes on average every 29 years.[1] Low average turnover rates for all industrial countries (less than 0.2) cannot reveal much

[1] Cukierman (1992) calculates the value, on average, at 33 years.

about variations of the CBI in this group. The developing countries, however, are characterized with a wide variation of TOR, thus making the analysis of the degree of CBI and economic conditions more realistic.

Following the previous work on the turnover indicator, Cukierman and Webb (1995) undertook a more sensitive analysis by looking at the probability of dismissing a central bank governor shortly after a political change of government. Their research resulted in the behavioural measure: "political vulnerability". The intuition behind this study lies in the belief that different kinds of political instability affect institutions, such as a central bank, differently. Cukierman and Webb explain: "If political changes reflected changes in the basic attitude towards economic policy or if they were traumatic and irreversible for the politicians involved, then the instability would motivate politicians to control the central bank tightly and keep it at their disposal to help them stay in power" (Cukierman and Webb 1995, 3). Hence, politicians are encouraged to choose governors for central banks according to their preferences and future re-election plans. Then again, politicians may be willing to support a current central bank governor who shares their inflation preferences. Nevertheless, the index is formulated on the basis of answers to the following questions:

1. Does turnover at the central bank significantly differ shortly after political transitions, than in other periods?

2. For how long after a political change does it increase the probability of a change of central bank governor?

3. Is the political vulnerability of the central bank systematically related to the level of economic development and the type of political regime?

4. Is the political vulnerability of the central bank systematically related to measures of economic performance such as inflation, growth and interest rates?

To quantify the vulnerability index, authors have gathered the data set for 64 countries, covering two main issues in this problem: political and central bank instability. Political instability is represented by the data on political transitions in a country, whereas instability of central banks is defined by the frequency and timing of the central bank governor's replacement. Examples of political transitions could be the following: (1) change of the head of government; (2) change of the party in government; (3) change of the fundamental rules of government that is present during the switches from authoritarian to democratic regimes and vice versa; and (4)

irregular changes of government from one authoritarian ruler to another. The index of political vulnerability is defined for each country as the fraction of political transitions that are followed by a replacement of the central bank governor.

Smaller values of this measure represent a weaker relationship between the change at the executive branch and the change of the central bank governor. During the period of the analysis, political vulnerability in developing countries had been over three times higher than in industrial ones. Cukierman and Webb conclude that the highest level of central bank vulnerability can be noticed in developing countries with mixed regimes, which additionally face a high level of political transitions.

2.1.3 Basic indicators of legal independence

First attempts aiming to quantify the degree of central bank autonomy, and later, to find relationships between effectiveness of monetary policies and central bank's design, are dated back around the 1980s. Although rarely or never re-calculated, they are considered equally important as studies by Grilli et al. and Cukierman et al. The pioneer work by Epstein and Schorr (1986), Bade and Parkin (1988), Alesina (1988, 1989), Burdekin and Willet (1991) and Eijffinger and Schaling (1993) have been inspirational and have boosted myriad of research on the relationship between the degree of CBI and economic performance. All indices are quite similar in the construction, and they describe degrees of CBI by focusing on the following three criteria:

1. The relationship between central banks and the government in the formulation of a monetary policy

2. The procedures in appointing the board of the central bank

3. The financial and budgetary relations between the central bank and the government

Indices coding is simple; it is an ordinal scale between 1, indicating the lowest level of autonomy, and 3 or 4 (depending on the index). Though relatively simple, there is a variety of differences among the various indices. For example, Alesina adds the criterion, "Is the central bank not required to absorb excess supply of short term Treasury bills?", which is absent in the Bade and Parkin analysis. In some indices, a value of 0 is considered the lowest. Discrepancies in coding originate in

personal understanding of some extreme cases, such as the central bank of Australia. Since, at the time of the analysis, the Minister of Finance was an *ex officio* member of the monetary policy board, Bade and Parkin, and Alesina understood this case as lacking any autonomy. The biggest differences in evaluations among indices concern the central banks of England, Japan and Italy, whereas in all other cases there is a wide consensus.

The CBI index developed by Eijffinger and Schaling (1993) is determined using the following criteria:

1. Is the bank the sole final authority? Is this authority not entrusted to the central bank alone? Is it entrusted completely to the government?

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

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

Eijffinger and Schaling (1993) opt for using different weights, compared to attempts by their predecessors. The Eijffinger and Schaling (ES) index is asymmetrical. For example, a central bank obtains two points when it possesses an exclusive power of policy making; it receives only one point when this power is shared; and none if the government is the sole authority in this area. For other questions, the answers are more obvious and there are only two possibilities: Yes or No (weighted 1 or 0 point). Table 2.2 summarizes lists of attributes considered in three selected indices. The two last characteristics come from the first ES question, and indicate the greater stress (asymmetry) put on the issue of policy making authority.

Eijffinger and Schaling compare values of their index with those of Bade and Parkin. They conclude that differences in numerical values depend on both interpretation and criteria effect. To challenge this subjectivity problem, they construct a "BP Asymmetrical Policy Types" index and argue that the total difference between these two measures can be decomposed according to the formula: $ES - BP = (ES - BPA) + (BPA - BP)$, where $(ES - BPA)$ is the interpretation effect and $(BPA - BP)$ is the criterion effect.

2.1.4 Subsequent studies on base indicators

Data collected in Table 2.1 informs that a diverse set of CBI indicators have been inspired by the base indicators mentioned above. Their construction is diverse;

Table 2.2: List of criteria used for formulating CBI indices

Attribute / Index	BP (policy)	Al (policy)	ES (policy)
Is the bank final policy authority?	*	*	*
Is there no government official on the bank board?	*	*	*
Are more than half of board appointments independent?	*	*	*
Financial and budgetary relations between CB and Government	*	*	
Is the central bank not required to absorb excess supply of short-term Treasury bills?		*	
CB and Government together formulate policy			*
Government alone formulates policy			*

Source: Bade and Parkin (1988), Alesina (1988) and Eijffinger and Schaling (1993)

some are less sophisticated (for example: Alesina and Summers 1993; De Haan and Van 't Hag 1995 or Hall and Franzese 1998) who have formulated their indices based on average values of previous measures. Some studies and their empirical testimony have become very influential. The findings of the strong negative relationship between CBI and inflation rate by Alesina and Summers (1993) have shaped quite intensively subsequent literature. Another approach introducing the combined index of CBI includes questions concerning coordinated wage bargaining. Although Hall and Franzese (1998) incorporate a simple mean of five most commonly used indices, they formulate three hypotheses, which unite the effects of CBI and coordinated wage bargaining on both the inflation and unemployment rate. Hypotheses are tested for 18 OECD countries during the period 1955–1990. However, the methodology of finding CBI indices based on average values of preceding indices is in general criticized for its simplicity and lack of new approach.

Other subsequent attempts are more sophisticated. Cukierman et al. (1992) in the same study suggest a modified version of their major index. An overall index of inflation-based CBI combines indicators by "setting the weights equal to the coefficients from the regressions in which they are used to explain the variation in the transformed inflation variable" (Cukierman et al. 1992, 379). Authors argue that including the turnover rate index in the construction of an overall measure improves the ability of the final index to predict cross-country variations in inflation. Moreover, in most cases, the overall index improves the prediction of a country's inflation, while turnover is added, since its low degree brings the prediction down closer to the actual one. For these reasons, cases such as Argentina or

Brazil, ranked relatively higher with a legal index of independence, are placed in the bottom part of the list when the overall index is considered.

Fratianni and Huang (1994; FH hereafter) construct an independence index based on nine different measures of CB independence (for example, GMT 1991) both political and economic or Cukierman 1992 (legal and questionnaire indices). Country samples were different from study to study. Therefore, FH included only central banks that appeared in at least four of the nine measures of CBI. The German Bundesbank was chosen to be the benchmark with the value of unity. Values for other central banks were assigned by calculating distances of each CB from the benchmark. The formula for distance is as follows: $distance = \sqrt{(average-1)^2 + variance}$. Average and variance are obtained from the nine separate measures of independence. Even though the method is different from the most common ones, Fratianni and Huang admit they were not able to avoid the limitation of measurement caused by a legal interpretation of the CB statutes.

Using the methodology devised by Cukierman et al. (1992), Elgie (1998) presents a detailed study on components of CBI and creates a new index that considers 37 CBI determinants. The author underlines that his methodology indicates continuity of an index, that is, central banks differ in small degrees of independence among one another. The two most independent central banks may still differ in important issues of operating. Moreover, the author claims that, thanks to his CBI measure, extremes of complete independence and complete dependence are unlikely to happen. Considering these advantages, Elgie undertakes a larger attempt to increase the number of central bank attributes from seventeen used in original study, up to 37. The second innovation is a method of coding the sets and sub-sets of independence indicators that gives greater emphasis to the indicators of political independence. Banaian, Burdekin and Willett (1998) question the reasoning behind building such a detailed index. Is it "the more the merrier" or is there a reason behind such an attempt? The authors indicate that already in a sample of sixteen CBI determinants originally suggested by Cukierman et al. (1992), only three are in fact significant in regression with inflation. Hence, the question arises, if introducing over twice as many characteristics, as in the Cukierman index, would result in a greater number of significant ones.

Mangano (1998) examines measures by Cukierman et al. and Grilli et al., and presents a critical exploration of methodological discrepancies between these indices. His comment does not focus only on the criticism, but also suggests a new modified way of calculating CBI measures. Siklos (2002, Ch.2) updates Cukier-

man's legal independence index both for the 1980s and 1990s. Higher values of this index for several European central banks represent the effect of institutional changes, introduced in member countries of the European System of Central Banks (ESCB). Change in values has been reported in the United Kingdom, Sweden and Portugal but the most significant increase of CBI has been noticed in Spain, where the index scored 0,73 from the value 0,21 in the 1980s (in [0;1] scale).

A modification of the Cukierman et al. legal index is performed by Jácome and Vázquez (2005). In the study on CBI in Latin America, the authors built on Cukierman's measure by adding a new category of central bank accountability. The modified index emphasises, for example, the restrictions on the executive branch to remove members of the board of directors–not only the central bank governor. The criteria for the appointment and dismissal of central bank authorities also receive a different weight in the new index. The second innovation refers to the legal provisions for policy formulation. The modified index includes an assessment of CBI in the formulation of exchange rate policy, which is crucial for the conduct of monetary policy in small open economies. In addition, the authors find important the evaluation of the central bank's role in the formulation of the government's budget, which is shifted to consider the central banks' role in approving public sector debt. A third modification of the Cukierman index relates to the economic autonomy, for example, by adding a criterion on whether a central bank acts as a lender of last resort. The final change in the index is made by adding criteria for accountability of central banks.

One of the newest updates of the work done by Cukierman et al. and Grilli et al. was prepared by Arnone, Laurens and Segalotto (2006; ALS hereafter), who calculated the degree of CBI for the sample of countries that include eighteen OECD countries, twelve emerging market economies and nineteen developing countries. Aiming to indicate changes in central bank autonomy, ALS find that independence of monetary authority in OECD countries, measured for political and economic independence, has increased significantly compared to the period analyzed by Grilli et al. The reasons for this improvement in many cases can be found, as the authors continued, in profound renovation of the legislation. This conclusion is supported by Kilponen (1999), who noticed a significant development of central bank laws, resulting in a higher degree of independence, already at the end of the 1990s.

The lasting interest in central bank independence and its measures led Crowe and Meade (2008) to compute an updated index for all but three of the 72 countries in the original Cukierman et al. (1992) sample. The update allowed the authors

to compare levels of CBI between the data of Cukierman et al. and the *status quo* in 2003. With respect to CBI, the authors find a marked increase in CBI since indices were first constructed in the late 1980s, with developing and emerging market economies showing the most comprehensive increase across all dimensions of independence.

De Haan and Sturm (2001) undertake the analysis of the relationship between CBI and inflation in developing countries. They choose a turnover rate of CB governors as their CBI measure. Their contribution to earlier studies concentrates on presenting a new data set for a larger sample of countries than suggested by Cukierman and Webb (1995) and covering a longer period, including the 1990s. Moreover, they focus on examining the role of high inflation countries, the approach originally suggested by Temple (1998). The study shows insignificant results from regressions where the CBI is used as a proxy, unless the sample is enriched with high inflation countries. Additionally, a new approach for measuring actual independence has been suggested by Krause and Méndez (2007). The authors constructed an index (CBI index "Prob") that incorporates the probability that there will be a turnover in the central bank governor following a government change. Similar to methodology suggested by Cukierman and Webb (1995), Krause and Méndez computed the measure by dividing the number of times that a central bank governor has changed within six months following an election, by the total number of elections, within a determined period.

2.1.5 Questionnaire based indices

Indices based on surveys form a separate group of CBI measures. Although their further application in empirical studies has been rather limited, this methodology of CBI measures' construction has been chosen by Cukierman (1992), Masciandaro and Spinelli (1994), Fry, Goodhart and Almeida (1996), and more recently, Beblavy (2003). These measures are based on responses sent by central bankers, hence accused of twofold partiality: in terms of personal knowledge and preferences by the author of the index, and personal opinions represented by central bankers. Eijffinger and de Haan (1996, 26) argue that the questionned personnel may not always answer honestly to the questions providing too positive an impression of their independence. Then again, the questionnaire, sent to qualified employees of central banks, prevents research from being incomplete and imprecise with respect to the knowledge of local central bank law. It also gives a chance to discover divergences between legal and actual independence.

Cukierman (1992) constructs a measure based on answers to a questionnaire from "qualified individuals in various central banks". Questions cover the following issues: (1) legal aspects of independence; (2) actual practice when it differs from the law; (3) monetary policy instruments and the agencies controlling them; (4) intermediate targets and indicators; and (5) final objectives of monetary policy and their relative importance. The study presents values of the measure for 24 countries and refers to the subperiod of 1950–89. Cukierman (1992) undertook two rounds of aggregation that result with both an unweighted (QVAU) and a weighted (QVAW) variant of the indicator. The questionnaire-based index, contrary to LVAU or TOR, combines both legal and actual information on central bank independence. It is also more dependent on the personal judgment of respondents.

Masciandaro and Spinelli (1994) computed a CBI index by asking ten major central banks in industrial countries to evaluate the importance of individual factors contributing to CBI. A major distinction of this research was an emphasis on the difference between the *functional* and the *political* independence. The former has been defined as central banks' power to arrange the instruments of monetary policy, and the latter relates to the power to set the targets of monetary policy. Masciandaro and Spinelli organized various determinants of CBI according to this key. First, they formulated a CBI index based on their own evaluation. Second, they built a questionnaire to quantify a measure based on subjective feeling of central bankers. In a group of political independence, the authors identified, for example, the statutory definition of price stability as the main goal, or the non-interference of the government in the personal election process.

The functional independence is characterized by the central bank's possibility to control quantities of money and credit, as well as the impossibility to practice monetary accommodation thanks to its banking supervision duties. The political and functional independence index was calculated for 21 OECD countries. Due to a lack of correlation between the two types of independence in some cases, the authors compared their findings with previously calculated indices and, to complete the picture, asked ten major central bankers for their weighting of individual CB attributes. The first test confirmed that central banks with the highest overall independence are those in Germany, Switzerland and the United States, while with the lowest in Portugal, New Zealand and Spain. The second test proved that the greatest importance is attached to the price stability as the major law-secured goal of monetary policy. The non-interference of the government in money matters appeared to be crucial as well. In the area of functional autonomy, full control over

the official discount rate and control of credit to the government were considered the most relevant. Followers of Masciandaro and Spinelli (1994) later took two directions. One considered an update of the index based on new institutional arrangements inspired by the Maastricht Treaty. Motivated by the significant change in central banks in many countries, Tavelli, Tullio and Spinelli (1998) calculated values of the measure based on the status quo in May 1997 for fourteen countries of the European Union. The survey confirms a crucial shift indicating the improvement in the degree of CBI.

The study by Beblavy (2003) on the other hand, concentrates on replicating the survey sent to central bankers in transition countries. The author asked central bankers in the Czech Republic, Hungary, Poland and Slovakia to fill out a questionnaire with questions identical to those in the Masciandaro and Spinelli paper, and to give weights from 1 to 10 depending on their subjective feeling about the importance of individual factors. The results were compared with those for industrial countries. The comparison shows an important phenomenon: despite some similarities in perceiving CBI, considerably more central bank attributes are felt to be much more (less) important by central bankers in transition countries than in industrial ones.

A broad questionnaire-based study, provided by Fry, Goodhart and Almeida (1996), examines the objectives, activities and independence of central banks in developing countries. It is based on macroeconomic data from the International Monetary Fund (IMF) and the World Bank, as well as responses to the questionnaire from central banks. The central bank questionnaire includes queries not only referring to central bank independence, but also gathers the data from other areas. The sample consists of 44 developing countries. A number of obtained answers differs from the main sample due to either non-applicability of a certain question to the reality in a certain central bank, or to ambiguity of the question. Nevertheless, each question contains a significant number of observations, later used for the correlation analysis with inflation rate in relevant countries. The outcome of the survey builds the status of the central bank in each country and on the international market. Fry et al. underline the importance of the skilled staff employed in a monetary institution right next to the institutional framework ensuring its independence.

2.1.6 Alternative form of central bank independence

Kilponen (1999) studied the relationship between central bank independence, wage bargaining structure and macroeconomic performance in OECD countries. His

main argument is that "a successful inflation policy might be conditional on both monetary and labour market institutions" (Kilponen 1999, 7). The author estimates a cross-sectional time-series model for inflation, nominal wage growth and unemployment for the period of 1973-1996. Despite some similarities to the Cukierman index (1992), the model aiming to measure financial independence, differs in certain areas. First, it includes the reassessment of the Dutch Central Bank law, as pointed out by Eijffinger and de Haan (1996). Second, the adoption of inflation targeting is distinguished here by introducing a dummy for those countries that adopted inflation targeting. Third, the recent changes in countries' central bank laws were revised, which allowed the undertaking of this analysis, as the final point of changes, with an extension of time until 1996. Hence, this paper introduces a new index based on the Cukierman's modified measure, named KICBI.

Kilponen summarizes the effects of central bank law changes on the legal independence and emphasises the effects of introducing explicit inflation targeting. The introduction of inflation targeting has caused a rise (in some cases, noteworthy) in the degree of central bank independence. As Kilponen underlines, countries that continued with monetary targeting, such as Germany or Switzerland, have had the most independent central banks in the historic perspectives.

In addition to finding a new measure of central bank independence, Kilponen compares different forms of independence. He ranks countries according to political, personal, financial independence, as well as the importance of price objective in the status of central banks. Later, he calculates Spearman rank coefficients between different forms during the time of investigation. The results show a close relationship between financial independence and price stability, and a weak relationship between policy and financial independence. Finally, Kilponen analyses the relationship between wage bargaining and central bank independence.

An alternative approach and a formulation of a "quasi" central bank independence index is proposed by Iversen (1998). A hard currency index (CUR) is created based on the differential growth in exchange rates. Varying values show either a relatively depreciating currency (low values) or a relatively appreciating currency (high values). The intuition behind Iversen's work lies in the literature's modesty in compiling two crucial approaches of central bank independence and the idea of centralized wage-bargaining institutions. The first approach, Iversen explains, has been enthusiastically accepted as a remedy to macroeconomic problems. The latter supports an idea that "centralized wage-bargaining institutions coupled with flexible government economic policies (including Keyne-

sian demand management) would produce superior macro-economic performance" (Iversen 1998). Hence, considering both approaches and their opposite conclusions of proper institutions and policies, Iversen seeks a more general argument by providing an empirical test to suggest that "a restrictive macro-economic policy regime with a credible commitment to low inflation, and a flexible economic policy regime aimed at maintaining full employment are elements of distinct institutional equilibria" (Iversen 1998). Iversen tests his argument against the data from ten industrialized countries, covering the 21-year period of 1973 to 1993.

Different methodology for explaining CBI has been presented by Eijffinger, Rooij and Schaling (1996; ERS hereafter), who introduced an empirical panel data approach of calculating the index. Their attempt aims to formulate an index of actual central bank independence, which, determined by many unquantifiable factors, has been measured by authors indirectly. Following Koskela and Virén (1991)[2], the authors estimate reaction functions for monetary policy in ten industrial countries (Australia, Canada, France, Germany, Italy, Japan, the Netherlands, Switzerland, the United Kingdom and the United States). The interest is put on the response of the money market with respect to inflation, economic growth and current account surplus. Additionally, authors emphasise an individual country-specific effect, which is interpreted as *actual* central bank independence.

Less independent central banks are expected to show a lower individual effect (CBI), and lower generalized individual effect (EMP). The formula for EMP_i is $EMP_i = \beta_0 + CBI_i$. Because CBI_i is expected to be lower for a more dependent central bank and β_o is the same for all countries, EMP_i is also expected to be lower for more dependent central banks. The signs of the coefficients received by authors suggest that the "common reaction to inflation and economic growth is a higher money market rate which is the result of a more restrictive monetary policy". Germany and the Netherlands belong to the first group with the central banks strongly independent. On the opposite side, Italy and United Kingdom have by far the least independent central banks.

Based on the general assumption that the cost of greater central bank independence is an increase in output variability, Crosby (1998) tests empirically the hypothesis that countries with lower output variability are more likely to have an independent central bank. The author does not formulate a new measure of independence. Instead, using an index proposed by Cukierman (1992) and data for

[2]Koskela, E. and Virén, M. (1991) "Monetary policy reaction functions and saving-investment correlations: Some cross-country evidence", Weltwirtschaftliches Archiv. 127, 452-471

44 countries, he determines the relationship between real shocks and the degree of CBI. The regression, which includes the variance of the terms of trade in each country, the measure of instability and the sum of the ratios of imports plus export to GDP, found that the coefficient for the variance of terms of trade is always negative, with a small p-value for industrial countries (however, results are not significantly different from zero). Crosby explains that this suggests that the data are consistent with the hypothesis that countries with small real shocks will more likely choose independent central banks.

The importance of central bank accountability has been underlined and included in the analysis on the optimal central bank design. Independence and accountability joins a very specific relationship stating that an independent central bank cannot be accountable and vice versa. Nolan and Schaling (1996) attempt to find out the real relationship between these two ideas. They use an indicator of accountability constructed by Briault et al. (1996)[3] and the Eijffinger-Schaling index of independence (1993). Their outcome suggests a negative relationship between central bank accountability and independence. However, de Haan (1997) proves that by taking the GMT index and Cukierman indicators, this relationship disappears.

2.1.7 Measuring CBI in countries with transition economies

Literature on CBI distinguishes a separate collection of CBI indices, which are formulated particularly for transition countries. The ongoing process of structural and institutional changes that takes place in these states creates an opportunity of quantifying the degree of these reforms.

One of the first attempts to include a transition country's specific characteristics to a CBI measure is a study by Loungani and Sheets (1997). The authors construct the index by combining elements of the Grilli et al. (1992) index and connecting it with the methodology by Debelle and Fisher (1995). They define two measures of independence for transition countries and they introduce the Bundesbank as the main anchor. The first one, CBI-DF, gives equal weight to goal and economic independence. The second measure, SIB, is formulated by evaluating similarities of attributes between a given central bank and the German Bundesbank. Similar to Fratianni and Huang (1994), the authors consider the German central bank the

[3]Briault, C.B., A.G. Haldane and M.A. King (1996), "Independence and Accountability", presented at the Seventh International Conference of the Institute for Monetary and Economic Studies, Bank of Japan, Tokyo, October 1995, BoE Working Paper Series, no. 49, April 1996.

model of an independent and effective central bank. Both indices profit from the characteristics classified on the grounds of fourteen questions, grouped into three categories: goal, economic and political independence. Due to data constraints, the sample is limited to twelve countries mainly from Central and Eastern Europe. The reason for choosing these countries is the profound information available about these countries prepared by Hinton-Braaten (1994) and Lewarne (1995)[4]. Therefore, the data are constrained by the time limit of the end of the 1980s and the beginning of the 1990s. The authors have provided detailed information extracted from central bank charters, national constitutions and legislations.

Äimä (1998) measures the degree of legal CBI in the Baltic countries using the Cukierman and the GMT indices. De Haan, Berger and Fraassen (2001) concentrate on choosing the right disinflationary instrument for these countries, considering independent central bank and currency board. Maliszewski (2000) and Dvorsky (2000) also calculate CBI indices for the chosen transition countries. However, Maliszewski enriches the previous list of attributes in the GMT index with two new ones, and looks for a relationship between the degree of CBI and inflation. The new factors refer to provisions for the governor's dismissal as non-political only (political independence) and consider whether all direct credit is securitised (economic independence). The overall independence index presents values in majority much higher than those calculated by GMT for industrial countries. Only Ukraine and Romania scored below 10 points with the mean 12 points for this sample. Bulgaria and Lithuania scored the highest degree of independence. Maliszewski formulates the measure for twenty transition countries that include changes in central bank laws made by the time of the study (hence, in most countries, it represents the current state of laws).

Dvorsky profits from the experience of Cukierman (1992) and presents indices of legal and actual central bank independence for five chosen countries. Further, she computes the GMT index and compares her outcome with those of Maliszewski. The author not only analyses national legislation and assigns scores for different central bank attributes, but also compares with respective requirements of the Maastricht Treaty. While assigning weights to each factor, the author modified the scoring system to adjust it to "real" conditions of the countries, and to a considerable degree of subjectivity in interpreting the laws. Dvorsky explains

[4]Hinton-Braaten, Kathleen. "New Central Banks", Mimeo, July 15, 1994. Lewarne, Stephen. "The Russian Central Bank and the Conduct of Monetary Policy", in Establishing Monetary Stability in Emerging Market Economies, edited by T.D. Willet, R.C.K. Busdehin, R.J. Sweeney and C. Wihlborg, 167-92. Boulder: The Westview Press, 1995.

that the provisions of the countries' laws do not clearly fit to the list of attributes prepared by Cukierman. For example, it was difficult to attribute Cukierman's scores to the issue concerning appointment procedures of the central bank governor. Furthermore, building the GMT index for the sample, Dvorsky indicates certain disagreements with the methodology offered by Maliszewski. This comes mainly from differences in interpreting national laws by both authors and is expressed with varying final values of CBI for these five countries. Finally, Dvorsky calculates the turnover rate of governors as an example of the index measuring the "actual" CBI, which, as the author concludes, under conditions of "real" political influences on the appointment of governors, does not truly reflect the degree of actual CBI in these countries.

Fundamental changes in monetary institutions in former socialist countries have also attracted interest of Cukierman, Miller and Neyapti (2002). The aim of the authors was twofold. First, review institutional changes of central banks in countries leading to a systematic comparison of variations. Second, examine if it is suitable to state that similar to developed countries, there is an association between the inflation rate and degree of central banks independence. The authors pursued the analysis based on sixteen central bank attributes, referring mainly to LVAU and LVAW indices, introduced by Cukierman (1992) and Cukierman et al. (1992). The list of characteristics, as well as the method of coding, is similar to those used by these authors. The analysis covers 26 former socialist countries including former Soviet republics and Central and European countries. The study results in three indices of legal independence: the aggregate index LVAW and two narrower indices, LVES and LVESX. The authors placed their interest not only in finding the degree of institutional change, but they also tried to understand whether legal independence is transformed into actual independence, and finally looked for relations between CBI and macroeconomic variables.

Another contribution was done by Freytag (2003), who constructed an index that covers both internal and external components, considered as important for monetary stability. In the methodology of weighting and covered area, it is similar to the Cukierman index. Nevertheless, it includes clusters of characteristics concerning: the stated objectives of monetary policy (0.1); locus of legal commitment (0.1); discretionary power belonging to the government (0.1); conditions for appointment and dismissal of the CEO (0.1); conditions for lending to the government (0.25); accountability of the central bank (0.05); external pledges of the government (0.1); convertibility restrictions (0.1); interaction with other curren-

cies (0.05); and existence of a multiple-exchange regime (0.05) (Freytag 2003, 29, Annex)[5]. Additionally, Freytag has included the central bank attribute concerning supervision and regulation of the financial system by the central bank.

Freytag, in contrast to his predecessors, distinguishes CBI between internal and external. The components relating to the external relation of a central bank include areas of: exchange rate regime (0.1); convertibility restrictions (0.5); citizens' capability to use foreign currencies (0.15); and finally the existence of multiple exchange rates (0.25)[6]. The importance of including external relation components in the study on transition economies, as Freytag explains, is due to the long history of inflation in these countries. A high value for this part of the CBI index could be interpreted as a higher commitment to disinflation, as well as the government's commitment to a stable policy. An advantage of the external components included in the analysis is the ability to show the existence of differences with respect to convertibility. Moreover, the analysis of exchange rate regimes may be interpreted as the need for discretion in monetary policy, in case of a flexible exchange rate.

Having a hypothesis that a higher degree of *de jure* autonomy and accountability of central banks in post-soviet republics is positively correlated with lower than average inflation. Lybek (1999) formulates another index including both central bank features. His indicator is based on 21 criteria that were commonly used in other indices. Moreover, he underlines the importance of clearly defined coordination and resolution procedures between central bank and government. That is, "the coordination of monetary policy and exchange rate policy; and the prominence of accountability, including the central bank's financial conditions and audits by independent external auditors" (Lybek 1999, 11). The method of coding used is simplified, even though the author acknowledges its importance and controversy. The grades range between zero and one, and are "merely" added up. The highest degree of autonomy and accountability is therefore 21. The analysis includes fifteen countries of the former Soviet union that are classified into three groups according to their central bank legal improvements. Taking values of the autonomy and accountability index and values of macroeconomic variables, Lybek confirmed the hypothesis that a higher degree of central bank autonomy and accountability is negatively correlated with average annual inflation (CPI) during 1995-97. Moreover, this negative relation remains when the period measuring inflation is reduced or extended (although the deviations become larger).

[5]Weighting of attributes in the total index in parentheses.

[6]Weighting of attributes in the external part of independence in parentheses.

In addition to this 'traditionally' searched relation, the author also found a positive relation between increased central bank autonomy and accountability, and higher average annual real growth (GDP) during 1995–97, as well as a strong correlation between the reform index constructed by the European Bank of Reconstruction and Development[7] and the index for de jure central bank autonomy and accountability. Finally, Lybek concluded, it was not possible to determine if modern central bank legislation has promoted sounder economic policies. Except for a commonly found negative relationship between CBI and inflation, other outcomes might remain debatable. However, Lybek concludes that the likelihood for better inflation and output performance in these countries may increase along the prospects of reforming central banks' operations.

2.2 Do CBI measures rise up to the challenge? An analysis of robustness

The previous section showed how much a definition of CBI can vary, in how many possibilities it can be quantified, and how different the empirical results it can lead to are. The following analysis aims to summarize criticism of CBI measures that can be found in the literature. For a phenomenon that is widely accepted around the world, it is rather poorly and inconsistently defined. This section also includes a few simple quantitative tests to show these discrepancies.

2.2.1 Reliability and relevance of CBI indicators

Precision

The precision of indices depends on the proper understanding of central bank laws and status, knowledge of the researcher concerning monetary policy but also political science, or how carefully certain characteristics are analyzed. Equally important, however, is the weight, the importance given to certain characteristics by the author of an analysis. The relativity of opinions and assigning certain values to central bank attributes brings the problem of subjectivity in CBI measures. Several authors have already pointed out the difficulties of measuring CBI. For example, Cukierman (1992) explains this problem in the following way:

[7] The EBRD has developed an index for transition economies measuring their progress against the standards of advanced market economies. This reform index covers enterprise restructuring (privatization and governance), price and trade liberalization, and financial sector reforms. For more details, see www.ebrd.com.

> Actual, as opposed to formal, central bank independence depends on the degree of independence conferred on the bank by law, but also on a myriad of less structured factors such as informal arrangements between the bank and other parts of the government, the quality of the bank's research department, and the personalities of key individuals in the bank and other policymaking organs like the Treasury. (1992, 369)

Authors, undertaking the process of formulating independence measures, are aware of the difficulties they face. For instance, Alesina (1988, 40) underlines, how difficult it is to quantify all elements of what constitutes the "independence" into one measure. Later he mentions the work of Bade and Parkin (1988) and Masciandaro and Tabellini (1988), and acknowledges their pioneer work by calling it "courageous attempts"[8]. Grilli, Masciandaro and Tabellini (1991, 367) conclude the list of attributes they prepared with the statement, "combining them is unavoidably arbitrary so we adopt the simplest procedure of adding them up". Similarly, Cukierman, Webb and Neyapti (1992, 383) also admit, "unavoidably, there were subjective or arbitrary decisions in coding, classifying, and weighting legal information". Concluding these "confessions" of imprecision of indices, Forder (1999) emphasizes how surprising it is that, despite these difficulties, the literature seems to have reached the consensus that there is an inverse relationship between the degree of central bank independence and the rate of inflation.

Precision of indices is of great importance since their main use is to find a relation between the index and macroeconomic variables. Eijffinger, Rooij and Schaling (1996) show that a common problem, while formulating indices on the basis of statute analysis, is an unavoidable arbitrariness. Each economist, while building an index, may be biased in favour of his/her country. Greater knowledge of the case "brings the recognition of the greater freedom of behaviour acquired in current practice by the national central bank compared to the formal rule". Therefore, Eijffinger and Schaling (1993, 50) stress three types of choices involved when constructing any index, where elements of subjectivity are often present: (1) which criteria should be included in the index; (2) how the legislation should be interpreted with respect to each retained criterion (which leads to their individual valuation); and (3) what weight should be attributed to each criterion in the composite index. Similarly, Mangano (1998) suggests areas of "special concern" that have to be considered while computing CBI indices: a criteria spread, an interpreta-

[8]This term is also used by Eijffinger and Schaling (1993) and Schaling (1995), as well as in this study.

tion spread and a weighting spread. The first one represents the extent to which the researchers' personal preferences affect the selection of the criteria included in the index. This spread can also describe the researcher's knowledge about central banks as institutions or be conditioned by the easiness of obtaining the data. The interpretation spread refers to the extent to which the researchers' reading of the legislation pertaining to these criteria is different. Finally, the last area is a weighting spread that refers to the extent to which the final value of the index is affected by the choice of relative weights to be assigned to each attribute.

In addition, Forder (2000) names "traps" in the measurement of central bank independence, focusing on the analysis of central bank statutes and laws. He assumes that the designers of statute-reading measures postulate an opinion that a central bank always sets what they believe to be the best policy, once given the power to do so. A similar opinion is presented by Woolley (1994) who remarks that a lack of interest is presented by measures in an area that should be of central importance, that is, whether independent central banks actually are able to act contrary to the government's wishes. Forder (2000) argues that the true power of an institution is determined by the actual practice in enforcing their own decisions rather than formal rules and "appearances". Elgie and Thompson quote an opinion presented originally by Woolley (1994) and say that the determinants of independence are:

> (...) not purely formal; they are not simply to be found in legal statutes and standing orders. Instead, they reflect the practice of core executive/central bank relations. In this sense, they reflect the behavioural relationship between the central bank and the core executive than just the statutory relationship (1996, 28).

The difficulty appears to be in finding a remedy to the problem of a "shallow" statutes analysis. Elgie and Thompson (1998) suggest including data on the actual procedures, which are very often informal ones. In their methodology, not only written law but also practical procedures used by the central bank can satisfy the condition that constitutes central bank independence. This approach addresses the criticism of Forder (2000), who argues that this solution "does not turn the resultant index into a measure of the extent to which monetary policy is set independently". He suggests an examination of the broader constitutional and intellectual environment to ameliorate or even replace the statute-reading methodology.

The measurement of legal independence seems to create a conceptual and empirical problem. As Kilponen (1999) suggests, even a comprehensive legal mea-

sure such as Cukierman's LVAU, may not provide an objective measure of actual central bank independence. Focusing on certain areas of CBI may neglect other issues. Financial independence is an area of interest during the study of the relationhip between central bank independence and the budget deficits. On the other hand, judging the link between inflation and independence, political and policy independence may play the most important role. Thus, in empirical analysis, Kilponen (1999) concludes that controlling is essential for the different forms of legal independence, contrary to using only the aggregated summary measures.

Criticism

Many approaches aiming at defining a CBI measure are vulnerable to the criticism of subjectivity. Mangano (1998) points out the seriousness of the measurement problems that affect most CBI indices, and implies that both GMT and Cukierman legal CBI index "suffer from a rather large subjectivity spread". He acknowledges that any empirical result based on these two indices may be imprecise and questionable. This opinion is shared by Siklos (2002, 67) who underlines the existence of some inaccuracies in Cukierman's index for the 1980s. He also presents an updated and revised Cukierman's index for the 1980s and values of legal independence calculated for 1990s. Siklos' major accusation concerns "weak justification for the decennial choice of periods to analyze" and names several reasons why one could question its soundness:

1. The chosen periods correspond poorly to the dates of actual changes in legal acts of several central banks

2. There exists considerable diversity among countries in the dating of the end of exchange rate regimes

3. There are no changes in any of the elements that make up Cukierman's index among most of the decades considered.

Further criticism of Cukierman's index can be found in the work by Banaian, Burdekin and Willet (1998) who argued that Cukierman has neglected the importance of the central bank's obligation of policy formulation putting more than three times as much importance to the problem of the central bank's participation in the primary market for government securities.

Mangano (1998) and Banaian et al. (1998) present two different methods of revising Cukierman's LVAU index[9]. To revise Cukierman's indices and propose an alternative way of calculating them, the former undertakes a method of direct comparison of indices' individual characteristics with the index calculated by Grilli et al. (1991). Later, he follows by using the country rankings in the empirical study rather than the value of the indices. In general, Mangano finds that two indices disagree nearly in 60% of all countries included, in the area of an attribute concerning central bank's ability (legal permission) of purchasing government debt in the primary market. Direct comparison of indices includes the procedure of refining the definition of some characteristics in order to be expressed in a binary scale (Yes/No). In effect, each index, normalised on a [0; 1] scale, obtains a new value that refers to the original value of CBI. A composition of supplementary indices (four altogether) underlines a certain area in which indices of legal CBI can be accused of subjectivity.

A different approach was presented by Banaian et al. (1998) whose analyses focus on finding the relationship among fifteen institutional categories of central bank frameworks and average inflation rates. The choice of Cukierman's index is explained by its most comprehensive data set that was available at that time. Banaian et al. (1998) use a principal components analysis to study, which categories out of fifteen used by Cukierman seemed to be more important in practice. The results point out that the majority of the attributes included in the Cukierman index are either insignificant or of the wrong sign, and therefore imply the possibility of wrong coding used by Cukierman especially for policy independence. Considering that Cukierman (1992) focused on legal as opposed to actual independence and tests done by Banaian et al. (1998) proving the insignificance of the Cukierman's choice of attributes, the index of legal central bank independence seems to be informative only in a limited area.

Additionally, Forder (2005) named several problems of CBI measures considering theoretical imprecision. First, he mentioned the theory of bureaucracy and an aspect of support for independence expressed in its failure to respond to the issues raised by this theory. Second, he found another fault on the empirical level. If central bank independence is to be laid on the presumption that the statutes of a bank determine its objectives and behaviour, then it is in contrary to the norms of conventional analysis.

[9] As mentioned before, the same index is presented by Cukierman et al. (1992).

Measures of legal independence have been widely criticised, and the use of indices measuring actual central bank autonomy has been supported by many. However the turnover of the governor (TOR) index has not been left without criticism. Although Banaian et al. (1995) acknowledge the contribution of Cukierman's indices, they argue that it is insufficient to read central bank laws on the financial relationship between central bank and government. Such a method does not explain the pressures on central banks when open market operations are concerned. The authors also claim that the turnover rate reveals little information about government influence on central banks, and what effect the degree of TOR will have on inflation in industrial countries. Moreover, it is possible, that a low degree of turnover indicates only an accommodating governor, who is unlikely to be replaced. Brumm (2000) follows this view and shows the imperfections of this indicator arguing that it might not consider the possibility that a central bank governor stays at his post for a long period simply thanks to an agreement with political leaders.

Indices formulated by Cukierman (1992), Cukierman et al. (1992) or Cukierman and Webb (1995) have been criticised many times, but have been used as a proxy of CBI in many other studies. Certainly, the precision of indices and the comprehensiveness of the data create the possibility of a profound analysis. The above presented list of faults they carry forces a question of whether these are really the proper indices defining what is currently seen as central bank independence.

Presence of decisive central bank attributes

The literature on the political and economic influence of an independent central bank on the economy pays careful attention to the detailed precision of central bank institutional attributes. It raises the question, "What are the most important elements of a strongly anti-inflationary institutional structure of the central bank?"

Eijffinger and Schaling (1993) decide to call a decisive attribute the one concerning final policy authority. It results with asymmetry in favour of this idea, giving less importance to questions concerning the presence of a government official on the board, or board appointments procedure. Similarly, Banaian et al. (1995, 1998) argue that basic theoretical principles direct the priority to attributes concerning the formal ability of the central bank to set monetary policy autonomously. Hence, they assign less importance to the central bank as an interventionist in the market for government securities. Naturally, all attributes, including the procedure of appointment or financial relationship with government, are informative when the political pressure placed on monetary authorities is concerned. However, "where

the government makes the basic policy decisions and the role of the central bank is limited to simply implementing the government's instructions, the effects of these other attributes are likely to be severely compromised" (Banaian et al. 1998, 3-4).

Constructing effective and optimal measure means knowing which attributes are good and which are poor. Forder (1999) argues that in practice, the literature distinguish effective from non-effective measures on the basis of their relations to inflation. That is, the optimal index will show (expectably) a negative relation with inflation rate, whereas a poor index will not show a relation of this kind. On the other hand, Elgie (1998) implies that the best measure uses the largest number of central bank attributes. In this sense, the approach of Cukierman et al. (1992) is by far the most sophisticated methodology. Forder (2000) challenges this opinion stating that increasing the number of characteristics in the measure may be damaging if they are of no relevance to the practical ability of the central bank to resist government pressure.

Forder (1999) compares three measures different in methodology and criteria: the one initiated by Parkin and Bade (1978)[10] and followed by Alesina (1988, 1989); the index formulated by Grilli, Masciandaro and Tabellini (1991); and the turnover rate of central bank governors' index by Cukierman, Webb and Neyapti (1992). All measures point the same way and seem reasonable, even though they differ in three important aspects: different approaches to measurement; different resultant measures; and different results from comparing the resultant measures with inflation. Interpreting the three measures, Forder (1999, 27) states that "none of these papers presents a true test of the independence hypothesis. They have in various ways identified more or less plausible proxies for independence that are related to inflation; but in the process they have identified equally plausible proxies that are not". He continues that these studies have different understanding of what he claims is the key issue of independence, that is, what constitutes independence on an empirical level. Therefore, Forder (1999) summarizes, "mutually confirming studies are more in the nature of being mutually contradictory".

Challenging the criticism of subjectivity in constructing CBI measures, Fry et al. (2000) defined their independence index based on central bank attributes mentioned in previous studies. The authors combined a range of characteristics, taken from Cukierman (1992) and Grilli et al. (1991). Although the method used

[10]Parkin, Michael and Robert Bade. (1978), "Central Bank Laws and Monetary Policies: A Preliminary Investigation", in M. Porter (ed.), The Australian Monetary System in the 1970s, Monash University, Clayton, Australia.

Table 2.3: Institutional determinants of CBI–specific questions

Attributes/Index	1	2	3	4	5	6	7
Is the bank final							
policy authority?	*	*		*	*	*	
Statutory objectives			*	*	*	*	*
Is there no Government							
official on the bank board	*	*	*	*	*		
Procedures of appointing the board							
of the central bank	*	*	*	*	*		*
Financial and budgetary relations							
between CB and Govern (e.g. Monetary							
financing of budget deficit							
and limitations on lending.	*	*	*	*	*	*	*

Notes: 1=Bade and Parkin(policy), 2=Alesina (policy), 3=Grilli et al. (political and economic), 4=Cukierman and Cukierman et al., 5=Eijffinger and Schaling (policy), 6=QVAU, 7=Fry et al.
Source: Bade and Parkin (1988), Alesina (1998), Grilli, Masciandaro and Tabellini (1991), Cukierman (1992), Cukierman, Webb and Neyapti (1992), Eijffinger and Schaling (1993), Fry et al. (1996)

could be again cricised for subjectivity, the key idea was to ask central bankers for their opinion on what is most and least important when talking about central bank independence. The index not only carries detailed knowledge on each country's central banks, but also was one of those few that distinguished between knowledge of academics and policy-makers.

Table 2.3 summarizes the list of CBI attributes that are based on a specific question, rather than a general idea, and indicates which question has been included in which measure. Measures are organized according to their date of publication, and thus the table gives a view on the development of indices. Moreover, first "courageous attempts" of quantifying CBI focused rather on whether later indices included more general ideas. Hence, this attribute representation is divided into two tables.

The subsequent table includes not only a few measures and their decomposition, but also policy-makers' view on CBI importance. According to central bankers, the most important CBI attribute is the one giving a central bank control over monetary instruments. Such a defined attribute is found only in the index by Loungani and Sheets. The second most important idea, that is, policy responsibility on monetary policy, is already included in all the measures considered here. Finally, whether central bank is responsible for financing budget deficit, has been considered as the least important by central bankers, and yet five out of seven mea-

Table 2.4: Institutional determinants of CBI in the literature

Determinants	1	2	3	4	5	6	7	8
Governor appointments		*	*		*	*	*	4
Governor term	*	*	*		*	*	*	5
Central bank Board appointment	*	*		*	*	*	*	4
Central bank Board term	*	*			*	*	*	5
Government participation in the Board	*	*		*	*	*	*	4
Policy responsibility on monetary policy	*	*	*	*	*	*	*	2
(Legal) Provisions in case of conflicts Government - Central bank		*	*		*		*	
Central bank statutory goals		*	*	*	*	*	*	3
Monetary financing of the budget deficit		*	*		*	*	*	6
Discount rate setting		*			*		*	
Policy responsibility on banking supervision		*			*		*	
Central bank control monetary instruments						*		1

Notes: 1 = Bade and Parkin; 2 = GMT; 3 = Cukierman; 4 = Eijffinger and Schaling; 5 = Masciandaro and Spinelli; 6 = Loungani and Sheets; 7 = Maliszewski; 8 = Questionnaire (ranking of importance according to Fry et al. 2000)

Source: Bade and Parkin (1988), Grilli, Masciandaro and Tabellini (1991), Cukierman (1992), Eijffinger and Schaling (1993), Masciandaro and Spinelli (1994), Loungani and Sheets (1997), Maliszewski (2000), Fry et al. (2000).

sures refer to this problem.

As already mentioned, assigning the degree of importance to each attribute also determines the final degree of CBI. The two main indices of CBI, Grilli et al. (1991) and Cukierman et al. (1992) have opposite weighting in the major areas of central bank autonomy. Banaian and Luksetich (2001) calculate that Grilli et al. (1991) weigh the fiscal relations between a central bank and government as much as $5/7$ of all economic attributes, whereas it is over half of the criteria in Cukierman's total index. The attribute "financial and budgetary relations" is a very wide characteristic. Even though it is included in all seven criteria, different weighting is put on its importance, from extensive analysis by Cukierman and Griili, Masciandaro and Tabellini, to one question in Bade and Parkin or Alesina. Studies by Cukierman and Webb (1995) resulting in building the vulnerability index, questionnaire-based indices by Cukierman (1992) or Fry et al. (1996) and the turnover rate index (Cukierman et al 1992, and followers) concentrate on completely different aspects than the previously mentioned indices.

Differences not only between academics, but also academics and policy-makers,

Table 2.5: CBI measures and their focus on central bank attributes

	Cukierman	Maliszewski	Loungani and Sheets	Rank (Fry et al.)
CEO	20	31.25	46	2
Policy Formulation	30	37.5	38.5	1
Lending Restrictions	50	31.25	15.5	3

Notes: Values for three first measures represent the percentage of focus put on certain attributes compared to the total number of central bank factors. The last column informs about the ranking given to these attributes by central bankers.
Source: Own calculations based on data provided by authors.

are summarized in the Table 2.5. It shows the percentage share of three major groups of CBI determinants within three various CBI measures, calculated for transition countries. Therefore, it is clear that determinants on lending restrictions are most important in the measure by Cukierman, and thus constitute half of all attributes. At the same time, Loungani and Sheets give only 15.5% of interest to these attributes in their index. Which measure is most accurate could be determined by the last column, the rank of importance given by central bankers in developing countries (third means least important), and the fact that only Loungani and Sheets, of these two, have calculated the measure especially for transition economies. Loungani and Sheets, on the other hand, focus 46% of all attributes on personal independence, which has also not been chosen most important by central bankers. Finally, Maliszewski, who builds his index on Grilli et al. (1991), as mentioned before, places the importance rather evenly on three groups of determinants, giving priority to policy formulation, and hence to policy-makers' opinion.

To focus more on central bankers' understanding of CBI, one should consider a study done originally by Fry et al. (1996), later replicated and updated with new countries by Fry, Julius, Mahadeva, Roger and Sterne (2000). Figure 2.1 presents a summary of their work. The analysis has included both developing and industrial countries, and one of its goals was to determine how central bank autonomy is perceived by policy-makers.

According to 80% of responses gathered among central bankers, CBI is understood as independence in operations, instruments and fulfilment of goals. Therefore, it relates to the "instrument" independence, according to Debelle and Fischer's (1995) classification. The ability to formulate these goals is perceived as the second most important factor of CBI, with almost half of responses. While it is understandable that communication without constraints may not be included among the most important CBI determinants (only 8%), policy-makers also marginalise

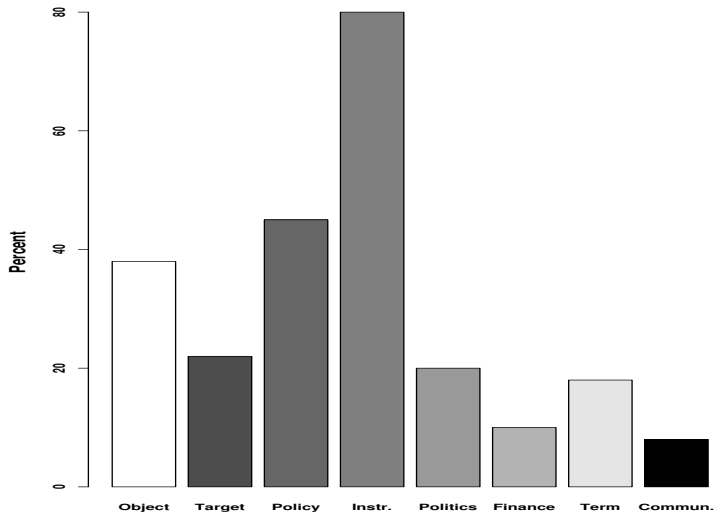

Figure 2.1: Distribution of opinions about CBI importance
Source: Fry et al. (2000), *Key Issues in the Choice of Monetary Framework*, in Mahadeva, L. and G. Sterne (eds), (2000), *Monetary Frameworks in a Global Context*, 111, Routledge

the fact of whether there are any limits on deficit finance.

As mentioned, Beblavy (2003) allows to distinguishe understanding of CBI between industrial and selected transition economies. The author shows the largest discrepancies in perceiving CBI on the question concerning provisions in the central bank law on conflict resolution. The mean value in Central Europe is 2.5 (small importance), whereas central bankers in industrial countries find it very important (the mean equals 7). Table 2.6 summarizes the most interesting deviance in central bank attributes values.

The author explains these differences with imprecision in the identification of criteria and mentions five additional factors to be included in future studies based on central bankers' suggestions. For example, the proposals concerned introducing a criterion of whether there are any (quasi) fiscal measures of the central bank financing the budget proposed by itself, or forbidding the direct credit altogether.

Franzese (1999) argues that the degree of central bank independence is connected with its ability to introduce the anti-inflationary actions. Therefore, the less anti-inflationary impact that the central bank has, the greater central bank independence. Pro-independence and anti-inflationary institutions should increase the degree of independence at the time of their rising power, meaning when they

Table 2.6: Importance of CBI criteria according to central bankers

	Mean: Central Europe	Mean: Industrial Countries	Difference
Provisions in the CB law on conflict resolution	2.5	7	-4.5
CB not in the primary govt. debt market	1	5	-4
Rest of the board not appointed directly by the government	7	4	3
Requirement in the CB law that CB pursues monetary stability	6	9	-3

Source: Beblavy (2003).

are able to force such a change. It happens not because it is necessary, but because it is possible at that time, and may become necessary in the future when, having been established, it may be harder to remove. Credible delegation of monetary policy authority to an independent and conservative central bank can serve as a commitment rule to walk around the time-inconsistency problem, and therefore the inflationary bias. Furthermore, he suggests that central bank independence cannot be constant and, therefore must vary with the broader political-economic environment in which the bank operates. Left-wing and right-wing governments are said to differ in the area of inflationary and wage pressures. Being aware of these differences, a central bank's level of autonomy should be greater in a market with left-wing (socialist) government, and therefore the anti-inflationary impact of central bank independence should be greater as well. The anti-inflationary impact of central bank independence will therefore be different in some countries, depending on the political environment and on whether the government is inflation-averse or not. These specific arguments about central bank independence show that the effects of any given institution are contextual; they depend on political, economic, structural and institutional configuration, and interactions among them.

Therefore, a measure of independence needs to observe common characteristics represented by each group of countries, whether industrial or transition, to depict effectively the actual degree of independence. Certain characteristics and peculiarities of these groups need to be underlined; such as narrow capital markets and limited access to foreign financing, price shocks or macroeconomic imbalances, as is the case with transition countries. An analysis needs to consider what role a central bank is playing in the country; whether it is a social player or banking agent, or whether it fulfils the responsibilities of a monetary agent.

Moreover, when further analysis of relationships with macroeconomic variables is undertaken, control variables used in a regression function ought to be distinctive for each sub-sample.

2.2.2 Transparency of design, similarity of means and coherence of measures in a few tests

In our presentation of CBI indices, we have already suggested that measures by Grilli et al. (1991) and Cukierman et al. (1991) have been chosen as a cornerstone in subsequent empirical analysis. This choice has been done, however, on purely subjective opinion, without performing any comparison tests of other candidate measures. The remaining part of this chapter is focused on a few simple tests of correlation and dissimilarities among CBI measures, while a more advanced analysis can be found in Chapter 3.

The first problem arises when attempting to find the right classification method. It is true that, CBI indices are often differentiated by the type of independence they describe, that is, legal or actual. However, other factors such as the numerical scale the measures are based on can be decisive, too. For example, some simple measures consider number 1 to represent the lowest level of CBI, while in case of the Cukierman index, 1 is always the highest value. Also, the time period for which measures have been calculated can be also decisive. Other classification method would assume grouping indices according to the number of countries they were calculated for.

We decide to focus first on the base indicators. These are indices prepared by Bade and Parkin (1988), Alesina (1988, 1989), Grilli, Masciandaro and Tabellini (1991), and later Alesina and Summers (1993), and Eijffinger and Schaling (1993). They are characterized by certain conditions: assigning equal weight to each attribute (0 for absence, and 1 for a factor being present); distribution differences [0; 1], depending on how many attributes are taken into account (e.g. GMT: 15 in total, Bade and Parkin: 4); analysis of the same group of countries (at first, twelve industrial countries, later twenty); similar period (up to the end of the 1980s, does not cover the huge wave of updates in industrial European countries that occurred in the 1990s).

The sample is enriched by legal measures formulated by Cukierman (1992) and Cukierman et al. (1992). These indices are characterised by extensive methodology and a much larger sample of countries. Moreover, certain attributes of central bank independence are given different degrees of importance, contrary to previ-

Table 2.7: GMT and Cukierman index

Country	GMT by Benhard (Mangano)	GMT by Eijffinger and Schaling	Cukierman (LVAU)
Germany	0.87	0.81	0.66
Switzerland	0.80	0.75	0.68
U.S.	0.80	0.75	0.51
Canada	0.73	0.69	0.46
Austria	0.60	0.56	0.58
Netherlands	0.67	0.63	0.42
Denmark	0.53	0.50	0.47
Ireland	0.47	0.44	0.39

Notes: GMT normalized with two methods

Source: Bernhard (1998), Mangano (1998), Eijffinger and Schaling, and Cukierman (1992)

ously mentioned studies. Therefore, the assumption of equal weight given to each factor does not exist here. Weights are descending along the smaller degree of independence they indicate, and they depend on the researcher's own assigning methods. Also, indices of this group characterize the biggest sample of countries; as well as commonly analyzed industrial countries, there is an extensive description of developing countries and countries with transition economies.

In order to continue with analytical tests and to overcome the dependency of results on the measurement scale, it is important to convert indices into a standard set of units. Converting them to one scale is problematic at first because the span of the scales has various interpretations. For instance, in Alesina (1989) the highest possible level of independence is 4, and there is no category 5; in GMT (1991) number 4 represents a medium level of independence in the scale (1-7) of political index and a low level in the combined index of economic and political independence (1-15). On the other hand, Cukierman (1992) and Cukierman and Webb (1995) rely on a scale of 0 to 1. Collating Alesina's highest value (4) and Cukierman's highest level of independence 0.68 (both values reported for Switzerland) raises the question of whether these two indices indicate similar "real" level of independence.

The "normalization" is justified by Eijffinger and Schaling (1995) who explained it in the following way: "Such a comparison is only possible if both the optimal degree and the legal indices are normalized on their theoretical scale".

Mangano (1998) tries to collate two indices–the GMT and the Cukierman index–and uses simple arithmetic calculations by dividing the value of an index by the number of attributes (this method is used also by Bernhard 1998). Table 2.7 presents normalized values of GMT index for several countries, and additionally compares them with Cukierman's index. One conclusion drawn from this table is that the imprecise conversion from one scale to another actually affects the CBI degree, and can be decisive in further empirical analysis.

An alternative method of unification of different scales used in measures is suggested by Forder (1999) and relies on a rank ordering expressed as a "percentage" to normalize for different sized samples. A central bank, which is the least independent of a sample of eight, will end up with 12.5% as its CBI level. Table 2.8 summarizes several percentage values for three independence indices offered by Forder with their original values.

Table 2.8: Rank order of independence presented in percentage

Country	**GMT**	**CWN**	**Alesina**
Belgium	50 (7)	7 (0.17)	55 (2)
Japan	36 (6)	14 (0.18)	88 (3)
New Zealand	8 (3)	26 (0.24)	12 (1)
Netherlands	78 (10)	62 (0.42)	55 (2)
U.S.	92 (12)	76 (0.48)	88 (3)
Switzerland	92 (12)	95 (0.64)	100 (4)
Germany	100 (13)	100 (0.69)	100 (4)

Notes: Original values in parentheses

Source: Forder (1999)

Alesina and Summers (1993) on the other hand, compare the Bade and Parkin measure with GMT (Grilli et al.) index and calculate their average, so their normalization requires only a convergence from the GMT (1-15) scale to a (1-4) scale comparable with the BP one.

Basic tests used in our analysis help to discover how close the CBI definitions really are to each other. One of those tests is the correlation analysis. Its primary objective is to measure the strength of linear association between two variables. Table 2.9 presents Kendall's correlation coefficients for indices with data. Kendall's statistics measure the correlation between two sets of rankings. Indices that describe a similar group of attributes and countries show high values of correlation. Measures constructed by Grilli et al. (1991) closely correlate with each other or

with some other indices. For example, GMTE, a legal index covering economic aspects of independence shows some similarities to Alesina and the overall measure combined from economic and political aspects of GMT.

Table 2.9: Kendall's correlation coefficients

Index	1	2	3	4	5	6	7	8
1	1	0.568*	0.262	0.585**	0.435*	0.385	0.651**	0.942**
2		1	0.321	0.729**	0.180	0.343	0.316	0.462
3			1	0.648**	0.326	0.496**	0.426*	0.337
4				1	0.306	0.480**	0.532*	0.532*
5					1	0.267	0.501*	0.704**
6						1	0.689**	0.341
7							1	0.571*
8								1

*Significant for $\alpha = 0.05$. **Significant for $\alpha = 0.01$.

1-Alesina, 2-Grilli, Masciandaro and Tabellini Economic, 3-GMT Political, 4-GMT Total, 5-Eijffinger and Schaling, 6-LVAU (Cukierman), 7-Fratianni and Huang, 8-Bade and Parkin.

Source: Own calculations based on original data. Sources in references.

The reasons for a low correlation between GMTP and BP, for example, can be found first, in a variety of criteria taken to construct the index, and second, in the way the authors interpret the relevant bank laws. The former explanation refers to different aspects taken into considerations by the authors. GMT indices cover both economic and political independence and, bring fifteen different central bank attributes. Bade and Parkin (1988) concentrate on four general criteria, which determine policy independence, included by the authors to a group of legal independence.

An explanation for inconsistencies among measures has been sought within the understanding of each country's law. The wider the knowledge of a central bank, the greater detail put on the measure, and larger variations in the value among indices for that country. For example, Eijffinger and de Haan (1996, 24) comment on Cukierman's (1992) interpretation of the Dutch central bank law, which they are most familiar with. Their knowledge lets them believe that the Nederlandsche Bank is more independent than Cukierman's coding suggests. A similar misinterpretation happened for Bade and Parkin's (1988) ranking of Italy, as Alesina (1998, 1989) explains, that resulted with a different value of ranks presented by the authors. The Eijffinger and Schaling's index (1992, and later 1995) covers the biggest number of similar attributes of those in Bade and Parkin and Alesina's indices. This can be seen in higher values of coefficients.

Table 2.10: Kendall's correlation coefficients

	GMTO	LVAU	LVAUCWN	LVAUS	LVES
GMTO	1	0.616**	0.556**	0.439*	0.452*
LVAU		1	0.846**	0.536**	0.427*
LVAUCWN			1	0.567**	0.415*
LVAUS				1	0.373*
LVES					1

Notes: *Significant for $\alpha = 0.05$. **Significant for $\alpha = 0.01$ Source: Own calculation based on data provided by the authors.

For the second correlation, we choose the following indices: GMTO, LVAU, LVAUCWN (calculated by Cukierman et al. 1992), LVAUS (calculated by Siklos 2002), LVES and their values calculated for advanced countries for the central banks' legal status quo at the beginning of the 1990s. When analyzing the correlation results, we look again at the coefficients between each pair of measures. However, here we are especially interested in correlation coefficients among three measures: LVAU, LVAUCWN and LVAU by Siklos. These measures are the same in construction. The only differing factor is the author, who was responsible for collecting the relevant data. If values of these indices show large differences, we conclude that values of CBI indices have a personal bias. The strongest expected correlation can be observed between legal measures LVAU and LVAUCWN (based on the data in Table 2.10). These two indices were calculated in parallel by a similar group of researchers. Next, the values of correlation among indices decrease and values around 0.6 are found for measures calculated by Grilli et al. (1991) and Cukierman et al. (1992). The coefficients of correlations are lower (around 0.5) for measures having the same definition (LVAU) but calculated by different researchers (Cukierman et al. 1992, or Siklos 2002). These last findings indicate that there is a weak personal bias in measuring CBI. One would expect to receive much higher correlation values for measures LVAU and LVAUS. Finally, the lowest values are found for correlation analysis between LVES and the rest of the indices was anticipated, because this measure's definition includes transition economies' special factors.

Often, studies on central bank independence treat the Bundesbank as the model of a perfectly independent central bank. In some studies, its level of CBI is not even calculated, but is assumed to have the highest value. A similar situation appears with the central bank of Switzerland. It is thus possible that CBI values correlation analysis is biased once these countries are included in the process. Table 2.11 pro-

vides Kendall's coefficient for indices without these two countries in the observed sample.

Table 2.11: Kendall's coefficients excluding Germany and Switzerland

Index	1	2	3	4	5	6	7	8
1	1	0.425	-0.023	0.423	0.188	0.152	0.500*	0.905**
2		1	0.165	0.673**	-0.081	0.187	0.100	0.238
3			1	0.565**	0.110	0.386	0.248	0.067
4				1	0.065	0.355	0.355	0.292
5					1	0.039	0.297	0.530
6						1	0.605**	0.00
7							1	0.349
8								1

*Significant for $\alpha = 0.05$. **Significant for $\alpha = 0.01$.

1-Alesina, 2-Grilli, Masciandaro and Tabellini Economic, 3-GMT Political, 4-GMT Total, 5-Eijffinger and Schaling, 6-LVAU (Cukierman), 7-Fratianni and Huang, 8-Bade and Parkin.

Source: Author's own calculations based on original data. Sources in references.

Excluding Germany and Switzerland from the sample shows an even greater lack of correlation between measures. Most striking is the negative sign of coefficient marking relation between GMT economic and Eijffinger and Schaling indices, as well as GMT political and Alesina indices. Though statistically insignificant, these results deny the possibility that indices measure the same variable. Forder (1999) points out that it may be a matter of concern when measures of the same subject give rise to such wide divergences in a substantial number of cases. Moreover, he claims that any similarity of measures depend highly on an agreement that the central banks in Germany and Switzerland are independent.

The choice of attributes (for example, subjects responsible for formulation of monetary policy) in constructing Eijffinger and Schaling's index indicates closer relations to the GMT political one. Nevertheless, even here the coefficient is close to zero, when Germany and Switzerland are excluded. Examples of such contradictions can be seen in Table 2.12. The case of Australia and Canada proves that GMTE and ES may describe different areas of CBI, and suggests closer relations between the latter and GMTP. GMT political values for Japan and New Zealand, on the other hand, contradict this supposition.

Formulating indices has been so far a process of finding the unified measure for various groups of countries. Researchers have challenged different approaches with various combinations of attributes in the analysis. Increasing the number of characteristics and countries in the sample helped attract attention from other

Table 2.12: Sample values for GMT E and P and ES

Country	GMT Economic (1-8)	GMT Political (1-9)	ES Policy (1-4)
Australia	6	3	1
Canada	7	4	1
Japan	5	1	3
New Zealand	3	0	3[a]

[a] Extension for New Zealand comes from Eijffinger and Van Keulen, "Central Bank Independence" (1995). It refers to central bank laws adjusted during the last ten years.

Source: Grilli, Masciandaro and Tabellini (1991), and Eijffinger and Schaling (1992)

researchers but at the same time, did not prevent the wave of criticism from others. Meanwhile, it may be reasonable to look for the perfect index to suit every country, knowing that unification of the world economic market may never become true. Is it worth the effort to search for an ideal measure of an idea like central bank independence, which does not even have a unified clear definition?

The questionnaire-based analysis, prepared by Fry et al. (2000) revealed that the most important factor that defines central bank independence, according to central bankers participating in the survey, was the capacity to set instruments and operating procedures autonomously. Around 80% of 97 central bankers mentioned this in their responses. In a group of developing countries, the absence of fiscal dominance becomes the most defining CBI. Moreover, the authors were able to distinguish two groups of countries that found their capability to meet clearly defined statutory objectives as a part of the independence definition. The first group is formed by central banks whose mandate and statutory objectives have been updated in recent years; for example central banks in transition economies and European central banks affected by the Maastricht Treaty. The second group contains central banks in money and exchange-rate targeting countries (Fry et al. 2000, 110).

Table 2.13 provides rankings of legal central bank independence for developed and transition countries, based on the comprehensive method formulated by Cukierman, Webb and Neyapti (1992) and updated by Cukierman, Miller and Neyapti (2002), and Siklos (2002). Columns provide a summary of statistics for the following: a sample of developed countries with data presented in the original study for the period 1950-1989 (column 1); developed countries with data updated

for the 1990s that includes the European Central Bank (column 2); a sample of 26 transition countries (column 3); and ten new EU member states (column 4). It is immediately obvious that there are high variations of central bank independence, and most surprising are much higher values in a sample of transition and later new EU member countries. Among developed countries, a common obligation of increasing central bank independence, as detailed in the Maastricht Treaty, and a common trend for non-European countries are visible (for example, comparing median and mean for two different periods).

All values have shifted upwards, and hence the value of independence in the upper quartile becomes the median value in the 1990s, whereas the latter is almost as high as the maximum value in the previous period. Reasons for this could be found in including in the analysis highly independent ECB, improvements in autonomy of EU states (e.g., Sweden), and the cases of Spain and New Zealand, which recorded more than a double increase in the degree of CBI. When developed and transition countries are compared, these differences are even more significant. It seems that, on the way to liberalization and democratization, transition states went even further than their predecessors did by securing the highest possible central bank independence in their amended laws. When all EU countries and their central banks are considered, including the European Central Bank, the bank with the highest degree of independence is neither ECB, which plays the role of independence pattern for all others, nor Germany, with years of monetary policy tradition, but the National Bank of Poland. According to measures of legal independence, the Romanian central bank is more independent than those in Australia, France or Finland; and central banks in Hungary or Slovenia are as independent as banks in Switzerland or Germany, not mentioning Lithuania or Estonia, whose central banks are given a degree of autonomy almost as high as ECB.

It is evident from the table, that political authorities in transition countries made significant efforts to increase the degree of central bank independence. It raises an important question, however, if such a big difference between the two groups of countries would be sustained when actual CBI is considered. Clearly, it is almost obvious that the degree of actual independence in transition countries cannot be as high, taking under consideration market imperfections, budgetary and deficit problems and a much shorter monetary policy tradition than in developed countries. The authors of the index for transition countries, Cukierman et al. (2002), present a similar comment stating that actual independence depends on the general regard for the law, which is likely to be higher in developed countries with a long

	Developed countries (1950-89) (1)		Developed countries (update for the 1990s) (2)		Transition countries (1990s) (3)		New EU members (1990s) (4)	
	Country	Index of legal CBI	Country	Index of legal CBI	Country	Index of legal CBI	Country	Index of legal CBI
Max	Germany	0.69	ECB	0.81	Poland	0.89	Poland	0.89
Upper quartile	Canada, US, Denmark	0.46	Germany, Switzerland, New Zealand, Spain	0.62	Belarus, Czech Republic, Georgia, Moldova	0.73	Estonia Lithuania	0.78
Median	Australia, Iceland, Luxemburg	0.34	Sweden, Denmark, Canada, Portugal	0.47	Bulgaria, Mongolia, Uzbekistan	0.55	Hungary, Slovenia	0.65
Lower quartile	Italy, UK, France, New Zealand, Sweden, Spain	0.24	Australia, France, Finland	0.29	Croatia, Kazakhstan	0.43	Bulgaria	0.53
Min	Belgium, Norway	0.17	Belgium	0.19	Azerbaijan	0.24	Romania	0.34
N		22		21		26		10
Mean		0.36		0.47		0.57		0.65
Std. Dev.		0.15		0.18		0.18		0.16

Table 2.13: Cross-national comparison of legal central bank independence

Source: Own calculations based on data from Cukierman, Webb, and Neyapti (1992), Cukierman, Miller, and Neyapti (2002), Siklos (2002).

democratic and free market tradition than in transition countries, especially during their first years of transformation from planned to market economy. When looking for relationships between CBI and inflation in these countries, immaturity of democracy and market shows that many factors (such as active regional conflicts that took place for at least part of the democratic time, wars and price decontrols or the extent of liberalization) also exerted an influence on the inflation rate.

Thanks to a variety of countries with economic and financial development, the result of the survey indicates certain grounds on which central banks are gaining independence. It specifies that the definition of *independence* is not homogeneous among countries, and hence measures of its degree need to vary. Therefore, a good understanding of the term "independence" can be a guide in formulating indices of independence for different groups of countries. The result of the survey indicates the need for dividing the sample of countries with respect to certain specifications. Not surprisingly, many studies (e.g., Cukierman et al. 1992) have found a legal measure of independence unreliable for developing countries. The incompleteness and noisiness of legal indicators of CBI, especially in developing countries have been widely acknowledged.

Inconsistent measures due to the country's specification is underlined by De Haan, Eijffinger and Waller (2005, 175–176). The authors present an example of Poland and opposite directions of the degree of central bank independence calculated for this country when two different measures are used. According to measures of legal independence, prepared by Loungani and Sheets (1997), Lybek (1999) or Maliszewski (2001), Poland has by far the highest scores among new European Union member countries. However, when another index of independence (i.e., turnover rate of governors) is calculated, Poland registers one of the highest values, which in this case means the lowest degree of independence. The problem of a country type specification is noticed also by Eijffinger and Stadhouders (2003) who argue that a shift from legal to actual central bank independence depends on the country's rule of law. Therefore, in their analysis of the degree of autonomy in both developed and developing countries, they introduce institutional quality indicators (IQIs) as proxies for the rule of law. Their result speaks loudly by finding that the rule of law and the institutional framework matter in keeping the rate of inflation low, especially in transition countries. Therefore, it also impacts the actual central bank independence.

There is a wide selection of CBI measures for transition countries. For the following analysis, we choose four of them–Maliszewski (2000), Cukierman, Miller

and Neyapti (2002), Freytag (2003), and Freytag and Masciandaro (2005)–due to the sample size they cover, and because they are calculated after the most important central bank law amendments. The group of transition countries is narrowed to ten; all of them current members of the European Union.

Table 2.14: Pearson and Kendall correlation coefficients

Index	Maliszewski	Cukierman et al.	Freytag	Freytag and Masciandaro
Maliszewski	1	0.66*	0.47	0.28
Cukierman et al.	0.395	1	0.15	-0.21
Freytag	0.35	0.07	1	0.84**
Freytag and Masciandaro	0.28	-0.14	0.78**	1

**Correlation is significant at the 0.01 level (2-tailed); *Correlation is significant at the 0.05 level (2-tailed). Original sample includes measures for ten transition countries, calculated for the 1990s.
Source: Based on data provided by authors

A starting point for these few comparison tests is again a correlation test among indices. Though the tests are simple, Pearson's and Kendall's correlation coefficients presented in Table 2.14 are very informative. Except for two measures, which share a common author, the indices show little or no correlation at all. The Maliszewski index seems to be the most correlated (Pearson) with the measures presented by Cukierman et al. However, the next part, with graphical representation shows important inconsistencies between these two measures. The negative sign of a coefficient between Cukierman's measure and the one of Freytag and Masciandaro's indicates significant differences in values. Having to choose between the two, some may point to the Cukierman index as the most comprehensive. However, Freytag and Masciandaro choose those central bank attributes that characterise transition economies (hence, should be more appropriate in this group of countries).

Continuing the comparison tests, Figure 2.2 presents values distribution of indices calculated by Cukierman et al. and Maliszewski. The index presented by Cukierman et al. is formulated based on Cukierman et al. (1992) and on Cukierman's original pattern consisting of sixteen central bank attributes grouped in four clusters. Methodology presented by Maliszewski profits from original research done by Grilli et al. (1991). The index enriches fifteen characteristics proposed by Grilli et al. with provisions for a governor's dismissal, non-political only, and all direct credit securitised. Therefore, it consists of seventeen questions, with the maximum value of CBI being eighteen (the question concerning financial supervi-

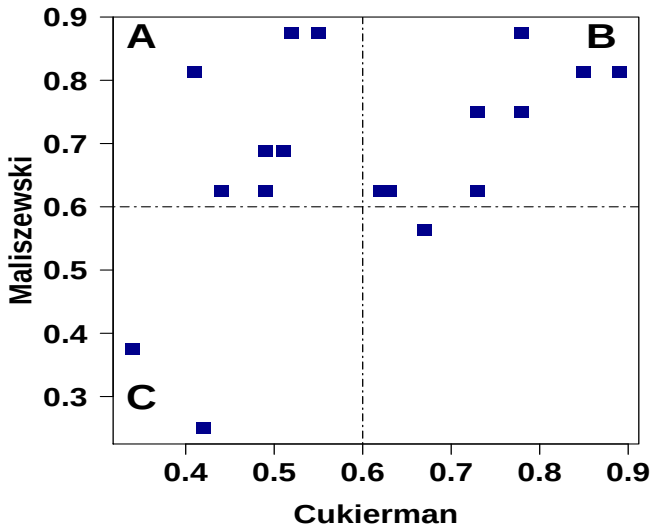

Figure 2.2: Values diversity in two CBI measures

sion has two possibilities).

A scatter plot with distribution of values for CBI measures shows the greatest difference in values in the quarter marked A, where CBI indices calculated by Maliszewski reached values higher than 0.6 and lower than 0.6 according to the Cukierman index. Countries that record the largest discrepancies between indices are: Albania, Bulgaria, Croatia, Kyrgyz Republic, Latvia, Macedonia and Russia. In quarter C, the value for Ukraine differs most. The greatest harmony between the two indices, on the other hand, can be seen in quarter B, where even though the values may differ, all points signify a high level of independence according to both measures ($CBI > 0.6$).

CBI measurements presented by the different authors place countries on a scale, ranking them from having the most to the least independent central banks. Table 2.15 summarizes the outcomes of four different indices by arranging countries according to their degree of CBI (top of the table represents the most independent central bank). Such a comparison refers to the method suggested by Mangano (1998) that, to avoid measures' arbitrariness, the rank of a country, instead of the value of CBI index, should be considered in empirical studies. The composition of measures done in table 2.15 is not random. Measures by Cukierman, Maliszewski and Freytag characterise a different methodology, as described earlier.

Table 2.15: CBI ranking: Comparison of indices

Maliszewski 2000	Cukierman et al. 2002	Freytag 2003	Freytag and Masciandaro 2005
Bulgaria	Poland	Estonia	Bulgaria
Lithuania	Estonia	Bulgaria	Estonia
Poland	Lithuania	Latvia	Latvia
Czech Republic	Czech Republic	Czech Republic	Lithuania
Estonia	Hungary	Lithuania	Romania
Latvia	Slovakia	Hungary	Czech Republic
Slovakia	Slovenia	Poland	Slovakia
Slovenia	Bulgaria	Romania	Hungary
Hungary	Latvia	Slovakia	Poland
Romania	Romania	Slovenia	Slovenia

Source: Based on data provided by authors.

Thus, inconsistencies have their origins in varying definitions of CBI. However, when measures by Freytag (2003) and Freytag and Masciandaro (2005) are compared, the methodology is similar, but the knowledge and the time of the analysis are different.

The first look at the table gives the impression of complete inconsistency of the four chosen measures. In this group of ten countries, Poland has the highest value by Cukierman, and one of the lowest by Freytag and Masciandaro. Similarly, values for Bulgaria can differ greatly when Maliszewski and Cukierman are compared with each other. Such large differences can be explained with different methods used to calculate these indices. However, all of them are based on the law and statutes of central banks.

To decide the final order of countries with respect to their level of CBI, as well as to find which of those indices may be the most accurate, the Borda count method[11] has been used by assigning weights to each rank. Countries with the same original value obtain the same rank; values are given from the range of (0; 1)[12]. The Borda count method shows the final ranking of countries and reveals the following result:

Estonia and Lithuania are the leading countries when central bank independence is concerned. Bulgaria is placed very high compared to other transition countries. Romania, which has often been mentioned as having the greatest problems with meeting EU standards, is found almost at the bottom of the list. The

[11] On Borda count, see for example D. G. Saari, *Basic Geometry of Voting*, Springer, 1995.

[12] Precision of the final value is less important than the final rank of the country.

Table 2.16: CBI ranking: Borda count ordering

Estonia	3,6
Lithuania	3,3
Bulgaria	3,2
Czech Republic	2,6
Poland	2,4
Latvia	2,3
Hungary	1,6
Slovak Republic	1,5
Romania	1,2
Slovenia	1,1

most astonishing result, however, is represented by Slovenia, which according to four measures, has the least independent central bank. This outcome is surprising because Slovenia joined the EMU the earliest of all transition countries, meaning that its monetary as well as fiscal policies fulfilled the Maastricht Treaty conditions the soonest. This implies that a high degree of central bank independence may be a sufficient but not always necessary, condition to conduct an efficient monetary policy in transition countries. It is not possible to indicate without doubt which measure is closest to this ranking. Concerning the first and last place, the measure prepared by Freytag (2003) could be the right indication of an accurate CBI measure.

An alternative approach to ranking the countries and finding their final rank based on the four measures is to construct standardised rankings. In the Table 2.17, the degree of independence of central bank $i(i = 1...10)$ as computed in the study $j(j = 1...4)$ and shown in column j is redefined as a percentage of the figure assigned to the most independent bank in study j. The last two columns give the mean values and the final ranking of the countries. Once again, Estonia, Lithuania and Bulgaria enjoy the highest levels of independence. Romania and Slovenia, on the other hand, proved again to have the least independent central banks in this group.

The wide appreciation in the literature of CBI measures by Grilli et al. (1991) and Cukierman et al. (1992), and their common approbation for empirical analysis, have brought us to the conclusion that these are the key indices in the literature. They seem to be superior to the rest in terms of their comprehensive understanding of independence, structure and the size of sample availability. We decided to test also their explanatory power in comparison with other CBI measures by using a

Table 2.17: Rankings of CBI in transition countries

Country	I	II	III	IV	Mean	Rank
Bulgaria	1	0,62	0,91	1	0,8825	2
Czech Republic	0,87	0,82	0,81	0,75	0,8125	4
Estonia	0,87	0,88	1	1	0,9375	1
Hungary	0,67	0,75	0,78	0,65	0,7125	7
Latvia	0,8	0,55	0,84	0,81	0,75	6
Lithuania	1	0,88	0,81	0,77	0,865	3
Poland	0,93	1	0,668	0,55	0,787	5
Romania	0,47	0,38	0,67	0,77	0,5725	10
Slovak Rep.	0,73	0,7	0,6	0,72	0,6875	8
Slovenia	0,73	0,71	0,53	0,47	0,61	9

Notes: I = Maliszewski (2000), II = Cukierman et al. (2002), III = Freytag (2003), IV = Freytag and Masciandaro (2005).

stepwise selection method. The stepwise selection method "evaluates each variable in turn on the basis of its significance level and accumulates the model by adding or deleting variables sequentially" (Greene 2000, 334). In the "forward" method, an initial model is defined that contains only the constant. Then, the first "best" predictor is chosen from those available. The method's criteria were based on probability of entering $F \leq 0.50$, and probability of removing from regression $F \geq 0.100$. This is the very simple method that introduces the reader to an exhaustive empirical analysis of independence measures presented in the next chapter.

First, we perform this test for a group of industrial countries[13], and we include the measures GMTO, GMTE, GMTP, LVAU, PROB and TOR, of which values are calculated for the 1980s and 2000s. In this test, the economic measure GMTE is added to the model in the first round, and hence can be treated as the strongest regressor of inflation among the considered measures. This measure is joined by GMTO in the second step. Their coefficients were negative and significantly different from zero, as expected. Measures LVAU and PROB join the model in the two subsequent steps. Their coefficients were also significant and both had positive signs. While a positive sign is anticipated from the measure of actual independence–PROB, this results is unexpected from the legal autonomy index–LVAU. We treat this results as a proof of superiority of GMT measures over LVAU. However, political counterpart of GMT and TOR were not included in the model at all. Next, we repeat the stepwise procedure for the three first measures of CB independence: those constructed by Bade and Parkin (1988), Alesina (1988)

[13] A complete description of the data used in this and forthcoming analysis is given in Chapter 3.

and Eijffinger and Schaling (1993). Their values were calculated only once and represent levels of CBI at the end of the 1980s. Only the measure by Eijffinger and Schaling is included in the stepwise selection process and it enters the model significantly.

A similar test for emerging markets and a group of indices, GMTE, GMTP, GMTO, LVAU and TOR, indicates that it is a measure of actual independence (TOR) being included as the first regressor with adjusted R^2 at the level of 0.24. LVAU is included in the next step improving the regression fit by 0.03, whereas GMTP enters in the third place, again with a positive sign. All in all, this test indicates that the measure of actual independence, TOR, explains changes in inflation the most accurately in a group of emerging markets. We draw a similar conclusion when we perform the stepwise selection among developing countries. In the decision process, in which measure GMT or TOR is the right proxy of CBI, the priority was given to the "actual" measure of independence. Only TOR enters the model with the expected sign and the statistically significant coefficient. Finally, among GMTO, GMTE, GMTP and LVAU[14] in a group of transition countries, only GMTE was chosen to be the "best" regressor of the inflation rate.

2.2.3 Conclusions

The literature on the institutional design of central banks focuses only in one part on the construction and analysis of the optimal measure of central bank independence. The majority of studies go beyond the methodological question and try to find, show and explain empirical links between macroeconomic variables and a variety of measures of the degree of CBI. Measuring the CBI is not the final aim but only the instrument in a further process of explaining economic performance. The majority of studies concentrate on the relationship between CBI and the inflation rate, sometimes enriching this approach with the search for links between CBI and output or long-run growth.

The description of CBI measures presented in this chapter summarizes the methodology of the most important work in this area. Table 2.1 and accompanying description reveal that the number of CBI definitions is truly overwhelming. The subsequent critical analysis of these indices educates the reader about the criteria one should consider on the way to the optimal index of CBI. Simple tests of correlation indicate that these measures cannot be used interchangeably. Though describing the same phenomenon, many of them show no correlation with their

[14]These measures have values calculated for the full sample of countries.

counterparts. Based on the frequency of appearance in the literature and the actual interest of researchers in updating CBI values, we conclude that measures by Grilli et al (1991) and Cukierman et al. (1992) are superior to the other of measures. To test this hypothesis, we apply a stepwise selection procedure. The results depend on the country-specific factors. The economic independence measure by Grilli et al. is chosen as the best regressor, when estimations are done for advanced countries. However, when inflation rates and CBI levels are analyzed in less developed nations, the measure of actual independence is superior to others.

A ranking test performed with the Borda count among transition countries helps arrange countries along the degree of CBI. Using four measures, the lowest position, indicating the most dependent central bank, is occupied by Slovenia. This result allows one to make the preliminary conclusion that it is not necessary to have an independent central bank and to conduct efficient monetary policy within the group of transition countries. In addition, despite large differences among the measures, almost all of them prove to have an inverse relation to the average rate of inflation.

Most indices surprisingly show weak, or a lack of, correlation with each other. It seems that all problems with the precision of indices appear to originate from problems with a criteria spread, an interpretation spread and a weighting spread. Those with similar methods of formulation and coding show a strong positive correlation. Comparing the two indices that vary in fundamental aspects leads to a failure in proving any correlation between them. Additionally, the presence of influential observations, such as the central banks of Germany and Switzerland, has a significant effect on relations between indices. These two countries' central banks are characterized by almost perfect independence in every study and in every index. On the other hand, most medium-independence level central banks vary greatly when ranking independence. Finally, the choice of attributes, and the choice of the most important ones, can be decisive in finding relationships between CBI and inflation rates, or other economic variables.

Chapter 3

Quest for the Best: How to Measure Central Bank Independence and Show its Relationship with Inflation[1]

3.1 Introduction

Chapter 2 summarizes the most important findings on measuring central bank independence. It also suggests cautiousness in using these measures in further studies by underlying their imperfections. It would be, as Mangano (1998) describes it "narrow-minded", however, to reject all measures of central bank independence (CBI). What is more interesting is to examine the consequences of such arbitrariness. Based on the literature review found in this chapter one will be able to understand that empirical work on relationship between CBI and inflation rate is also unsatisfactory and in high disagreement.

The objective is to check measures for explanatory power of central bank independence (CBI) using a series of econometric tests. These tests are in the spirit of the belief that each institutional improvement of central banks always aims to obtain more efficient monetary policy. Therefore, as found by other studies, it is believed that the main, and perhaps the only, reason to introduce higher degree of central bank independence is to help achieve a lower inflation rate.

[1] A paper based on this chapter is published in AUCO Czech Economic Review, vol. 5(2), 132-161

The title "Quest for the Best" seems to suggest a winner of this "competition"; that is, the most accurate and adequate measure. In fact, we wish to prove that existing CBI indices are not perfect substitutes. We test the CBI hypothesis using the same models and methodology, and exchanging only independence measures. The results are expected to caution against arbitrary choice of the CBI definition in various studies on economic relationships. Another aim of this analysis is to check robustness of the Cukierman's (1992, 425) conclusion that "any divergences in results between our full sample and that of the ATC [Alesina, and Grilli, Masciandaro and Tabellini studies] is due to differences in institutional features across the samples of countries rather than to differences in the legal proxies of CB independence." Although one can agree with Cukierman that institutional development of countries matters, it may be possible to see that some measures are even stronger predictors of inflation rate than others having the same sample under investigation.

This chapter extends the analysis of the central bank independence hypothesis in several directions. It incorporates a broader set of CBI indices and thus presents an explicit comparison of alternative measures. It also includes a broad set of controls variables and analyzes the hypothesis in a time series cross sectional context. The next section presents a literature review on testing the CBI hypothesis. It focuses on few most important contributions. The description of the model, methodology of estimation and the type of data used can be found in section 3, which is followed by the estimation results (section 4). Section 5 concludes this chapter. Additional information is placed in appendix.

3.2 Literature Review

The theoretical and empirical discussion on central bank independence describes the phenomenon in a two ways. The first characterizes determinants of central bank independence, and focuses on required institutional development of the country that helps the bank succeed in obtaining monetary goals. The second method attempts to quantify degrees of CBI around the world and search for a relation between a level of CBI and economic variables.

Determinants of central bank independence can be affected by the nature of political and legal institutions, as well as by a nation's accepted practice, culture and personalities. Among political and economic determinants, one can mention the role of the equilibrium or natural rate of unemployment, the stock of government debt, political instability, the quality of supervision of financial institutions

or financial and public opposition to inflation. As Eijffinger and de Haan (1996) explain these determinants are not necessarily mutually exclusive and may partly overlap.

Along the work on CBI determinants, a rather extensive research was held on quantifying the degree of independence among the world's central banks. This part of research started in the late 1980s with the work of Bade and Parkin (1988) and later Grilli, Masciandaro and Tabellini (1991) and Cukierman, Webb and Neyapti (1992). Recently Eijffinger and de Haan (1996) and Arnone et al. (2006), among others, provide a detail survey of CBI measures, whereas Klomp and de Haan (2010) present a meta-analysis of publications based on CBI studies.

The idea of independence measures lies in identifying presence of certain CBI attributes that may define this phenomenon. Legal measures are constructed of attributes from several groups relating to a central bank's governor, policy formulation, policy objectives, ability of government to borrow from the central bank and external monetary relations of the central bank. A major assumption behind these measures depends on attaching a numerical value to selected central bank institutional factors, which constitute the power and ability to conduct monetary policy.

Despite the same methodology, these indices differ in the choice of CB attributes and their weighting, and sometimes in the final degree of CBI. As it is explained in chapter 2, the way these measures are constructed have been under severe criticism. Their artibrariness and imperfection was one of the arguments against the acceptance of the possible relation between an inflation rate and central bank independence. The subsequent, by many considered as spurious, empirical evidence of such a relation became a second argument.

Quantifying degrees of central bank independence allows searching for its relation with macroeconomic variables, especially with inflation rate. The 1990s witnessed a series of institutional changes in central banks, aiming at ensuring that monetary authorities are the sole policymaker, immune from political pressure. At the same time, over the past fifteen years, global inflation has dropped from 30% to 3% (based on historical data from IMF's World Economic Outlook, available at www.imf.org). From this evidence, one may assume that a higher degree of independence is conducive to a lower level of inflation. On the other hand, a high rate of inflation is likely to result in a lower level of independence. Therefore, as Cukierman (1992, 427) explains it is "conceivable that there is a two-way causality between inflation and the actual degree of CB independence."

Empirical evidence of such causality is given by Cukierman (1992, 429), who shows evidence of a two-way Granger causality between inflation and CB independence, as proxied by governors' turnover. Posen (1993) argues that the relationship "higher degree of CBI - lower rate of inflation" is not causal, and may be caused by society's preferences for low and stable inflation. Posen was criticized by de Haan and Van 't Hag (1995), who show that Posen's results are confirmed only when the Cukierman's legal indicator is used.

Most empirical literature considers central bank independence an exogenous variable and focuses on explaining some elements of a country's economic performance. For example, cross-country data for developed countries show a negative relation between a degree of central bank independence and inflation, but no correlation with output or employment (e.g., Bade and Parkin (1988), Grilli et al. (1991), Cukierman (1992, ch. 19), Eijffinger and Schaling (1993)). These studies have been criticized for using a bivariate type of regressions by Campillo and Miron (1997). Their significant contribution was to include several other explanatory variables like openness, debt-to-GDP ratio or exchange rate regime, along with typical economic variables of political instability. The work of Campillo and Miron, among other authors such as Eijffinger, Schaling and Hoeberichts (1998), Sturm and de Haan (2001) and many more, inspired the following analysis. Table 3.1 summarizes findings and methodology of selected empirical studies on CBI.

Table 3.1: Summary of selected empirical studies on CBI

Authors	**Posen (1993, 1995)**
Sample	17 industrial countries; period over 1950-1989 32 countries; 1960-1989
Mathod	Regress average annual level of inflation on LVAU, a measure of financial sector opposition to inflation and other control variables.
Results	Any observed negative correlation between inflation and CBI is spurious. If there is a negative relation, it exists because countries with a financial sector more opposed to inflation are also the most likely to be eager to grant their central bank an autonomous activity from political influence.
Authors	**Campillo and Miron (1997)**
Sample	49 countries;
Method	Cross-country analysis with LVAW and a broad range of national institutional and structural characteristics of a country's economy. OLS estimations.
Results	CBI enters with the wrong sign in all samples except the high-income sample, and even then the coefficient is not significant. CB autonomy has no effect on inflation when control variables relating to the degree of openness in the business environment and of political instability, a country's inflation

	and debt history are introduced.
Authors	**Temple (1998)**
Sample	18 countries with high income; period covering 1974-94. Larger sample of 49 countries as in Campillo and Miron (1997).
Method	Recursive estimation method with a legal indicator for CBI. Including past inflation, CBI, political instability, openness, log GDP, the log of GDP per capita, a dummy for fixed exchange rate regimes, the debt/GDP ratio in 1975 and index of data quality as regressors.
Results	The findings are very sensitive to outliers. A significant negative relationship between CBI and inflation when high inflation countries are excluded from the sample.
Authors	**Oatley (1999)**
Characteristics	Eight indicators including: LVAU, TOR, three variants of GMT, the Alesina index and two variants of the Alesina index (dummy variables for each level of independence and a single dummy variable that distinguishes only between high and low CBI.
Sample	21 OECD countries; period covering 1970-90
Method	Estimation of eight models of inflation. Next to CBI measures, other regressors are: three measures of labour market organization, partisan preferences, government budget balance, openness, degree of unemployment.
Results	The CBI hypothesis is supported even if one controls for a relatively large set of other economic and political-institutional variables known to cause inflation. The statistical relationship between CBI and inflation rate is not independent of the measurement of CBI.

Notes: Information collected by the author based on original studies.

A few conclusions can be drawn from this table. First, neither methodology of estimation, nor the final model were the same in these studies. On contrary, each author aimed to prove his model is "better" than the previous one and his methodology fits "better", as well. What does it mean "better"? For many authors identifying new determinants of inflation rate and CB autonomy meant improving on previous studies. Some of them were widely acknowledged. For example, it is accepted that proxies of political (in)stability have to be added to a regression performed for developing countries.

Second, results of analyses are often contradictory to each other. For example, Temple (1998) proves that it is possible to obtain a significant negative relationship between CBI and inflation but only when high inflation countries are excluded from the sample. Sturm and de Haan (2001) proves the opposite. Their study shows insignificant results from regressions where the CBI is used as a proxy, unless the sample is enriched with high inflation countries. One should note, however, that

the latter study includes only developing countries and uses TOR as a CBI proxy, whereas Temple includes 49 countries that vary in development, and uses a legal CBI indicator instead.

Therefore, the third conclusion is the following: results of estimations vary on the proxy of CBI. Oatley (1999) performs an analysis using eight CBI measures. Some of them are simply combinations of each other. He concludes that the statistical relationship between CBI and inflation rate is not independent of the measurement of CBI. This finding was known already to Cukierman et al. (1992), who constructed legal and actual independence measures, and concluded that results were sensitive depending whether TOR or LVAU were used as CBI proxies. It was later confirmed by other authors. The litearure, however also proves that results vary depending on the type of the *legal* CBI proxy. Mangano (1998) analyzes several regressions where the only CBI proxy is a combination of legal measures (by Cukierman (1992) and Grilli et al. (1991), as explained earlier). He summarizes that despite obtaining expected signs of coefficients in interest, the statistical significance of the relevant coefficients is rather erratic. Out of ten regressions, only two produce a f-statistic which is above its null-hypothesis rejection value at a 5% level of significance.

3.3 Review of Methodology

The methodology used in the forthcoming analysis differs from what is normally presented in papers on this topic. Much of empirical work is unsatisfactory for three reasons. First, previous studies relied strongly on cross-country estimations, which are done with a reference to a specific point of time, and are generally connected to the calculation of the level of central bank independence. Most of empirical analysis do not consider the changing value of CBI in time. Second, many of studies do not include other explanatory variables than the degree of CBI. Finally, previous analysis has not yet undertaken a comparison of alternative indices of CBI to the extent we are proposing in this chapter. Therefore, our aim is to address all weaknesses by testing the explanatory power of up to seventeen original measures. We use methodology designed to benefit from the data designed in two dimensions: both time series and cross-section (TSCS).[2]

There are several advantages of using panel data over cross-section or time

[2]Often literature use TSCS and panel data interchangeably. However, as we will explain later, there are significant differences between these two data structures that could affect estimation results.

series. Baltagi (2005, 4-5) explains that techniques of panel data estimation can take heterogeneity among units into account by allowing for individual-specific variables. Second, panel data give more informative data, more variability, less collinearity among variables, as well as a greater degree of freedom and more efficiency. Next, panel data are better suited to study the dynamics of change. Finally, by making data available for many more units, panel data can minimize the bias that might result if we aggregate individuals or firms into broad aggregates.

The type of data we work with is not a typical example of panel, though. The choice of country sample, in our case is non-random and time series is long, even longer than 15 years. Political economists tend to call such data "time-series cross-section" (TSCS), underlying that this term cannot be used interchangeably with "panel data". The standard theory on panel data assumes that N (number of units) is very large and tends to infinity (N$\rightarrow \infty$), while T (number of time periods) is fixed, and usually very small (T can be even 2 or 3 periods long). These assumptions have certain repercussions to our analysis. Greene (2003, 284) explains that standard panel analysis techniques are focused on cross-sectional variation and the time-series methods may be problematic. Therefore, procedures that work well as the number of units gets large should work well for panel data. They may not, however, work that well for TSCS data.[3]

The Feasible General Least Square (FGLS) estimator by Parks (1967), our first choice of estimation method was designed to take into account the panel error structure and to be more efficient than Least Square estimator (OLS). The FGLS can be the right estimator in the case of panel heteroskedasticity, that is in a situation when each country has its own error variance. It is preferred in studies of political economy in open economies, where shocks that affect one nation can also be expected to affect their trading partners. In the previous studies on CBI, this methodology has been used, for example by Jácome and Vásquez (2005). An alternative methodology is the Panel Corrected Standard Errors estimator (PCSE). The proponents of this method, Beck and Katz (1995) explain that in the presence of panel heteroskedasticity and contemporaneous correlation of the errors one may still use the OLS if robust standard errors are calculated using the PCSE method. This estimator is widely used in political economics study, however in the area of our interest we have found the study by Kilponen (1999). In our analysis of inflation rate dynamics we include past inflation rate as one of explanatory vari-

[3]Most of the classical panel data books (Hsiao 2003; Baltagi 2005; Wooldridge 2002) focus their method analysis on "standard" panels, that is N tends to infinity and T is fixed (and small).

ables, making our model a dynamic panel. An instrumental variable (IV) approach is most often used in this case with the usual approach of using the Generalized Method of Moments (GMM) introduced by Hansen (1982). The IV estimator has been only recently used by a few authors analysing the relationship between CBI and inflation, Neyapti (2003), Dreher et al. (2008), and Acemoglu et al. (2008) naming a few. Therefore, this is our third estimation method.

There are several methodological considerations why we do not rely on only one method. Beck and Katz (1995) suggest that, while IV can be more appropriate when N is much larger than T, OLS with panel corrected standard errors (PCSE) should be used in the opposite case. In their study authors criticize the GLS (FGLS) making a Monte Carlo analysis and showing that the Parks estimator may understate variability by between 50% and 300%. Beck (2001) proposes that GLS (FGLS) is an "old-fashioned" way of estimating that treat properties of TSCS as "nuisances" that cause estimation difficulties. In another Monte Carlo test, Beck and Katz (2011) compare OLS estimation of a simple lagged dependent variable (LDV) model with fixed effects to the Kiviet and Anderson-Hsiao estimators. Results show that when T is 20 or more, OLS performs about as well as Kiviet and much better than Anderson-Hsiao. Hence, authors recommend using OLS for models with country-specific intercepts.

Heterogeneity of units in TSCS is modelled by assuming that each unit has its own intercept. Choosing how to model the effects, in particular whether they are fixed or random is of great debate in the literature on panel data. If we assume our data possess characteristics of TSCS then it is clear that fixed effects are appropriate (Hsiao 2003, 41-43). Hsiao explains that fixed effects are appropriate when one makes inference conditional on the effects that are in the sample, whereas the random effects model is appropriate if one treats the observed units as a sample from a larger population and when one wants to make inference about the larger population. The use of fixed effects, however, comes with its own cost.

Studies on TSCS analysis point out, however that there may be estimation problems when a model consist of time-invariant and slowly changing variables. Time-invariant or slowly changing variables are characteristic for political economy analysis and central bank independence is one of them. Changing central bank legislature allows us to observe evolution of CBI levels among many countries. Thus CBI is not a pure time-invariant variable. These changes, however, take place rather rarely and hence values of CBI change slowly. Persistent (or "quasi-persistent") variables create also a problem of estimation using General Methods of

Moments (GMM) because it is difficult to have first-difference equation with such variables. A crucial condition of presenting a model as first-difference is that Δx_i (first-difference of independent variables) must have some variations across units. Wooldridge (2000, 422-423) explains that this fails if the explanatory variable does not change over time for any cross-sectional observations, or if it changes by the same amount for every observation. Differencing to eliminate an unobserved effect can greatly reduce the variation in the explanatory variables. Even if x_{it} substantially varies in the cross section for each period, Δx_t may not have much variation. A solution might be estimating a model only in levels and having instruments in first-differences, or using Two-Stage-Least-Square (2SLS). Estimates of GMM however are said to be more consistent.

Several estimation techniques and redefining the inflation model act as a robustness check. We decide to add one more test, which to our knowledge has not been performed while testing competing measures of CBI, namely a test for non-nested models. Testing non-nested models helps to answer, whether, once a CBI measure is changed in the primary model, there is any evidence that the models fit significantly differently to the data. Recent developments in testing non-nested hypotheses have been structured around a common idea of the "encompassing principle" (Mizon and Richard 1986). This principle directs attention to whether a maintained model can explain the features of its competitors (Greene 2000, 302). Davidson and MacKinnon (2004, 655) describe several approaches to testing non-nested hypotheses. We will use their approach, the Davidson-MacKinnon J-test (and J statistic) which assumes that, if one model is the correct one, then the fitted values from the other competitive model should not have explanatory power, when estimating that model.

3.4 Models and Data

3.4.1 Estimations Roadmap

The above discussion shows differences in estimating data and proves that "panel data" is not always a substitute word for "time-series cross-section data". While this distinction has consequences in estimation methods and is a reason for further studies on efficient estimator of TSCS, one should not discard the standard, classical methods of panel data estimation. The research on how properly and efficiently estimate data that incorporates characteristics of TSCS is still growing. Therefore, we choose to proceed by estimating our models using varying methods. We do not

want to non-judgmentally accept the Beck and Katz estimator – PCSC, neither do we want to be perceived as "old-fashioned" by estimating only with the FGLS.

We have time series cross section data for three groups of countries. In two of those, advanced and emerging, number of periods (T) is larger than number of units (N). This allows applying the "Beck and Katz estimator" of panel corrected standard errors. However, number of developing countries is much larger than time series, and as a consequence OLS with PCSE cannot be estimated. Even though N is relatively large, the standard panel data estimators may not apply here entirely due to the long time series (T>20). Despite being criticised in some studies, FGLS is still accepted in others and hence it is our second way of estimation method. To compute standard errors that are robust to serial correlation and time-varying variances in the disturbances (Arellano 1987; White 1984) one should choose the White period robust coefficient variance estimator. Estimated FGLS is more efficient compared to the OLS, once one is willing to make assumptions about the form of heteroskedasticity (Verbeek 2004, 95). The standard errors for the GLS approach are much smaller, so there is an estimation efficiency gain. Finally, we will use instrumental variable approach and estimate our equations in levels, using both lagged variables in levels and lagged differences as instruments.

We choose to include a lagged dependent variable on the right hand side as one of regressors. We decide to do so for three reasons. First, the lagged dependent variable captures the dynamic adjustment. It is suggested, for example by Aisen and Veiga (2008) that in models explaining changes in inflation rate, such a dynamic adjustment should be included. Second reason lies in the characteristics of TSCS data which often show dynamics. This can be modelled by including lagged dependent variables. Beck (2001) suggests that such modelling allows researchers to estimate their specification using OLS with PCSEs. Finally, we investigate whether changes in inflation rates are correlated with institutional changes of central banks. We support the idea that there is some delay in the way how increased (or decreased) degree of CBI is related to an inflation rate. The process dynamics modelled with the lagged dependent variable is proper in a case, Beck and Katz (2011) explain, when one expects some initial effects that increase to some limit over time.

Following Hsiao's explanation, in our study we choose cross-country fixed effects. Our sample is a group of certain countries hence these units are fixed, while the choice of the sample cannot be viewed as a random draw from some underlying population. Moreover, it is a standard practice in those few studies that analyze

CBI-inflation rate relation to apply panel or TSCS analysis. Furthermore, for each sample a Hausman test, checking the null hypothesis that $x_i t$ and α_i are uncorrelated, was applied.

Our general estimated model is of the form

$$\pi_{i,t} = \alpha + \beta_1 CBI_{i,t} + \beta_2 X_{i,t} + u_{i,t} \tag{3.1}$$

π, is the inflation rate corresponding with the country and a year; it can be changed into a transformed inflation according to the formula $d = \frac{inflation_{i,t}}{1+inflation_{i,t}}$. *CBI* is the value of CBI degree, which depends not only on the country or a year, but also on the type of CBI measures used. X is a vector of other explanatory variables, and $u_{i,t}$ is an i.i.d. disturbance. Since some data are not available for all countries and years, the panel data may be unbalanced.

Models are estimated using stacked pooled data and results of estimations are presented in tables organized in the following manner: columns represent single regressions differentiated by the CBI measure, list of regressors is placed in rows; and additional information describes goodness-of-fit of each regression along with the type of methodology is given under the table.

3.4.2 Data

Central Bank Independence Measures

The key element of all of the following estimations is the measurement of central bank independence. There are approximately seventeen original CBI measures (the full list in table 3.2), and few modifications, such as an update of Alesina index–Alesina2, and an update of TOR–TORMAS. These updates, performed by the author of this thesis, include new information about changing degrees of CBI. Therefore, they allow using larger number of CBI measures for regressions thanks to their changing values withing considered period. TORMAS was calculated based on the information collected from central banks. Alesina2 index is composed of information gathered by other researchers.

Recalculations of indices based on new and more current information allow to see how degrees of independence differed not only among countries (cross-country analysis) but also within time (time-series analysis). Not all measures, however, were popular enough to be updated. Therefore, the data set on CBI indices can be divided into two groups: “long-term” measures (a group of GMT measures, legal and actual indices by Cukierman at al., PROB by Krause, Alesina2) and

"short-term" measures (BP, ES, OPCBI-N measures, a set of measures for transition countries). For example, economic measure of independence by Grilli et al. (1991), GMTE, has been recently updated by Arnone et al. (2006). This implies a possibility of analysing changes in degrees of CBI for one country within time. This makes a measure "long-term".

Table 3.2: List of CBI measures

Authors	**Bade and Parkin (1988)**
BP	Legal indicator of political economy
Authors	**Alesina (1988, 1989)**
Alesina	Political independence is taken to depend on the institutional relationship between the central bank and the executive, the procedure to nominate and dismiss the head of CB etc.
Authors	**Grilli, Masciandaro and Tabellini (1991)**
GMTO	Overall - combines economic and political measures
GMTE	Economic - It is based on 7 attributes concerning the influence of the government in determining how much to borrow from the central bank etc.
GMTP	Political - It is based on 8 attributes covering 3 aspects of monetary regime and connected with appointment and dissmisal of a CEO and responsibilities of a CB.
Authors	**Cukierman (1992)**
LVAU (LVAW)	Legal independence based on CB laws.
TOR	Measure of actual independence depends on the frequency of changes at the CEO position.
Authors	**Eijffinger and Schaling (1992) and later Schaling (1995)**
ES	Index of policy autonomy (degree of policy independence) On contrary to BP and GMT, each attribute is not weighted equally and therefore the index is assymmetrical in this sense.
Authors	**Fratianni and Huang (1994)**
Distance	Average of nine different indicators. German Bundesbank is a benchmark with a value of unity. Values to other CBs are assigned by calculating the distance of each CB from the German Bundesbank.
Authors	**Cukierman and Webb (1995)**
VUL	De facto measure of actual independence (political vulnerability defined for each country as the fraction of political transitions that are allowed promptly by a replacement of the CB governor)
Authors	**Eijffinger and Schaling (1995)**
OPCBI-N	Optimal degree of CBI calculated using the "ultimate" determinants of CBI.
Authors	**Loungani and Sheets (1997)**
CBI-DF	Legal measures (statutory independence)
SIB	CBI-DF (Debelle and Fischer based index) and SIB obtained by assessing the similarity between the characteristics of a given CB

	and characteristics of the German Bundesbank
Authors CBI-Account	**Lybek (1999)** De jure index of independence and accountability - based on 21 attributes
Authors LVES	**Cukierman, Miller and Neyapti (2002)** Legal measure calculated for transition countries
Authors Freytag	**Freytag (2003)** Internal and external components of CBI. Similar to Cukierman index.
Authors CBI-Index	**Freytag and Masciandaro (2005)** An extensions of the Freytag measure
Authors PROB	**Krause and Mendez (2007)** Measure of actual independence - probability of the governor being fired from his post

Notes: The first column includes CBI measures names' abbreviations used later in the text.

Some measures have been unified and connected by the definition. Hence, there is no measure calculated by Arnone et al. (2006) but their work is used as the update for the Grilli, Masciandaro and Tabellini index (1991, GMT index). Similarly, one may find measures of the turnover rate of governors (TOR) calculated by many authors that help to build a long data set for this index. All sources of data have been acknowledged and included in the references. Our expectations about empirical results are clear - there should be a significant negative relationship between degree of CBI and inflation rate.

Table 3.3 presents a summary of differences in the construction of few measures. Most of columns indicate whether the particular attribute of central bank independence was included in selected measures. The last column, however, is based on the questionnaire among central bankers done by Fry et al. (2000) and gives a rank of importance to these characteristics of central bank's autonomy that were found as important (where 1 means "the most important", and 6 - "the least important").

A Dependent Variable

Defining a dependent variable may cause as many problems as finding a suitable collection of explanatory ones. Many previous studies used the average annual inflation rate as the dependent variable and others introduced different definitions. For example, Cukierman (1992) chose to use a depreciation in the real value of money, defined as $d = \frac{inflation_{i,t}}{1+inflation_{i,t}}$, also called *transformed inflation*. He claimed

Attribute/Measure	BP	Alesina	ES	GMT	LVAU	CBI-Index	CBI-DF	Rank
Policy responsibility								2
* is CB the sole final policy authority	•	•	•	•	•	•		
* is this authority not entrusted to the CB alone			•	•	•	•		
* is it entrusted to G			•		•	•		
* is CB given an active role in formulation of the G's budget					•			
Presence of the G's representative in the CB's board	•	•	•	•				
* does he has a vote							•	
* does he has a veto power							•	
CEO and board appointment								4
*CEO not appointed by the G				•	•		•	
* length of CEO appointment				•	•		•	5
* CEO allowed to hold other office					•			
* CEO an expert						•		
* more than half of the board appointed independently	•	•	•				•	
*none of the board appointed by the G				•			•	
* length of board appointment				•			•	
Financial and budgetary relations between CB and G								6
* direct credit facility not automatic				•	•	•		
* DCF is at the market interest rate				•	•			
* DCF is temporary				•	•	•		
* DCF is of limited amount				•	•	•	•	
* CB does not participate in the primary market				•	•	•		
* discount rate is set by the CB				•	•			
* circle of potential borrowers					•			
* who decides control of terms of lending					•			
Conflict resolution rules		•		•	•		•	3
Responsibilities for commercial banks supervision		•						
Locus of legal commitment					•	•	•	
Accountability of the CB						•		
CB controls monetary instruments							•	1

Table 3.3: Similarities among measures

Notes: BP–Bade and Parkin, ES–Eijffinger and Schaling, GMTO–Grilli, Masciandaro and Tabellini, LVAU–Cukierman, CBI-index–Freytag and Masciandaro, CBI-DF–Loungani and Sheets, Rank-Frey et al.

Table 3.4: Examples of calculations of the transformed inflation rate

	I			**II**		
Country	1990	1991	1992	1990	1991	1992
Germany	2.7	4.0	5.1	0.026	0.038	0.049
Nicaragua	3004.1	116.6	21.9	0.968	0.538	0.179
Thailand	-9.5	5.7	4.2	-0.105	0.054	0.040

Notes: Panel (**I**) of the table reports annual averages of inflation in percentages. Panel (**II**) of the table reports the transformed inflation rate (D). It is calculated from the relation $D = \pi/(1+\pi)$ where π is the average yearly rate of inflation in decimals. Values in the second panel are purposely shown with three numbers after the decimal due to the fact that D is in the scale of (0,1). Therefore, the precision of calculations matters.

that there are several explanations for doing so; first, it better represents the real losses on the holding of money balances; and second, it moderates the effect of outliers with very high levels of inflation. Moreover, as pointed by Jácome and Vázquez (2005), rescaling values of inflation rate according to this procedure helps to ameliorate potential heteroscedasticity. Table 3.4 presents examples of such transformation as suggested by Cukierman, that is transformed inflation rate is obtained using average annual inflation rate expressed in decimals (see Appendix in Cukierman et al., 2002). Eijffinger et al. (1998) performed a sensitivity analysis and, besides the mean inflation, they included interchangeably elasticity and variance of inflation.

Before estimation, one should examine the data to see if there is sufficient within- and inter-country heterogeneity to use the TSCS analysis and make it meaningful. This can be analyzed using a standard box plot of inflation rates (a dependent variable). Figures 3.1-3.3 present box plots for full samples of advanced and emerging countries, whereas from a group of developing states we choose a sample. Analyzing box plots we notice that all samples have cross-country variability; some countries show little variation in their inflation rates, other, for example Greece, New Zealand or Portugal (advanced); Argentina, Brazil or Peru (emerging); Dominican Republic, Nicaragua or Zambia (developing) show large variations in their inflation rates.

Next we want to graphically describe relations between the dependent variable and CBI measures. We do it with scatter plots of two main CBI measures - GMT and LVAU versus inflation rate (expressed as "transformed inflation"), both for advanced countries, and scatter plots of TOR and inflation rate for developing states (figure 3.4-3.6). First idea is to compare the redistribution of data within the time.

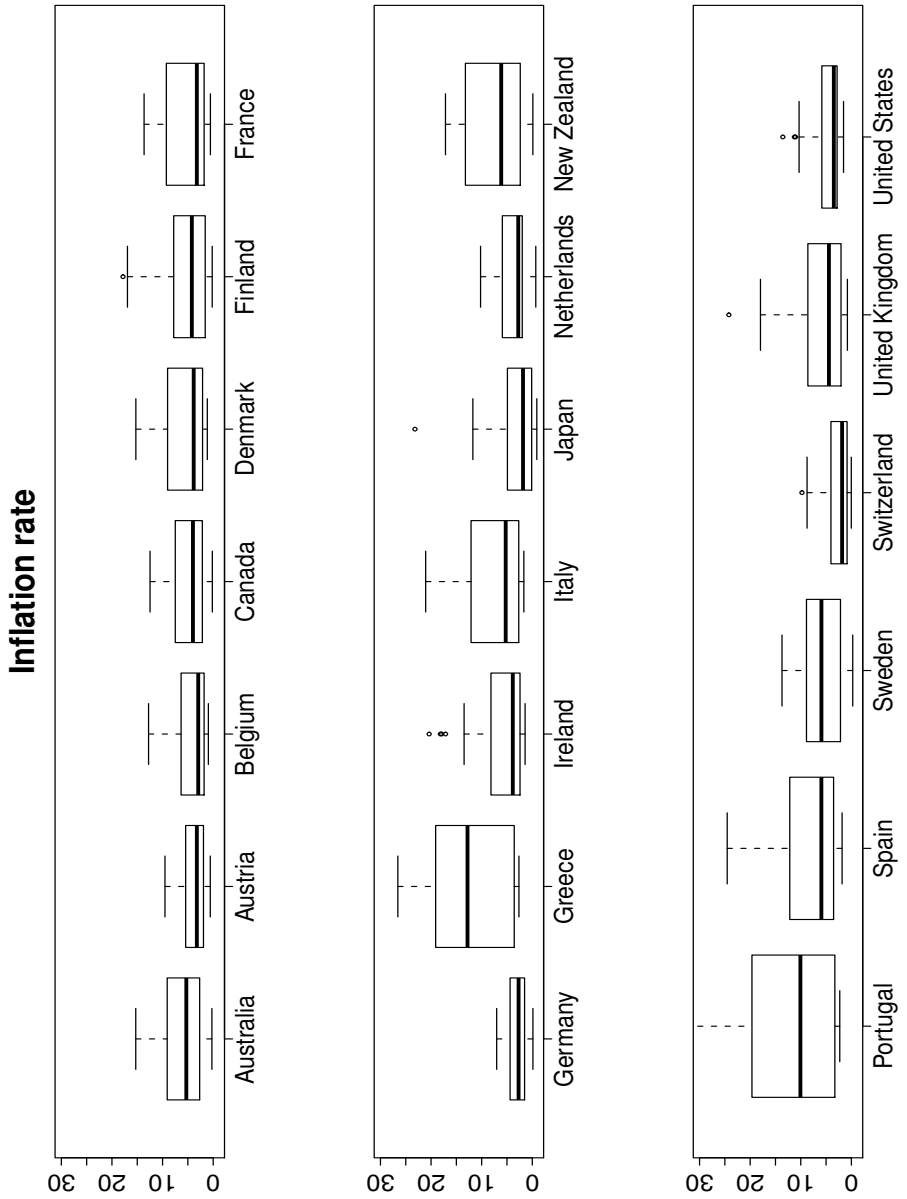

Figure 3.1: Box plots of inflation rate by country (advanced states), 1970-2007.

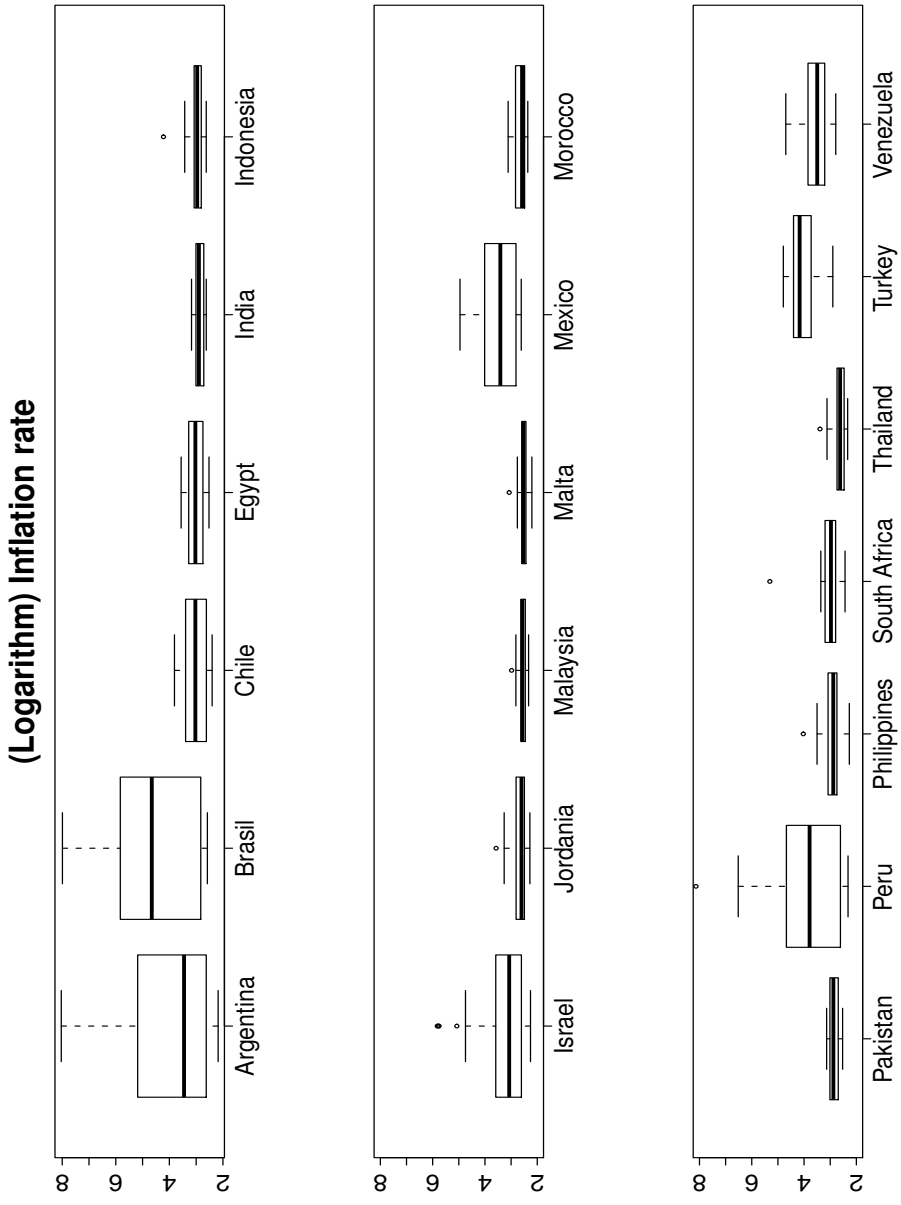

Figure 3.2: Box plots of inflation rate (expressed as a logarithm) by country (emerging states), 1980-2007.

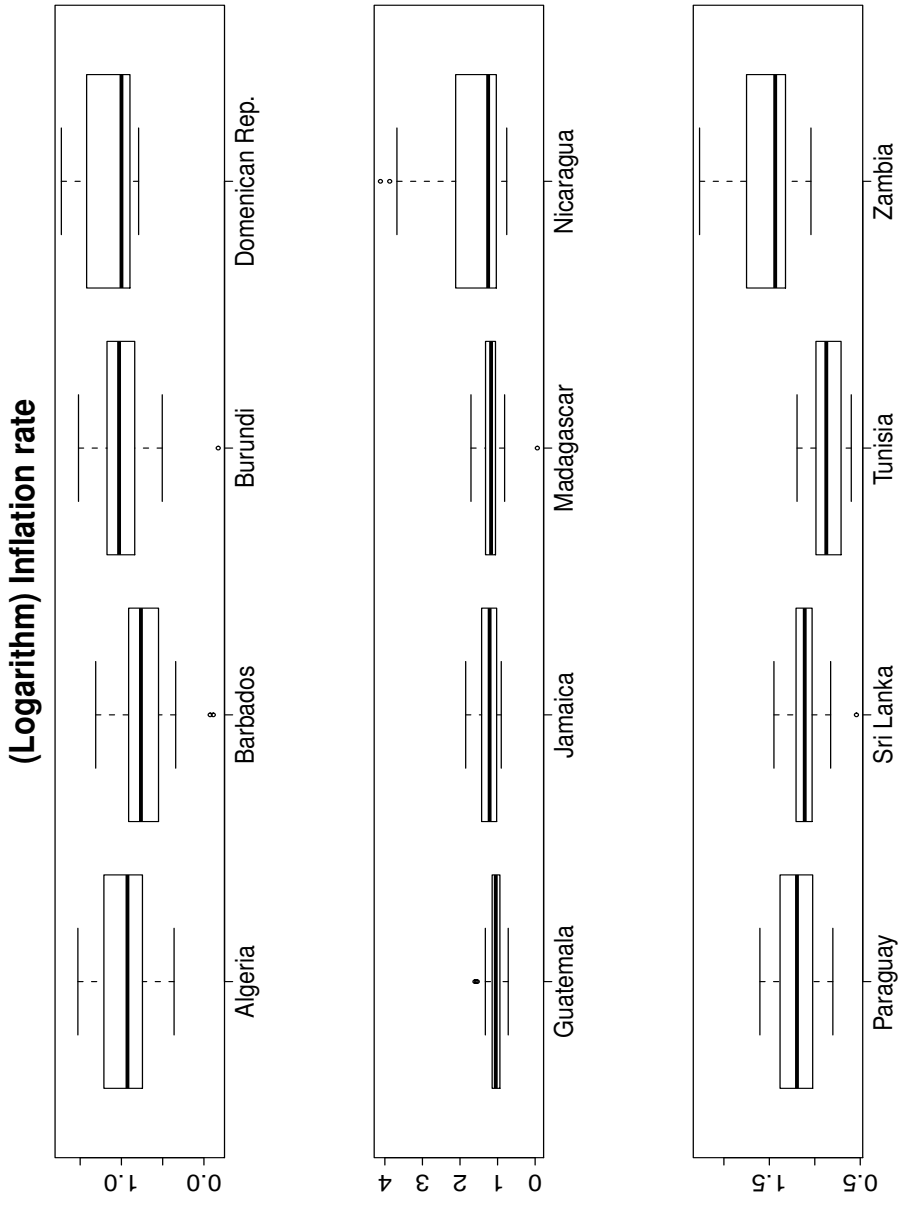

Figure 3.3: Box plots of inflation rate (expressed as a logarithm) by country (a sample of developing states), 1980-2007.

Thus, figures include seperated data for the 1980s and the 1990s. Second, in the case of advanced states, is to compare between indices.

In the first sample of countries, one can notice a clear negative relation between CBI and inflation rate in the 1980s. This period is characterized with relatively high inflation rate for some countries (for example Italy and Portugal) and the outset of the central bank legal status changes that led to increased CBI. The decrease in inflation rate in the next decade can be noticed from the different scale of the X-axis for the 90s and the 80s. The scale changes also for CBI measure - GMT. In this case it marks a general increase in CBI degrees in the 1990s. Comparing the decades lead us to another conclusion: while the group of countries in the 1980s is clearly divided according to the pattern: high inflation rate-low CBI versus low inflation rate-high CBI, the data speak differently in the 1990s. In this decade there is a concentration of countries with similar levels of inflation rate (around 0.02, expressed as transformed inflation rate; this concentration is around 2.3% in levels) and a similar concentration of countries with rather high CBI level (above 0.7 for GMT and around 0.6-0.7 for LVAU). The last observation leads us to the next one: values of GMT are in general higher than for LVAU.

Trends among developing countries are not such distinctive. It is true, as we can observe from the scatter plot, that there has been an improvement in the "de facto" CBI level: values of this measure are lower in the 1990s, which implies less frequent change on the position of the CB governor. One can also observe a decrease in the inflation rate scale. After closer examination of the data, however, we notice that only seven out of twelve countries have their inflation rates lower in the 1990s. Thus, the change in the X-axis should not be treated as a general trend of decreased inflation (at least in the chosen sample). Moreover, outliers in the upper and lower graph are not the same country (it is Nicaragua and Zambia respectively). Therefore, we conclude this figure analysis that such differences in levels of CBI measures and inflation rate give reasons for further empirical analysis.

Other Control Variables

Much of the empirical work supporting the CBI hypothesis have been unsatisfactory due to its omittance of variables that explain changes in inflation rates. Early analysis relied heavily upon bivariate correlations between indices of CBI and inflation. Some economic variables, that have received attention include the degree of trade openness, government budget balances, levels or growth rates of GDP, proxies for the type of exchange rate regimes and membership in exchange rate

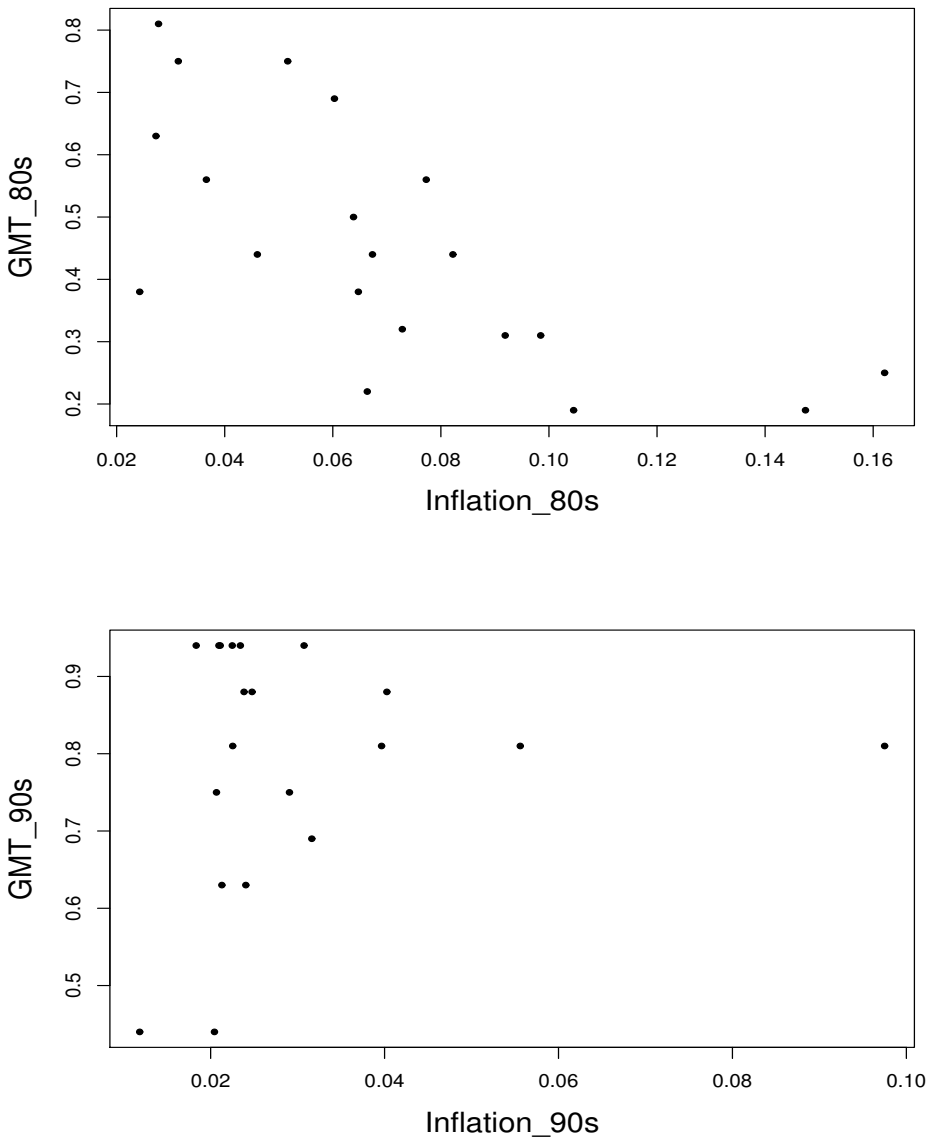

Figure 3.4: Scatterplots of GMT and inflation rate (expressed as transformed inflation according to the equation $\pi/(1+\pi)$, where inflation rate is expressed in decimals) for advanced countries.

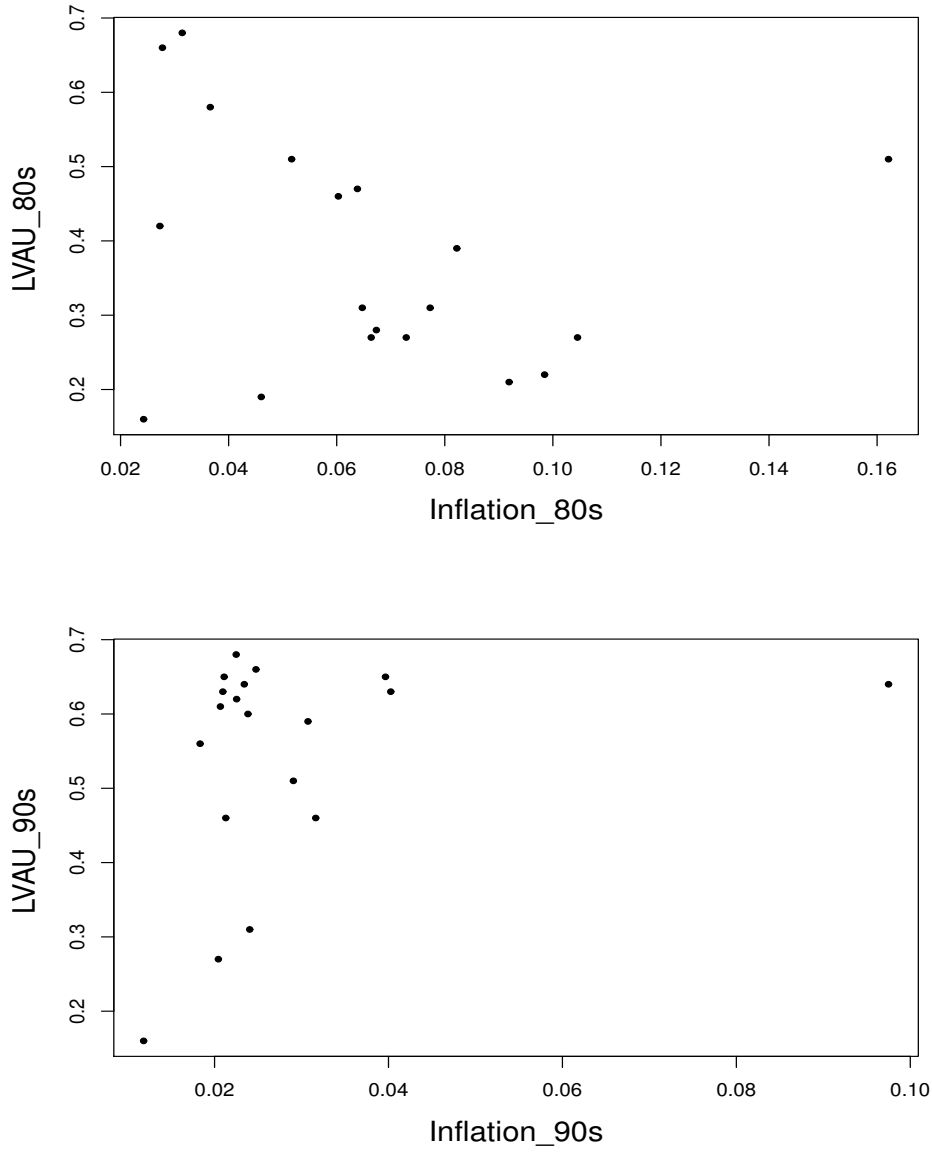

Figure 3.5: Scatterplots of LVAU and inflation rate (expressed as transformed inflation according to the equation $\pi/(1+\pi)$, where inflation rate is expressed in decimals) for advanced countries.

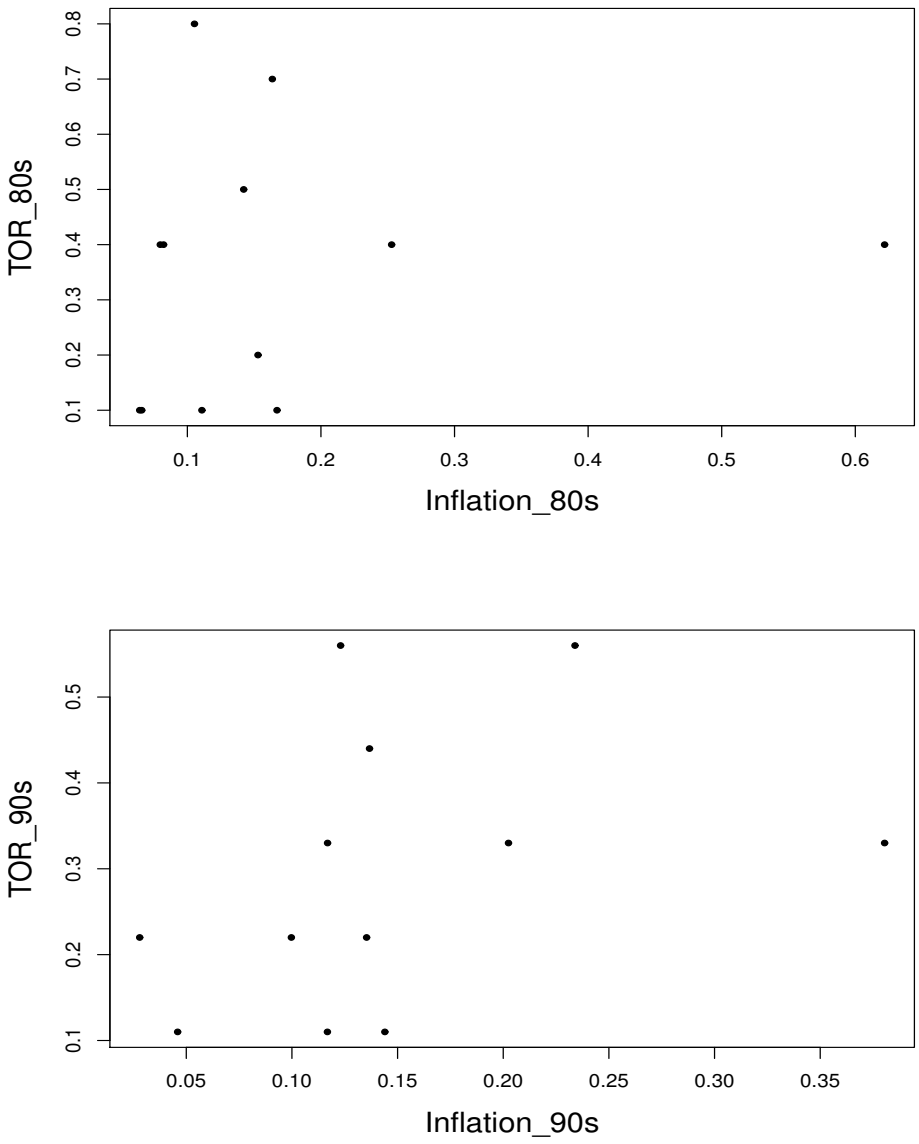

Figure 3.6: Scatterplots of TOR and inflation rate (expressed as transformed inflation according to the equation $\pi/(1+\pi)$, where inflation rate is expressed in decimals) for a sample of developing countries.

systems. Recently political-institutional variables have been included into models, for example variables detecting a presence of checks and balances, number of conflicts or the type of governing party.

The idea of an existing relation between central bank independence and inflation rate originated from the studies focusing on the group of major, often OECD economies. Once this phenomenon was established, further research concentrated their interest on other groups of countries but keeping in mind varying level of development among them. While explaining levels in the inflation rate over time, it seems rational to differentiate all causes depending on the type of economy. Thus, the following analysis divides the sample into industrial, transition (Central and Eastern European), emerging and developing countries. Reports of empirical results follow this division.

Robust relationship between openness and inflation rate is suggested with empirical work by Romer (1993). Therefore, an indicator of openness, defined as a sum of exports and imports in relation to GDP is included as one of regressors. Based on the Philips curve theory which suggests that when the unemployment rate is low inflation tends to increase, we include the measure of unemployment rate, as well. The cost-push and demand-pull theory of inflation suggest that causes of increased inflation rate may depend on higher costs of production, larger consumer demand or volumes of government consumption levels. Relying on these assumptions, the list of variables is enriched by the level of GDP per capita, world levels of oil prices and measure of governments' volumes of expenditure. Due to non-tationarity of GDP per capita[4], we consider also a first difference of this variable. Literature has also been concentrating on the role of fiscal policy in determining inflation. Sargent and Wallace (1981) linked monetary policy effectiveness to its coordination with fiscal policy pointing, that increased government debt leads to inflationary pressures. Our fiscal policy elements in the model are represented by the ratios of debt and deficit to GDP.

History of past inflation and events of hyperinflation are another determinant of inflation rate. Therefore, we include a dummy variable for periods of hyperinflation, as well as we analyze effects of world inflation rate. A dummy for hyperinflation considers countries and periods when inflation was above certain level. This level can be set arbitrarily. However, an example given by Peltonen (2006) has been used: hyper-inflation when average annual inflation rate is above 40%.

Aisen and Veiga (2006), among many find it reasonable to include political and

[4]Detected with the Levin, Liu and Chu (2002) test

institutional determinants to the model of inflation. These can relate to political regimes, like the number of veto players in the parliament (checks and balances), or can describe economic conditions, such as presence of banking sector reforms, for example. An index of economic freedom has been constructed by the Fraser Institute (Gwartney and Lawson 2006). The index comprises 21 components designed to identify the consistency of institutional arrangements and policies with economic freedom in five major areas: size of government; legal structure and security of property rights; access to sound money; freedom to trade internationally; and regulation of credit, labor and business. The index ranges from 0-10, where 0 corresponds to less economic freedom and 10 to more economic freedom. The choice of political and institutional variables can be additionally complemented with a variable describing number of conflicts in which the government of the country is involved. This variable come from UCDP/PRIO Armed Conflict Dataset (Gleditsch et al. 2002)[5]. This variable's minimum value is (0) and the maximum depends on the number of observed conflicts in a single year; very often it is (1) but not always. It is expected that a larger number of conflicts introduces destabilisation in the market and may be positively correlated with a higher inflation rate.

3.5 Empirical Results

3.5.1 Central Bank Independence Among Industrial Countries

The analysis time span for advanced countries is the longest and covers annual data for years 1970-2007. Among many determinants of inflation after World War II, one may point to the break-down of the Bretton Woods system in 1971: excessive government spending and thus growing deficit and debt-to-gdp ratio increased money holding or few oil crises with cost-push inflation effects.

Because we use several competing measures of central bank independence, and because we choose to apply varying estimation methods, we are going to repeat and report many estimation results. One has to remember that there is the reason why we repeat the same estimations several times. One one hand, describing the same phenomenon, these measures should be perfect substitutes of each other. If they react in the same way then they could be used interchangably in other studies without a threat that estimation results are constrained on the measure chosen. As

[5]Gleditsch, N.P., P. Wallensteen, M. Eriksson, M. Sollenberg and H. Strand (2002), "Armed Conflict 1946-2001: A New Dataset", *Journal of Peace Research*, vol. 49, no. 5.

result, my hypothesis that CBI measures give varying estimation outcomes within the same group of countries would fail. However, if they do indeed give different results, and we have to remember we mainly refer here to legal measures, then this hypothesis is supported and it rejects the Cukierman statement quoted in the introduction. So in a subsequent description of estimation findings we will focus on two ideas: whether there is a proof of a relation between CBI and inflation rate, and if it is an expected one; and whether there is a significant difference among these findings depending on CBI measures.

Table 3.5 reports the estimation findings from the first round that incorporates the Feasible Generalized Least Squares (FGLS) methodology. We place in one table all results that we found interesting. These are findings where "long-time" CBI measures (i.e. those that were calculated more than once) were used as CBI proxies. For the convenience of comparison, we placed results of two varying models: in the upper panel the dependent variable is defined as a "transformed inflation", whereas in the lower panel it is a lagged inflation rate. Moreover, in the latter case the GDP per capita is used in levels, not as a difference. These all act as a first robustness check, a test of whether CBI measures keep their explanatory power when the dependent variable is defined differently and some other regressors change their forms.

The reported results show that all CBI coefficients seem to have the correct sign and many of them are statistically significant. However, not all of them. Simple data modification, like a presentation of a dependent variable in its original form, showed that some indices lose their explanatory power. Two measures-overall GMT index and its economic definition-appeared to be good regressors of inflation rate, in spite of varying definitions of the inflation rate. The coefficients of these two measures are significant at least at the 5% level in both models. Its greatest competitor LVAU records significant values of its coefficient only with "transformed inflation" as a dependent variable. This significance is also lost in the case of PROB, which is a good regressor of "transformed inflation". The significance of this measure makes the whole exercise even more interesting. PROB is a similar type of the measure like TOR, that is both are classified as "actual" independence measures. There is a general agreement in the literature that "actual" measures perform better, that is are good regressors, when used for data from countries other than industrial ones. Whilst coefficients of the actual frequency of changes at the CEO position in central banks (TOR) have not recorded any significance in any possible combination of the model, the measure of the probability of

Table 3.5: Estimation results for industrial countries with FGLS - "transformed inflation" and inflation rate (logarithm) as a dependent variable

Dependent - transformed inflation rate	**LVAU**	**GMTO**	**GMTE**	**GMTP**	**PROB**	**Alesina2**
CBI	-0.07**	-0.03**	-0.11***	-0.04**	0.14***	-0.01
	(0.03)[-2.87]	(0.02)[-1.95]	(0.02)[-4.10]	(0.02)[-2.43]	(0.04)[3.3]	(0.03)[-0.34]
Transformed	0.68***	0.70***	0.64***	0.68***	0.67***	0.65***
inflation $d_{i,t-1}$	(0.06)	(0.06)	(0.06)	(0.06)	(0.07)	(0.07)
dlogGDP p.c.	0.69***	0.67***	0.52***	0.63***	0.70***	0.89***
	(0.13)	(0.14)	(0.12)	(0.13)	(0.16)	(0.18)
Openness (-1)	-0.0005**	-0.0008**	-0.0005**	-0.0004	-0.0005**	-0.0007
	(0.0002)	(0.0003)	(0.0002)	(0.0002)	(0.0006)	(0.0005)
Constant	0.25	0.24	0.33	0.23	0.20	0.23
	(0.05)	(0.04)	(0.06)	(0.05)	(0.05)	(0.05)
Observations	715	734	734	734	560	420
Weighted stats						
Adjusted R^2	0.97	0.97	0.97	0.97	0.96	0.96
S.E.of reg.	0.33	0.32	0.32	0.32	0.37	0.40
Dependent- inflation rate	**LVAU**	**GMTO**	**GMTE**	**GMTP**	**PROB**	**Alesina2**
CBI	-1.17	-0.63**	-1.59**	-0.29	1.31	-0.18
	(0.75)[-1.56]	(0.23)[-2.74]	(0.68)[-2.35]	(0.58)[-0.49]	(0.96)[0.96]	(0.43)[-0.41]
Inflation	0.72***	0.72***	0.70***	0.72***	0.79***	0.76***
rate($y_{i,t-1}$)	(0.04)	(0.05)	(0.05)	(0.04)	(0.04)	(0.04)
logGDP p.c.	-1.75***	-1.77***	-1.64***	-1.8***	-1.10	-1.35
	(0.48)	(0.50)	(0.48)	(0.53)	(0.87)	(0.90)
Openness (-1)	0.03**	0.02**	0.03**	0.03**	0.01	0.02
	0.01	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
Constant	16.98	17.47	16.95	17.24	10.59	13.17
	4.36	(4.56)	(4.40)	(4.69)	(7.86)	(8.28)
Observations	715	734	734	734	560	420
Weighted stats.						
Adjusted R^2	0.82	0.80	0.81	0.80	0.84	0.83
S.E.of reg.	2.08	2.26	2.26	2.26	1.74	1.61

Notes: Method for all regressions: Fixed effects with GLS cross-section weights and White cross-section coefficient covariance method. Coefficients' standard errors in parentheses, and t-statistics in square brackets. Stars ***, **, * indicate results significant at the 1%, 5%, and 10% respectively. Transformed inflation defined as $d = \frac{inflation_{i,t}}{1+inflation_{i,t}}$

Abbreviations (and hereafter): LVAU–legal CBI index by Cukierman et al. (1992); GMTO, GMTE, GMTP–indices by Grilli et al. (1991); PROB-index by Krause et al. (2008), Alesina2 - measure by Alesina (1988) with updated values for the 1990s; $d_{i,t-1}$–transformed inflation rate lagged one period; dlogGDP p.c.–difference in log GDP per capita; Openness(-1)–lagged one period measure of openness

such a change occurring (PROB) can be considered as a good regressor of inflation rate.

With a group of "short-term" indices (those whose values do not change over

time) it was possible to estimate simple cross-country models. Coefficients of all these measures were insignificant in the model with "transformed" inflation. In the second case, the first original measures by Bade-Parkin, Alesina and Eijffinger-Schaling performed relatively well as regressors. Their coefficients did not only significantly differ from zero, but also had smaller standard errors. Other measures, including TOR and VUL but also measures based on distance from Germany or OPCBI, did not perform well in this test. Moreover, an updated values of Alesina (done by the authors of this thesis) were insignificant in all models combinations. To sum it up, the first estimations results support our hypothesis that, as far as legal measures of CBI are concerned, the results can differ also within a group of homogenous countries, in this case advanced ones. The next step is to strengthen or reject this conclusion by repeating estimations using methods: Least Square with PCSE and instrumental method GMM.

Since FGLS makes certain assumption about the form of heteroskedasticity, one can eliminate this assumption and estimate models with a simple Least Squares estimation, keeping fixed effects but introduce Panel Corrected Standard Errors (PCSE). To make it more interesting, we will exchange some explanatory variables, that is the measure of openness will be later replaced with an unemployment rate. The theory supports the choice of this variable; additionally such a change works as a robust check for the previous results.

The following analysis of estimation findings will relate to both tables 3.6 and 3.7. The first one reports data of Least Square with PCSE, table 3.7 presents the estimation outcomes with instrumental variable approach. Both tables are constructed in a similar way as before, that is they consist data for all models combinations. We decide to drop some data in the lower panel of tables, like results for certain explanatory variables because they did not differ significantly from those reported in the upper part.

There is not much change in the estimation results when we compare table 3.6 with the previous one. There is a pattern with strongly significant coefficients of three GMT measures, significance of those for LVAU and PROB but also a loss of significance for coefficients of these two measures when models are redefined. Therefore, it is one more proof that not all CBI indices are such strong regressors of inflation rate among advance countries and this significance depend on the construction of the model, as well. Again, our hypothesis is supported here - there are differences in estimations between GMT and LVAU with unemployment and transformed inflation rates included in the model.

Table 3.6: Estimation results for industrial countries with PCSE - inflation rate (logarithm) and "transformed inflation" as a dependent variable

Dependent - inflation rate	**LVAU**	**GMTO**	**GMTE**	**GMTP**	**PROB**
CBI	-0.26**	-0.28***	-0.36***	-0.17**	0.49**
	(0.10) [-2.59]	(0.08) [-3.71]	(0.08) [-4.31]	(0.05) [-3.02]	(0.21) [2.29]
Inflation	0.79***	0.78***	0.77***	0.79***	0.78***
rate ($y_{i,t-1}$)	(0.03)[31.10]	(0.03) [29.81]	(0.03) [29.28]	(0.03) [31.76]	(0.03) [27.41]
dlogGDP p.c.	3.89***	3.53***	3.50***	3.83***	3.64***
	(0.45) [8.57]	(0.45) [7.86]	(0.44) [7.99]	(0.44) [8.28]	(0.57) [6.43]
Openness	0.00	0.00	0.00	0.00	0.00
	(0.00) [0.49]	(0.001) [1.00]	(0.007) [0.05]	(0.001) [0.94]	(0.00) [0.69]
Constant	0.17	0.24**	1.90**	0.13	-0.02
	(0.12) [1.43]	(0.12) [1.99]	(0.00) [0.49]	(0.11) [1.21]	(0.11) [-0.19]
Periods incl.	37	37	37	37	28
Cross-sections	20	20	20	20	20
	LVAU	**GMTO**	**GMTE**	**GMTP**	**PROB**
CBI	-0.25**	-0.27**	-0.32**	-0.18**	0.42**
	(0.12) [-2.16]	(0.08) [-3.17]	(0.10) [-3.27]	(0.06) [-3.00]	(0.21) [1.99]
Unemployment	-0.02***	-0.02***	-0.02***	-0.02***	-0.02***
rate	(0.00) [-4.72]	(0.00) [-4.64]	(0.00) [-4.32]	(0.00) [-4.71]	(0.00) [-4.01]
Dependent - transformed inflation rate	**LVAU**	**GMTO**	**GMTE**	**GMTP**	**PROB**
CBI	-0.02**	-0.02***	-0.02***	-0.01**	0.01
	(0.01) [-2.82]	(0.00) [-3-91]	(0.00) [-4.34]	(0.00) [-3.18]	(0.01) [1.29]
Openness	0.00	0.00	0.00	0.00	0.00
	LVAU	**GMTO**	**GMTE**	**GMTP**	**PROB**
CBI	-0.01	-0.01**	-0.01*	-0.01**	0.01
	(0.01) [-1.14]	(0.00) [-2.08]	(0.00) [-1.93]	(0.00) [-2.10]	(0.01) [0.88]
Unemployment	-0.00***	-0.00***	-0.00***	-0.00***	-0.00***

Notes: Method for all regressions: OLS with PCSE and fixed effects. Coefficients' standard errors in parentheses, and t-statistics in square brackets. Stars ***, **, * indicate results significant at the 1%, 5%, and 10% respectively.

Abbreviations: Periods incl. and cross-sections – number of periods and countries included in the estimations.

Finally, we use the General Methods of Moment. All models are in represented in levels but we have included differences of lagged values of the dependent variable. The set of instruments is all the time the same and it includes: inflation rate or values of transformed inflation (lags 2,3), differences of lagged inflation rate defined as $(x_{i,t-2} - x_{i,t-3})$ and $(x_{i,t-3} - x_{i,t-4})$, unemployment rate lagged one period, GDP per capita, the measure of CBI used in the estimation lagged one period and a similar other measure. Thus, only instruments that differed were the relevant CBI.

Despite a different estimation methodology, all CBI measures report again the

Table 3.7: Estimation results for industrial countries with GMM - inflation rate (logarithm) and "transformed inflation" as a dependent variable

Dependent - inflation rate	**LVAU**	**GMTO**	**GMTE**	**GMTP**	**PROB**
CBI	-0.43**	-0.47**	-0.55**	-0.34**	0.79**
	(0.19) [-2.19]	(0.17) [-2.75]	(0.18) [-3.00]	(0.13) [-2.63]	(0.33) [2.39]
Inflation	0.77***	0.72***	0.72***	0.74***	0.77***
rate ($y_{i,t-1}$)	(0.05) [14.19]	(0.06) [11.87]	(0.06) [11.26]	(0.05) [13.51]	(0.06) [13.50]
Unemployment	-0.02**	-0.02**	-0.02**	-0.02**	-0.01*
rate	(0.01) [-2.32]	(0.01) [-2.47]	(0.01) [-2.27]	(0.01) [-2.47]	(0.01) [-1.80]
S.E. of reg.	0.32	0.31	0.31	0.32	0.32
J-stat	35.00	28.36	28.78	28.10	32.17
p-value	0.05	0.20	0.19	0.21	0.10
Dependent- transformed inflation rate	**LVAU**	**GMTO**	**GMTE**	**GMTP**	**PROB**
CBI	-0.02**	-0.02**	-0.02**	-0.02**	0.03
	(0.01) [-2.06]	(0.01) [-2.44]	(0.01) [-2.6]	(0.01) [-2.55]	(0.02) [1.54]
Inflation rate	0.77***	0.74***	0.74***	0.74***	0.81***
Unemployment	-0.00**	-0.00**	-0.00**	-0.00**	-0.00
rate					
S.E. of reg.	0.01	0.01	0.01	0.01	0.01
J-stat	16.25	24.09	17.09	13.30	25.31
p-value	0.84	0.40	0.80	0.94	0.33

Notes: Method for all regressions: GMM and country fixed effects. Coefficients' standard errors in parentheses, and t-statistics in square brackets. Stars ***, **, * indicate results significant at the 1%, 5%, and 10% respectively. In all estimations number of periods is 27 and number of cross-sections is 20.
Abbreviations: S.E. of reg. – standard errors of regression, J-stat – J-statistic by Hansen (1982), p-value – (1958) test for over-identifying restrictions

right sign of estimated coefficients and high significance. Moreover, a series of "short-time" measures like Alesina, BP, ES record the correct signs of their coefficients. They're also significant, but only at the 10% level. What is interesting, this time the results reject our hypothesis: LVAU and GMT perform in the same way and in the same scale. However, all measures did not pass the robustness test, that is, when unemployment rate is replaced with GDP per capita, none of the CBI indices record significant estimated coefficients. Replacing independent variables has some additional costs, as well as we observe that the fit of estimations gets worse. Hence, we accept and report here estimation results obtained from the model including an unemployment rate. We continue tracing explanatory power of CBI measures with some additional tests.

Robustness Check

From panel estimation one can notice that coefficients of GMTO measure of independence were for all the tests significantly different from zero, while few other measures suffered from the lack of robustness when the dependent variable was redefined. This outcome gives incentive to test whether a model, where the GMTO represents a CBI definition should be accepted over all other models.

For this reason and assumption, we perform the J-test for non-nested models, proposed by Davidson and MacKinnon (1981). This test assumes that if one model is the correct model, then the fitted values from the other model should not have explanatory power when estimating that model. In a model with an inflation rate, as a dependent variable and Least Square estimation, all models (with "long-term" indices) were evaluated in a pair-wise comparison. For example, choosing between two specifications including either GMTO or GMTE followed a procedure:

$$H_1 : y_{i,t} = \alpha + \beta_1 GMTE_{i,t} + \beta_2 y_{i,t-1} + \beta_3 loggdpcap_{i,t} + \beta_4 openc_{i,t-1} + u_{i,t}$$
$$H_2 : y_{i,t} = \alpha + \beta_1 GMTO_{i,t} + \beta_2 y_{i,t-1} + \beta_3 loggdpcap_{i,t} + \beta_4 openc_{i,t-1} + u_{i,t}$$

If fitted values of $y_{i,t}$ based on representation H_2 enter significantly in model H_1, model H_1 can be rejected. However, if the opposite happens, fitted values of $y_{i,t}$ of H_1 are significant when included in H_2, model H_2 can be rejected as well. This is a drawback of this method: it is possible to either reject both specifications or fail to reject both models, at the same time. In this case the data do not provide enough information to discriminate between the two models.

Here, fitted values of $y_{i,t}$ of the model with CBI measure defined as GMTO enters significantly to all other models with "long-term" indices[6]. At the same time, none of these models' fitted values of $y_{i,t}$ were significant in the GMTO estimation. Additionally, considering other pairs, fitted values of $y_{i,t}$ of the model with CBI measure defined as GMTE were significant in the LVAU estimation; opposite did not happen.

One other test for the explanatory power of competitive variables is to regress the model that consists of all these elements, for example a model where all regressors are CBI measures. Table 3.8 summarises outcomes of these tests. The general idea is the same: which coefficients of CBI measures will be significantly different from zero in a set of many similar definitions. Due to high correlation

[6]For a reminder: GMTE, GMTP, LVAU, PROB

Table 3.8: Results for industrial countries with CBI as the only regressors with inflation rate and "transformed inflation" as dependent

Dependent - inflation rate	(1)	(2)	**Transformed inflation (*d*)**	(3)	(4)
GMTE	-8.79***	-1.53**	GMTE	-0.40***	-0.15***
	(-8.59)[1.02]	(-2.99)[0.51]		(-12.39)[0.03]	(-3.47)[0.04]
GMTP	-5.15***	-0.63	GMTP	-0.06	-0.01
	(-4.12)[1.25]	(-1.05)[0.60]		(-1.52)[0.04]	(-0.57)[0.02]
LVAU	3.55**	0.92	LVAU	0.07**	0.02
	(2.23)[1.59]	(1.05)[0.87]		(2.16)[0.03]	(0.58)[0.04]
PROB	1.51	0.64	PROB	-0.03	-0.01
	(1.02)[1.48]	(0.39)[1.61]		(-0.58)[0.04]	(-0.44)[0.03]
Lagged inflation		0.82***(13.78)	Lagged *d*		0.64***(8.28)
Method	LS	LS	Method	FGLS	FGLS
Dependent - inflation rate	(1)	(2)	**Transformed inflation (*d*)**	(3)	(4)
GMTE	-8.57***	-1.54*	GMTE	-0.08***	-0.01**
GMTP	-6.10***	-0.62	GMTP	-0.05***	-0.01
LVAU	5.99**	0.89	LVAU	0.05**	0.01
PROB	1.74	0.64	PROB	0.01	0.00
TOR	16.54***	-0.14	TOR	0.14**	-0.00
Lagged inflation		0.82***	Lagged inflation		0.82***
Method	LS with PCSE	LS with PCSE	Method	LS with PCSE	LS with PCSE

Notes: Coefficients' standard errors in square brackets, t-statistics in parentheses. Stars ***, **, * indicate results significant at the 1%, 5%, and 10% respectively. Transformed inflation defined as $d = \frac{inflation_{i,t}}{1+inflation_{i,t}}$
Abbreviations: LS–Least Square; GLS–Generalized Least Square, PCSE–Panel Corrected Standard Errors

between GMTO and GMTE (GMTP), the overall index is eliminated. One should note that GMTP and GMTE have completely different definitions and are uncorrelated. Once we have eliminated the overall measure of independence GMT from the model, its economic counterpart performs very well. GMTE scores negative and significant coefficients of estimation despite changing elements of the model and the method of estimation. The most surprising are positive and significantly different from zero values of coefficients for LVAU. In a bivariate models, when only LVAU is a regressors, this measure performs as expected and its coefficient's value is negative. However, once the GMT measures are included, LVAU reacts differently as a regression of inflation rate. Probability of the central bank CEO change records mixed results, albeit in general its coefficients have positive, hence expected values (however, not significantly different from zero). When an additional regressor is added, that is a lagged value of the dependent variable, only coefficients of GMTE have their expected signs. Thus we can conclude from this simple test that GMTE is the best regressor of inflation rate among other CBI in-

Table 3.9: Estimation results for industrial countries using averaged data with FGLS

	GMTO	**GMTE**	**GMTP**	**LVAU**	**PROB**	**TOR**
CBI	-9.35***	-8.30***	-6.93***	-8.87***	9.15***	11.55**
	(-11.76)[0.79]	(-10.24)[0.81]	(-9.23)[0.75]	(-3.83)[2.31]	(5.59)[1.64]	(2.88)[4.02]
Less D and CH	**GMTO**	**GMTE**	**GMTP**	**LVAU**	**PROB**	**TOR**
CBI	-9.09***	-8.04***	-6.80***	-8.23**	8.3***	2.36
	(-9.01)[1.00]	(-7.24)[1.1]	(-7.49)[0.91]	(-2.89)[2.84]	(4.19)[1.97]	(0.37)[6.34]

Notes: Least square, fixed effects with White cross-section coefficient covariance method. Coefficients' standard errors in square brackets, t-statistics in parentheses. Stars ***, **, * indicate results significant at the 1%, 5%, and 10% respectively.

Abbreviations: TOR - index created by Cukierman et al. (1992), Less D and CH-estimations without Germany and Switzerland.

dices in a group of advanced countries.

Data mining, like averaging of time series, can affect estimation results. It happens due to loss of information during such data modification. This averaging introduces smoothness into the data by reducing larger fluctuations. The presence of outliers and/or influential points can dramatically affect the regression line, as well. This means that these points are capable of pulling the regression line toward itself, thus distorting the slope of the regression line. In order to show effects of both situations, Table 3.9 presents panel data estimation (only for CBI measures) based on four periods (averages of decades between 1970-2007), with or without influential observation. In general literature on CBI, it is accepted to believe that Germany and Switzerland could be influential points. The model is defined in the same way throughout all estimations.

Averaging data appears to significantly affect the estimations' results. The key difference comes from the fact that now all coefficients of CBI measures have expected negative signs and its values are significantly different from zero. Not only do legal measures of independence matter, but so do those so-called "actual" measures connected with a change (or probability of a change) of a CB governor. Much higher coefficients (often, ten times larger than produced in the annual analysis) can be connected with the data modification; now, CBI is related to decennial change in inflation rate. However, comparing annual versus decennial data analysis, one should notice much larger standard errors of estimated coefficients in the latter type, especially with LVAU, PROB and TOR. Elimination of influential points does not bring big differences in estimations. Coefficients values decrease slightly, standard errors increase, but all the measures have strong explanatory power, except

the turnover rate of governors.

Two more robustness tests that investigate CBI measures' explanatory power are performed. We re-define again a dependent variable. We introduce variability of inflation (calculated as a 12-month moving average of the variance of the inflation rate) and the annual growth of narrow money (M1). Similarly to levels of inflation rate, we expect to find a negative relationship between CBI and these two new variables. Measures LVAU, GMTE, GMTP, GMTO, and PROB have expected explanatory power of variability of inflation only when a model is estimated with OLS and PSCE (another regressor in this model is level of inflation). Legal CBI measures could also be accepted as regressors (at the 10% level) when a model is regressed with GMM method. Again, one of the GMT measures, GMTO performs better than the rest of CBI measures. Its coefficient is significant at the 5% level. All measures lose their explanatory power in a model estimated with FGLS. However, in a model with M1 growth as a dependent variable, all CBI indices have strong explanatory power, despite the estimation methodology.

Table 3.10: Robustness check–estimation results from a complex model for advanced countries

Model (1)					
LVAU	-4.77**				
	(1.64)				
GMTO		-4.72***			
		(0.87)			
GMTE			-5.58***		
			(0.67)		
GMTP				-2.93***	
				(0.74)	
PROB					4.44***
					(1.23)
dlogGDPCAP	2.94	-2.87	-2.52	0.91	4.41
Openness	-0.08***	-0.06**	-0.07**	-0.07**	-0.08***
Unemployment	-0.57***	-0.44***	-0.43***	-0.48***	-0.52***
Deficit/GDP	-0.24***	-0.22***	-0.23***	-0.22***	-0.25***
Gexpenditure	-2.65	-2.09	-2.92	-1.47	-1.45
Wagebargain	-0.55***	-0.60***	-0.56**	-0.60***	-0.52***
World	0.06**	0.07***	0.06**	0.07***	0.06**
Oil	0.19***	0.21***	0.21***	0.21***	0.21***
Constant	13.42***	12.57***	13.54***	11.85	10.13***
Adjusted R^2	0.70	0.71	0.71	0.70	0.68

S.E. of reg.	2.18	2.37	2.41	2.41	2.59
Model (2)					
LVAU	1.22**				
	(0.49)				
GMTO		-3.40***			
		(0.62)			
GMTE			-4.92***		
			(0.51)		
GMTP				0.22	
				(0.31)	
PROB					4.89***
					(0.70)
dlogGDPCAP	-3.29	-2.90	-5.39	-2.07	-3.68
Openness	-0.01**	-0.00	-0.00*	-0.00**	-0.01***
Unemployment	0.05*	0.06**	0.02	0.04*	0.01
Gexpenditure	13.81***	10.70**	4.78	14.55***	13.11***
Wagebargain	-0.15**	-0.36***	-0.14**	-0.16**	-0.17***
Adjusted R^2	0.41	0.46	0.49	0.41	0.45
S.E. of reg.	2.73	2.84	2.74	2.99	2.86

Notes: Model (1)–analysis with cross-country fixed effects, FGLS with cross-section weights and White cross-section coefficient covariance method; Model (2)–analysis with period fixed effects, FGLS with period PCSE; inflation rate as a dependent variable. In all estimations: number of time periods–25, number of cross-sections: 20. Coefficients' standard errors in parentheses. Stars ***, **, * indicate results significant at the 1%, 5%, and 10% respectively. Abbrevations: dlogGDPCAP–first difference of logged GDP per capita; Gexpenditure– growth of government's expenditure; Wagebargain–measure of wage bargaining centralization; World–level of world inflation rate; Oil–values of world oil prices; CBI measures' abbreviations as before.

Next, our plan is to regress level of inflation rate with all economic variables we have found for this analysis, that is, apart from CBI indices, GDP/capita, openness, unemployment, ratio of deficit to GDP, growth of government's expenditure, index of centralized wage bargaining and levels of world inflation and prices of oil in the global market. The aim of this test is again to determine: does central bank independence matter for the levels of inflation if many other regressors of inflation are included in the model. Table 3.10 presents results of this test.

As expected, the presence of supplementary regressors does not diminish effects of CBI on inflation rate. In a model estimated with cross-country fixed effects (model 1) all coefficients of CBI measures have anticipated signs and are significantly different from zero. Other regressors explain the inflation rate in the expected way, as well. This is true except for the ratio of deficit to GDP, which indicates that the higher deficit/GDP, the lower inflation rate. Therefore, we estimate model 2. For the first time we estimate the model with period fixed effects. Due to problems with estimations of this model, we eliminate some regressors, that

is deficit/GDP, level of world inflation and oil prices. In a group of CBI indices, only GMTO, GMTE and PROB have their coefficients with anticipated signs and strongly significant. This conclusion is different for LVAU. Its coefficient is positive and significant, indicating that lower levels of inflation is associated with lower degrees of inflation.

3.5.2 Central Bank Independence in Emerging Markets

A few emerging markets, especially those from Latin America, are characterised with short periods of very high inflation (table 3.11 presents descriptive statistics for some countries). Argentina, Brazil or Peru are countries where the annual change of inflation rate was measured in thousands of percent. As explained earlier, one of the solutions to these data is to represent a dependent variable as a transformed inflation, as suggested by Cukierman (1992). This treatment, however, as pointed out by Jácome and Vázquez (2005), has an undesirable effect of bounding the dependent variable in the interval [0,1]. For this reason, we decide to apply an alternative measure, $ln(k+\pi)$. The variable k is a positive number that helps avoid finding a logarithm from a negative number. Because of Thailand's example with a negative inflation rate of -9.5% in the 1990, k is number 10.

Table 3.11: Descriptive statistics of inflation for selected emerging countries

Country	**Obs**	**Mean**	**Std Dev.**	**Min**	**Max**
Argentina	28	295.17	709.29	-1.17	3079.46
Brazil	28	424.54	760.02	3.21	2947.73
Chile	28	12.71	9,66	1.06	35.14
Peru	28	461.02	1518.67	0.16	7481.69
Thailand	28	4.01	4.73	-9.5	19.7
Venezuela	28	30.62	22.63	6.24	99.88

Availability of data on CBI in emerging markets allows to perform this analysis for the years 1980-2007. The estimated model looks different than the one for industrial countries, for example. Apart from the CBI measure and lagged inflation rate, we decide to check effects of world inflation (lagged 1 period), the measure of economic freedom and a dummy for high inflation countries. We perform the same estimation roadmap as previously: we estimate the base model and modify it for a robustness check, and we perform these tests using three different estimation methods. The results of these tests are reported in tables 3.12, 3.13 and 3.14.

Table 3.12: Estimation results for emerging markets with FGLS - inflation rate (logarithm) and a "transformed" inflation as a dependent

Dependent - inflation rate	**LVAU**	**GMTO**	**GMTE**	**GMTP**	**TOR**
CBI	-1.02	-0.10	-0.13**	0.04	0.37***
	(0.07)[-1.57]	(0.09)[-1.14]	(0.04)[-2.85]	(0.08)[0.47]	(0.09)[4.20]
Inflation	0.67***	0.67***	0.66***	0.67***	0.62***
rate ($y_{i,t-1}$)	(0.07)	(0.07)	(0.07)	(0.06)	(0.06)
World	0.01***	0.01***	0.01**	0.01***	0.01***
inflation (-1)	(0.002)	(0.001)	(0.001)	(0.001)	0.002
Obs.	450	450	450	450	450
	LVAU	**GMTO**	**GMTE**	**GMTP**	**TOR**
CBI	-0.07	-0.16*	-0.12**	0.01	0.59***
	(0.08)[-0.88]	(0.09)[-1.85]	(0.05)[-2.65]	(0.07)[0.19]	(0.09)[6.48]
HYPER	0.84***	0.85***	0.84***	0.87***	0.86***
	[0.08]	[0.08]	[0.08]	[0.089]	[0.08]
CBI	0.06[0.79]	0.02[0.25]	-0.02[-0.55]	0.11*[1.80]	0.49***[5.87]
ECONFREE	-0.10***	-0.10***	-0.09***	-0.11***	[-0.05***]
Dependent transformed inflation	**LVAU**	**GMTO**	**GMTE**	**GMTP**	**TOR**
CBI	-0.07**	-0.05**	-0.04**	-0.02	0.15***
	(-2.82)[0.02]	(-2.18)[0.02]	(-2.48)[0.01]	(-0.85)[0.02]	(4.19)[0.04]
with lagged dependent	and	world	inflation		
CBI	-0.001	0.05*	0.01	0.05**	0.07**
	(-0.041) [0.02]	(1.82)[0.03]	(0.68)[0.01]	(2.09)[0.02]	(3.08)[0.03]

Notes: ***, **, * indicate results significant at the 1%, 5%, and 10% respectively. t-statistics in square brackets. Standard errors in regular brackets.

Abbreviations: World inflation (-1)–world inflation rate lagged one period; HYPER–a dummy for countries and years with inflation rate over 40%; ECONFREE–index of economic freedom; Obs.–number of observations

Thanks to a large number of CBI indices available, we can again test our hypothesis that legal measures of CBI perform differently within the homogenous group of countries. However, we expect this hypothesis to be dominated by the general findings that measures of "actual" independence (like TOR) are better proxies of CBI in countries other than advanced ones. This is visible throughout all three tables - with only one exception (model estimated with Least Squares and PCSE and modified with different regressors) estimated coefficients for TOR are positive (as expected) and significantly different from zero. Hence, if "actual" independence will dominate here, then there may be not much space for comparison between legal measures. The first table reporting estimations with FGLS shows

Table 3.13: Estimation results for emerging markets with PCSE - inflation rate (logarithm) as a dependent

	LVAU	**GMTO**	**GMTE**	**GMTP**	**TOR**
CBI	-0.34**	-0.47**	-0.30***	-0.22**	0.51**
	(0.11) [-3.09]	(0.14) [-3.43]	(0.09) [-3.54]	(0.10) [-2.26]	(0.24) [2.15]
Inflation	0.54***	0.53***	0.53***	0.55***	0.55***
rate $y_{i,t-1}$	(0.05) [10.77]	(0.05) [10.57]	(0.05) [10.30]	(0.05) [10.90]	(0.06)[9.82]
HYPER	1.02***	1.03***	1.01***	1.06***	1.05***
	(0.11) [9.24]	(0.11) [9.24]	(0.11) [9.17]	(0.11) [9.27]	(0.12) [8.60]
Periods incl.	25	25	25	25	25
Cross-sections	18	18	18	18	18
S.E. of reg.	0.45	0.45	0.44	0.45	0.44
	LVAU	**GMTO**	**GMTE**	**GMTP**	**TOR**
CBI	-0.48**	-0.47**	-0.37**	-0.02	0.25
	(0.15) [-3.21]	(0.19) [-2.54]	(0.12) [-3.05]	(0.14) [-0.17]	(0.28) [0.90]
World	0.01**	0.01**	0.01*	0.01***	0.01***
	LVAU	**GMTO**	**GMTE**	**GMTP**	**TOR**
CBI	-0.34**	-0.43**	-0.30**	-0.08	0.25
	(0.16) [-2.18]	(0.17) [-2.47]	(0.11) [-2.73]	(0.12) [-0.62]	(0.27) [0.89]
ECONFREE	-0.16**	-0.17***	-0.16**	0.20***	-0.18***

Notes: ***, **, * indicate results significant at the 1%, 5%, and 10% respectively. t-statistics in square brackets. Standard errors in regular brackets.
Abbreviations: World–world inflation rate; HYPER–a dummy for countries and years with inflation rate over 40%; ECONFREE–index of economic freedom

the opposite. One can notice that GMT performs quite well as a regressor here, on contrary to LVAU. Tables 3.13 and 3.14 show that all legal measures perform unexpectedly well. One could conclude that the ongoing economic development and stability of democratic institutions allow these countries to advance to a group where legal acts also matter and are binding. When we compare results form these two tables we can notice that there is no significant difference between LVAU and GMT. For most of the cases their coefficients are not only of expected sign but also significant. Standard errors of these coefficients are small in both PCSE and GMM methods. However, we notice that there is a small predominance of the economic independence measure GMT. It keeps being a good regressor of inflation in all cases of estimations with LS PCSE and GMM, also when the measure of economic freedom is included in the model.

CBI in a Few Latin American Countries

It is also possible to do another type of robustness analysis. Certainly, it is by now obvious that estimation outcomes depend on the type of countries. The relation

Table 3.14: Estimation results for emerging markets with GMM - inflation rate (logarithm) as a dependent

	LVAU	**GMTO**	**GMTE**	**GMTP**	**TOR**
CBI	-0.23**	-0.40**	-0.29**	-0.32**	0.33**
	(0.10) [-2.27]	(0.13) [-3.12]	(0.09) [-3.17]	(0.11) [-2.89]	(0.15) [2.19]
HYPER	-0.06	0.91	1.62	1.63**	0.14
J-stat	2.95	2.07	1.41	0.96	1.94
p-value	0.08	0.15	0.23	0.33	0.16
Periods incl.	23	23	23	23	23
Cross-sections	18	18	18	18	17
S.E. of reg.	0.51	0.49	0.49	0.49	0.50
	LVAU	**GMTO**	**GMTE**	**GMTP**	**TOR**
CBI	-0.21**	-0.23**	-0.25**	-0.05	0.31**
	(0.09) [-2.37]	(0.10) [-2.19]	(0.08) [-3.06]	(0.07) [-0.67]	(0.14) [2.20]
World	0.00	0.00	0.00	0.00	0.00
J-stat	4.91	6.36	6.05	10.50	3.97
p-value	0.18	0.09	0.11	0.01	0.26
	LVAU	**GMTO**	**GMTE**	**GMTP**	**TOR**
CBI	-0.01	-0.10	-0.14*	0.02	0.32**
	(0.08) [-0.08]	(0.09) [-1.02]	(0.08) [-1.90]	(0.08) [0.29]	(0.16) [2.06]
ECONFREE	-0.18***	-0.18**	-0.17**	-0.18***	-0.19**
J-stat	3.37	2.60	1.67	5.48	4.69
p-value	0.34	0.46	0.64	0.14	0.20

Notes: ***, **, * indicate results significant at the 1%, 5%, and 10% respectively. t-statistics in square brackets. Standard errors in regular brackets.

Abbreviations: World–world inflation; HYPER–a dummy for countries and years with inflation rate over 40%; ECONFREE–index of economic freedom. Instruments: Inflation rate (lagged periods 2 and 3), difference between these inflation rates, world inflation rate, lagged one period values of respective additional explanatory variable (ECONFREE, HYPER or world inflation) and adequate CBI measures)

between degree of CBI and inflation rate is much stronger among advanced countries than emerging ones, for example. This strength lies mainly in the fact that this relation is visible with many different definitions of CBI.

Among emerging markets, it is plausible to distinguish a separate group of countries. Some papers, such as Jácome and Vásquez (2005), for example, focus only on Latin American countries. Here, those countries are Argentina, Brazil, Chile, Peru, Mexico and Venezuela. Therefore, the following analysis will include only these six countries.

Table 3.11 with descriptive statistics for these countries, clearly indicates that almost all of them experienced periods of hyper-inflation. In the 1990s, these countries experienced waves of currency and banking crises. Mexico registered major exchange rate devaluations in both in the 1980s and 1990s. Argentina and Venezuela faced additional banking crises in 2002 and 1994-1995, respectively.

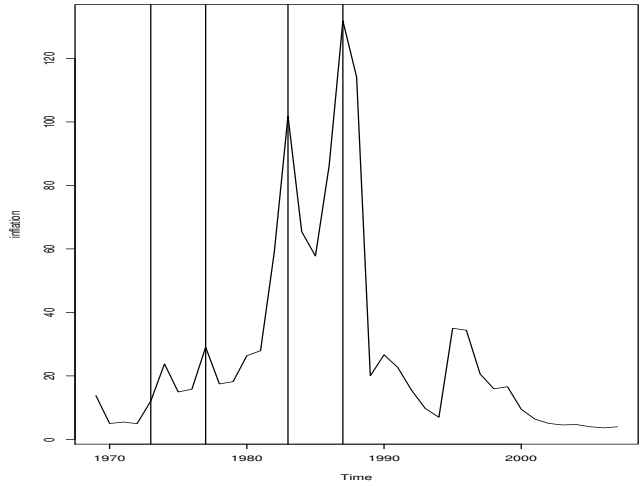

Figure 3.7: Inflation rate in Mexico
Source: IMF statistics and Gould and Marion(1998)

At the same time, many of these countries had undergone fundamental changes to their political and economic structures since the 1980s.

Increasing degrees of central bank independence aimed to create a credible message to the public concerning a reduction in inflation rates. Prior to the 1990s, for example, Mexico suffered bursts of inflation after several failed inflation-fighting programmes (Gould and Marion 1998). Figure 3.7 presents a history of inflation rate with, vertical lines marking years in which an anti-inflation programme was introduced. As figure 3.7 shows, during the 1970s and 1980s, anti-inflation programmes implemented at inflation peaks were eventually abandoned, succeeded by a new acceleration of inflation rate.

Past and recent experience of governors of the Central Bank of Argentina prove that changing legislation is not enough for the rule to be enforced. In fact, central bank governor, Martin Redrado was recently dismissed from his position for refusing to repay the country's international debt from the central bank's funds. This is an example of the discrepancy between legal and actual degree of central bank independence, often observed in non-advanced countries. The above analysis has shown that the turnover rate of governors, an example of the measure of the actual degree of CBI, is mainly (if not solely) significantly able to explain changes in the level of inflation among emerging markets. Jácome and Vásquez (2005) showed that, in some cases, legal measures can also be a reliable independent variable

Table 3.15: Estimation results for selected emerging markets with FGLS

Dependent-log inflation	**LVAU**	**GMTO**	**GMTE**	**GMTP**	**TOR**
CBI	-0.84**	-0.47**	-0.29**	-0.50**	0.40**
	(0.27)[-3.16]	(0.17)[-2.74]	(0.11)[-2.73]	(0.24)[-2.14]	(0.18)[2.23]
Inflation	0.56***	0.60***	0.60***	0.60***	0.57***
rate $y_{i,t-1}$	(0.10)	(0.11)	(0.11)	(0.11)	(0.11)
world inflation(-1)	0.006**	0.002	0.002	0.005*	0.006**
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
HYPER	0.59***	0.71***	0.67***	0.73***	0.78***
	(0.18)	(0.18)	(0.18)	(0.18)	(0.18)
Observations	150	150	150	150	150
	LVAU	**GMTO**	**GMTE**	**GMTP**	**TOR**
CBI	-0.65**	-0.37**	-0.22**	-0.40*	0.26*
	[-2.57]	[-2.66]	[-2.64]	[-1.97]	[1.92]
ECONFREE	-0.06	-0.09	-0.0989*	-0.11*	-0.09
	[-0.92]	[-1.59]	[-1.66]	[-1.87]	[-1.44]

Notes: ***, **, * indicate results significant at the 1%, 5%, and 10% respectively. t-statistics in brackets.
Abbreviations: log $y_{i,t-1}$–logarithm of GDP lagged one year; HYPER–a dummy for countries and years with inflation rate over 40%; ECONFREE–index of economic freedom

among Latin American countries. In the full emerging markets sample analysis we have already received supporting this hypothesis evidence and we saw that measures of legal independence tend to be good regressors of inflation rate, as well. Thus, table 3.15 summarizes the verification of these hypothesis and results only with the use of FGLS method estimation.

In a group of six Latin American countries, all CBI indices appear to have a strong explanatory power of inflation rate. Not only TOR, but all legal measures again have their estimated coefficients significantly different from zero. It remains so even after including another independent variable–economic freedom index. These results act as another proof that measures of CBI, despite their varying method of constructions, are able to grasp the most important issues that constitute CBI and become good regressors of inflation even if both methodology and estimated models change.

Robustness tests for emerging markets

Estimations results for emerging markets and a narrow group of Latin American countries show that the effect of central bank independence on the inflation rate was slightly different. While only a few CBI indices turn out to be significant regressors

among nineteen varying countries (from Argentina, through India to South Africa), all five measures enter significant (and with expected signs) regressions for Latin America.

To test the robustness of these results, especially the strength of CBI measures explanatory power, a few tests are performed: a J-test for non-nested models and an estimation of a model that includes CBI measures as the only regressors. For all tests, $lninflation$ is the dependent variable.

J-test for non-nested models is performed in the same way as the one for industrial countries. Regressions include lagged dependent variable, lagged world inflation rate, dummy variable for hyper-inflation and a measure of economic freedom. The first tests included all nineteen emerging markets. The hypothesis that the model with TOR as one of regressors is accepted; fitted values of $lninflation$ of the model with TOR as a CBI measure entered significantly to all other models. Additionally, based on the same procedure, fitted values of $lninflation$ of the model with economic measure of GMT as a CBI measure entered significantly the model with its political counterpart (GMTP).

As explained, estimation results were slightly different for only six Latin American countries. Therefore, the J-test for non-nested models is repeated for this group. From the original estimation results, it has been determined that economic freedom has a weaker explanatory power. At first, this variable was excluded from the regression during the test. As a result, only fitted values of $lninflation$ of the model with the legal measure of independence LVAU as a regressor entered significantly (though, at the 5% level) into all competing models. Reinserting the economic freedom variable weakened the effect of LVAU, and it was not possible to point at any model to be accepted.

The next table (3.16) summarizes results from estimations of models, which include only CBI measures as regressors of inflation. GMTO is excluded, being in the strongest correlation with both its sections: economic and political. The Durbin-Watson statistic (0.55), as expected, indicates positive autocorrelation.

The estimation coefficients are obtained with the Least Squares method but, Generalised LS and LS with PCSE have supported these results. Among all estimations, the positive (unexpected) sign of GMT political is the most surprising. As a reminder, it describes procedures for appointing and dismissal of the central bank's governor and the Monetary Policy Committee. In this way, it is related to the turnover rate of governors, which also describes the change in the office of the CB governor. Although the TOR's construction determines that the relation with

Table 3.16: Estimation results for emerging markets - CBI as regressors

Dependent- ln inflation	(1)	(2)	**Dependent- transformed infl.**	(1)	(2)
GMTE	-0.30*	-0.13	GMTE	-0.10***	-0.03**
GMTP	0.48***	0.22**	GMTP	0.10***	0.04**
LVAU	-0.61**	-0.24*	LVAU	-0.11**	-0.04*
TOR	1.15***	0.30**	TOR	0.10**	0.02
Lagged infl.		0.66***	Lagged infl.		0.71***
Method	FGLS	FGLS	Method	FGLS	FGLS
Dependent- ln inflation	(1)	(2)	**Dependent- transformed infl.**	(1)	(2)
GMTE	-1.01**	-0.45**	GMTE	-0.22***	-0.07**
GMTP	1.51***	0.66***	GMTP	0.33***	0.13***
LVAU	-1.53***	-0.60**	LVAU	-0.33***	-0.13**
TOR	1.46***	0.26	TOR	0.26***	0.02
Lagged infl.		0.72***	Lagged infl.		0.78***
Method	LS with PCSE	LS with PCSE		LS with PCSE	LS with PCSE

Notes: t-statistics in brackets. Abbreviations: FGLS–Feasible General Least Square, LS with PCSE–Least Square with Panel Corrected Standard Errors, Lagged infl.–lagged values of inflation rate.

inflation rate is expected to be positive, values of GMTP are expected to produce a negative coefficient of estimation. The rest of CBI measures perform as expected: the expected sign is received for GMTE, LVAU and TOR and in most cases their coefficients are statistically significant.

3.5.3 Central Bank Independence among Developing Countries

The group comprising all developing countries is very diversified. In fact, it includes approximately seventy countries, among which it is possible to create several sub-groups. Very few measures have been calculated for these countries. It is reasonable (based on the size sample) to include only two: TOR and the overall GMT index. Both represent two completely different definitions of central bank independence, so it is rational to perform a comparison between these two. These measures also allow for the analysis within the years 1980-2007.

Looking at the list of countries in the Appendix, one notices a wide variety among them. One common characteristic is a rather unstable political situation among these nations. Many of them have recorded periods of hyper-inflation, whereas some have had years of negative inflation. Several summarising statis-

tics regarding the inflation rate can be found in table 3.17.

Table 3.17: Descriptive statistics of inflation for selected developing countries

Country	Obs	Mean	Std Dev.	Min	Max
Cambodia	21	30.46	55.89	-31.25	191
Haiti	28	10.55	23.14	-95.44	42.56
Maldives	28	6.47	7.67	-9.16	27.88
Mozambique	28	30.93	32.06	1.49	164.12
Nicaragua	24	83.01	206.80	3.7	885.20

In a group of countries with such large variance of inflation rate, it is difficult to find a proper its representation. Nevertheless, it is again believed that a transformed measure of inflation[7] would well represent changes in the inflation rate (with natural logarithm of inflation rate as a robustness check).

Finally there are two alternative models, which estimation results can be found in the table 3.18. One includes proxies for conflict and economic freedom. The second one replaces economic freedom with a dummy for hyper-inflation and a possible effect of the world inflation on the domestic one.

Estimations, where a natural logarithm of inflation rate is the dependent variable, are performed using a Least Square estimator. Results are rather unstable in this group of countries, that is signs of CBI coefficients and its significance are vulnerable to changes in the primary model. Therefore, estimations are also repeated with a GLS method. Again, on contrary to theory and previous studies claiming that TOR is the right proxy for developing countries[8] here its coefficient records a negative sign (although it depends on the model and method used). GLS, in general, is able to "produce" the expected sign for TOR.

Results of estimations with a transformed inflation rate as the dependent variable are quite similar to previous ones. GMT, again, proves to be a good regressor of modified inflation rate. Now, TOR looses the negative sign in all estimations. It enters the model significantly, however, only with a hyper-inflation dummy and values for the world inflation rate.

[7] $d = inflationrate/(1+inflationrate)$

[8] Although there are also few studies that claim the opposite. For example an early study by Cukierman et al. (1992) reported a negative relationship between legal CBI and inflation for industrial countries, but failed to obtain similar results for developing countries. De Haan and Kooi (2000), using the turnover of central bank governors as a more direct measure of effective CBI for a sample of 82 countries in the 1980s, also failed to find a robust relationship between CBI and inflation.

Table 3.18: Estimation results for developing countries with LS and FGLS

Dependent-inflation rate	**GMT**	**TOR**	**Transformed inflation (*d*)**	**GMT**	**TOR**
CBI	-0.14**	-0.01	CBI	-0.15*	0.03**
	(0.07)[-2.07]	(0.01)[-0.88]		(0.06)[-2.33]	(0.01)[2.25]
Inflation	0.67***	0.49***	transformed	0.63***	0.48***
rate (-1)	(0.13)	(0.05)	inflation(-1)	(0.11)	(0.04)
Conflict	0.05**	0.005	Conflict	0.03	0.01***
	(0.02)	(0.006)		(0.01)	(0.005)
ECONFREE	-0.04**	-0.02***	Hyper	0.06*	0.11*
	(0.01)	(0.003)		(0.05)	(0.06)
			World	0.002***	0.001***
				(0.0007)	(0.0002)
Obs.	728	859	Obs.	919	1134
Countries	47	36	Countries	63	48
Adjusted R^2	0.63	0.99	Adjusted R^2	0.63	0.99
Method	LS	FGLS	Method	LS	FGLS

Notes: Stars ***, **, * indicate results significant at the 1%, 5%, and 10% respectively. t-statistics for CBI measures in square brackets. Standard errors for all variables in round brackets.
Abbreviations: Conflict - measure of number of conflicts in the region, ECONFREE - index of economic freedom, Obs.–number of observations

Estimations of the model have been repeated using GMM. The results are reported in table 3.19 and they are unanticipated for this group of countries. Both CBI measures have their coefficients significantly different from zero. However, while GMT records the expected negative sign, coefficients of TOR have also, very unexpectedly, negative signs. Hence, our results could be in line with those of de Haan and Kooi (2000), that is no robust relationship with TOR and inflation rate. In our GMM estimations we used the following instruments: inflation rate (lagged 2 and 3 periods), differences of lagged values of the dependent variable (inflation rate or transformed inflation - $(x_{i,t-2} - x_{i,t-3})$ and $(x_{i,t-3} - x_{i,t-4})$), values of world inflation, a dummy variable for hyper inflationary countries, lagged one period values of the measure of conflict, and relevant CBI measures.

3.5.4 Central Bank Independence in Transition Countries

Former socialist countries in Central and Eastern Europe (CEE) have been in the centre of research interest since the beginning of the 1990s. One of the results of this is a creation of a large number of CBI measures. Besides " standard" measures such as LVAU or GMT, literature provides indices like modified legal index LVES

Table 3.19: Estimation results for developing countries with GMM

Dependent-inflation rate	**GMT**	**TOR**	**Transformed inflation (*d*)**	**GMT**	**TOR**
CBI	-0.30**	-0.32**	CBI	-0.19***	-0.16**
	(0.10) [-3.06]	(0.14) [-2.34]		(0.05) [-3.63]	(0.07) [-2.22]
Inflation	0.60***	0.67***	Inflation	0.52***	0.61***
rate(-1)	(0.11) [5.51]	(0.09) [7.62]	rate(-1)	(0.11) [4.85]	(0.10) [6.19]
ECONFREE	-0.05**	-0.05**	ECONFREE	-0.04**	-0.03**
	(0.02) [-2.66]	(0.02) [-2.98]		(0.01) [-2.85]	(0.01) [-2.66]
Conflict	0.18**	0.09	Conflict	0.05	-0.00
	(0.08) [2.16]	(0.06) [1.46]		(0.04) [1.39]	(0.03) [-0.06]
Constant	2.33***	1.81***	Constant	0.34***	0.28***
	(0.61) [3.84]	(0.47) [3.87]		(0.09) [3.66]	(0.08) [3.32]
Periods incl.	21	21	Periods incl.	21	21
Cross-sections	36	36	Cross-sections	36	36
S.E. of reg.	0.11	0.11	S.E. of reg.	0.06	0.07
J-stat	26.34	39.69	J-stat	33.76	48.38
p-value	0.96	0.48	p-value	0.75	0.17

Notes: Stars ***, **, * indicate results significant at the 1%, 5%, and 10% respectively. t-statistics for CBI measures in square brackets. Std error for all variables in round brackets.
Abbreviations: Conflict - measure of number of conflicts in the region, ECONFREE - index of economic freedom; S.E. of reg. – standard errors of regression

(Cukierman et al. 2002), an index of CB independence and accountability calculated for former Soviet Union republics (Lybek 1999), or two indices constructed by Loungani et al. (1997) that include only twelve transition countries.

The period of the analysis is relatively short (1990-2007) but ongoing institutional changes give opportunity to distinguish to periods: before and after introducing new central bank acts. New CB legislation had not been introduced right away in all countries. In some of them, like Poland, the major increase in CB independence took place in 1997. However, there is a large number of measures that were calculated only once and for this reason a cross-section analysis will be the major one.

The political and economic regime change and the process of democratisation also affected the quality of statistical data. In some cases, definitions of observed variables have changed several times. For example, countries being currently within the European Union need to follow European statistical standards. These all have a effect on the precision of data and for this reason and to avoid large variability in statistics due to the change in definitions, an analysis is per-

Table 3.20: Estimation results for transition countries

	GMTO	**GMTE**	**GMTP**	**LVAW**	**LVES**	**TORMAS**
CBI	-4.18***	-3.14***	-2.87**	-1.55	-1.62	5.35***
	(0.89)[-4.7]	(0.69)[-4.49]	(1.11)[-2.59]	(1.00)[-1.55]	(0.93)[-1.74]	(1.04)[5.12]
GDP p.c.	-0.58***	-0.47***	-0.72***	-0.59**	-0.54**	-0.82***
	[-4.46]	[-3.15]	[-4.86]	[-3.64]	[-2.67]	[-5.57]
OPEN	0.01**	0.01**	0.01*	0.01*	0.01	0.01**
	[2.58]	[2.17]	[2.05]	[1.91]	[1.48]	[2.22]
Obs.	25	25	25	25	21	18
Adjusted R^2	0.54	0.45	0.48	0.35	0.26	0.65
D-W	1.7	1.7	1.42	1.34	1.3	2.1
	Freytag	**CBIAccount**	**CBIDF**	**SIB**	**CBIIndex**	
CBI	-4.5**	-0.16**	-0.29	0.33	-0.38	
	(1.42)[-3.16]	(0.06)[-2.87]	(1.07)[-0.27]	(1.8)[0.18]	(1.72)[-0.22]	
GDP p.c.	-2.70***	-0.37**	-0.82**	-0.81*	-0.95	
	[-6.33]	[-2.48]	[-2.56]	[-2.05]	[-1.83]	
OPEN	0.02**	0.004	0.004	0.003	0.00	
	[3.46]	[0.46]	[0.43]	[0.32]	[0.004]	
Obs.	10	15	12	12	13	
Adjusted R^2	0.79	0.48	0.06	0.05	0.14	
D-W	1.35	2.9	0.46	0.49	0.99	

Notes: Stars ***, **, * indicate results significant at the 1%, 5%, and 10% respectively. t-statistics in square brackets. Standard error for CBI measures in round brackets. White heteroskedasticity-consistent standard errors.

Abbreviations: LVAW, LVES - indices by Cukierman et al. (1992), GMTO, GMTE, GMTP - indices by Grilli et al. (1991)., TORMAS - index by Cukierman et al. (1992) updated by Maslowska., Freytag - measure constructed by Freytag (2003), CBIAccount - index by Lybek (1999), CBIDF and SIB-two measures constructed by Loungani and Sheets (1997), CBIIndex - index by Freytag and Masciandaro (2005); GDP p.c. - GDP per capita, OPEN-measure of openness, D-W-Durbin-Watson statistics, Obs.-number of observations.

formed on the averaged data.

One obvious justification for additional modification of the sample would be the European Union membership of some countries. This allows transition countries to be divided into a group with total number of countries and the one including only EU members (members as for January 2009). However, one may never be sure if an anti-inflationary process undertaken among the newest EU members was due to an increased degree of CBI, or due to the general adjustment process required before the membership.

To benefit from including all CBI measures prepared for transition countries, simple cross-country estimations are performed, with averaged data in period 1995-2005. It is necessary to say that estimation coefficients are very vulnerable to a change in the model. A few "political" variables, which are typically used (as described earlier) in estimations did not enter significantly to the model and did

not improve goodness-of-fit of the estimation. Table 3.20 presents the results of the model that include GDP per capita and a measure of openness as additional regressors.

A cross-country analysis is done at the particular point of time, it includes averaged data and only one value of CBI. Thus, it is not that informative as panel data, where "before-and-after" recorded data help to compare different periods in time. Thus table 3.20 has a limited value-added, although, as stated, many previous studies on CBI were based on this kind of estimations.

Estimated coefficients, as well as information on the goodness-of-fit of regressions, indicate that several measures do not have much explanatory power, i.e. both measures by Loungani et al. (1997; CBIDF and SIB), index formulated by Eijffinger and Schaling (CBIIndex) or legal measures constructed by Cukierman et al. (1992) and Cukierman et al. (2002) - LVAW and LVES. After eliminating few countries which recorded average annual inflation rate above 40%, few measures recorded significant and expected coefficients: GMTO, GMTP and TOR.

3.6 Conclusions

The major goal of this chapter, choosing the most adequate central bank independence definition, is done by the empirical verification of their impact on economy. The value added of this work is gathering and comparing several various measures of independence. To our knowledge, this is the most comprehensive study on measuring CBI that includes such a large number of indices and uses them in an empirical investigation. The comparison of explanatory power of CBI indices is done in four groups of countries, divided based on their economic development. Apart from our "quest for the best", our general idea was also to test if the strong negative relationship between CBI values and inflation rate holds with the new data and new estimations' methods, in general. Finally, we challenged the hypothesis originally stated by Cukierman (1992) that measures of legal independence give the same results within the homogenous group of countries.

We claim that any improvement in the degree of CBI is performed to guarantee a central bank's mandate to "fight" with high inflation and keep the low and stable price levels in the long run. Hence, we use long time-series to determine if the high CBI level - low inflation rate relation is visible around the world. We support our hypothesis and methodology with publications in the special edition of the European Journal of Political Economy devoted to the phenomenon of central bank

independence. In one of articles, Siklos (2008) argues that CBI should be interpreted as a collection of characteristics that are related to inflation. Consequently, he claims, there is no single definition of CBI that is 'right' for all countries. This paper has the same conclusions after performing several empirical tests.

Measures of central bank autonomy offer a useful expression of the extent to which a central bank is able to keep the government away from influencing a change in the inflation rate. The more a measure represents this idea, the more easily one can find a relation between the CBI value and inflation rate. For example, the estimation results reported in this chapter suggest that proxies by Grilli et al. are very often strong regressors of inflation rate, on contrary to those by Cukierman et al. Siklos (2008) justifies this explanatory strength of GMT with the fact that existing indices, however with the exception of the GMT index, tend to focus excessively on statutory aspects of CBI, while omitting non-statutory factors that influence the *de facto* degree of CBI. Thus it should be of no surprise that the measure of *de facto* CBI proves to be a significant explanatory variable among many countries where statutory aspects of CB autonomy matter to a lesser extent.

The group of advanced countries is the strongest example that the process of disinflation has been accompanied by increasing degree of central bank independence. Long time span, several recorded changes in the degree of CBI with the upward trend and, despite financial turbulences at the beginning of the 1990s, decreasing inflation rate, this all prove to be significant in the search for a negative relation between CBI and inflation. All measures performed as expected indicating a negative relationship. However, additional tests of non-nested models showed that fitted values of $y_{i,t}$ of the model with CBI measure defined as GMTO entered significantly to all other models, proving to be a "superior" to all other CBI measures in this type of regressions.

Turnover rate of governors, the measure of so-called 'actual' CBI has proven to be a good regressor of inflation among emerging markets. Not surprisingly, after all these countries' quality of democratic institutions should be described rather by the actual practice and not legal acts. More interestingly, however, measures of legal independence appeared to be rather good regressors within a group of Latin emerging countries. In a group of six Latin American countries, all CBI indices appear to have strong explanatory power of inflation rate. Not only TOR but also all legal measures have their estimated coefficients significantly different from zero. It remained so even after including another independent variable - economic freedom index. However, additional tests like the J-test for non-nested models pointed the

TOR as the most accurate definition of central bank independence.

Analysis for developing and transition countries was rather limited but gave some interesting outcomes. First of all, only two measures, TOR and GMT provide data for a group of around seventy developing countries. Between these two measures, TOR estimated coefficients were rather vulnerable to applied tests. On the other hand, GMT proved to be a rather good regressor of inflation, even after the model's modifications. This type of measure had also a strong explanatory power within transition countries. Many other measures, i.e. by Loungani (1997), Eijffinger and Schaling (1995) or measures by Cukierman et al. (1992, 2002) did not manage to prove that there is a negative relation between a degree of CBI and inflation rate in transition countries.

The analysis performed by Cukierman (1992), which led him to the conclusion that institutional differences among countries matter, not the measure used in the analysis, is one of the most influential in the history of studies on CBI and its relations with inflation. At the moment of his study, a limited number of CBI measures was available. One of the aims in this paper was to check robustness of these findings. With considerably long time series and large cross-country data, as well as varying tests, it was possible at least to hint the idea that one may obtain contradictory results also within one sample of countries when using "competing" CBI measures.

This study assumes that a proxy can become a good approximation of the definition if it is not vulnerable to data or specification change. It can be seen already within a rather homogenous group of industrial countries that some indices perform "better" than others. For example, legal proxies by Grilli, Masciandaro and Tabellini performed in the majority of tests as expected, while we received unstable results of coefficients for a measure by Cukierman et al. (LVAU), due to changes in the estimated models or the estimation method.

These results question the correctness of the fact that the most popular CBI measure used for further analysis is the legal measure by Cukierman (1992) and Cukierman et al.(1992), as reported recently by Klomp and de Haan (2010). The presented here analysis show that there is no reason why this measure would be chosen more often than others, except for the usual argument that Cukierman's measure provides data for larger number of countries and longer time series. This measure's major "rival" i.e. the legal measure by Grilli et al. performed better in the statistical point of view. Its recent update done by Arnone et al. (2006) thus should be acknowledged.

3.7 Appendix

3.7.1 List of countries: IMF classification based on 2007

1. Industrial countries: Australia, Austria, Belgium, Canada, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Japan, Netherlands, New Zealand, Portugal, Spain, Sweden, Switzerland, the United Kingdom, the United States

2. Transition countries: Albania, Armenia, Azerbaijan, Belarus, Bulgaria, Croatia, Czech Republic, Estonia, Georgia, Hungary, Kazakhstan, Latvia, Lithuania, Macedonia, Moldova, Mongolia, Poland, Romania, Russia, Slovak Republic, Slovenia, Tajikistan, Turkmenistan, Ukraine, Uzbekistan

3. Emerging countries: Argentina, Brazil, Chile, Egypt, India, Indonesia, Israel, Jordan, Malaysia, Malta, Mexico, Morocco, Pakistan, Peru, Philippines, South Africa, Thailand, Turkey, Venezuela

4. Developing countries: Algeria, Bahamas, Bahrain, Bangladesh, Barbados, Belize, Benin, Bhutan, Bolivia, Botswana, Burundi, Cambodia, Cape Verde, Colombia, Costa Rica, Dominican Republic, Ecuador, El Salvador, Ethiopia, Fiji, Ghana, Guatemala, Guinea, Guyana, Haiti, Honduras, Iran, Jamaica, Kenya, Kuwait, Lesotho, Libya, Madagascar, Malawi, Maldives, Mauritania, Mauritius, Mozambique, Myanmar, Nepal, Nicaragua, Nigeria, Oman, Panama, Papua New Guinea, Paraguay, Rwanda, Saudi Arabia, Senegal, Seychelles, Sierra Leone, Solomon Islands, Sri Lanka, Sudan, Suriname, Syria, Tanzania, Trinidad and Tobago, Tunisia, Uganda, United Arab Emirates, Uruguay, Vanuatu, Vietnam, Zambia.

3.7.2 Data sources

Table 3.21: Data sources of CBI measures

Variables for CBI index	Source
GMTO, GMTE and	Grilli, Masciandaro and Tabellini (1991)
GMTP	and update from Arnone et al. (2004)
LVAU	Cukierman (1992), Cukierman et al. (1992)
	and update from Arnone et al. (2004)
TOR and VUL	Cukierman (1992), Cukierman et al. (1992)
	and update from Sturm and de Haan (2001)
TORMAS	author's own calculation in 2007
PROB	Krause and Méndez (2007)
BP	Bade and Parkin (1988)
Alesina	Alesina (1988, 1989)
Alesina2	Alesina (1988, 1989) and author's own update
ES	Eijffinger and Schaling (1993)
Distance	Fratianni and Huang (1994)
CBI-Index	Freytag and Masciandaro (2005)
OPCBI-N	Eijffinger and Schaling (1995)
CBI-DF	Loungani and Sheets (1997)
SIB	Loungani and Sheets (1997)
OI - overall independence	Maliszewski (2000)
Freytag	Freytag (2003)
CBI-Account	Lybek (1999)

Table 3.22: Data sources of variables

Variables	Source
Inflation rate	OECD, IMF
World inflation rate	IMF
Hyper inflation dummy	Own calculations
GDP and GDP/capita (current prices)	OECD and IMF
Openness (current prices)	Penn World Tables
Economic freedom	Fraser Institute (Gwartney and Lawson, 2006)
No of Conflicts	UCDP/PRIO Armed Conflict Dataset (Gleditsch et al. 2002

Chapter 4

Does central bank independence matter? An examination using the Taylor Rule[1]

4.1 Introduction

Since the 1980s many central banks of major industrial nations have been successful at lowering levels of inflation rate. Several of them have at the same time decided to narrow their policy responsibilities to control inflation. Woodford (2003, 2) emphasizes that these developings have coincided with central banks choosing clear monetary rules rather than following discretionary policy. These rules act as principles with which monetary authorities accentuate their commitments. One of the new rule-based approaches to monetary policy is to highlight maintaining low and stable rate of inflation. In recent years, interest rate rules like the one suggested by Taylor (1993) have become the core in describing monetary policy in theoretical analysis. This rule assumes that a central bank chooses an inflation objective as the "nominal anchor". "Taylor rules" that specify a relation between the target for a short-term interest rate and deviations of inflation from its target and of real output from its potential level have become the norm for the analysis of the impact of monetary policy (Rasche and Williams 2007). They provide a useful framework for the analysis of historical policy and a helpful econometric evaluation of specific alternative strategies that a central bank can use in its interest rate decisions.

The literature on political economy affirms that institutional design of central

[1] A paper based on this chapter is published in Homo Oeconomicus, 27(4), 419-442, 2011

banks matters for real economy, as well. Many economists agree that it is preferable to have a central bank autonomous from a third party's influence.[2] Several empirical studies showed that a country with a high degree of central bank independence (CBI) often records low levels of inflation. Although a causal relationship has not been explicitly proven, CBI has been accepted as a necessary institution, ever since. The requirements of the Maastricht Treaty imposed on European countries, as well as a debate on the design of the European Central Bank, have kept the idea of CBI relevant until today. This discussion, however, has been accompanied by several other views underlying that not only is a monetary authority's autonomy unnecessary for price stability, but also insufficient (Hayo and Hefeker 2001).

Our aim of this study is to employ Taylor rule's ability of analysing of the impact of monetary policy with the opinion that it matters for economy, whether a central bank makes its monetary policy decisions autonomously or not. This approach is an alternative technique of tracing the potential effects of the higher degree of CBI. Most of previous studies analyzed this problem by estimating models, where an inflation rate is a dependent variable and a CBI measure is explanatory. It is rather difficult to specify what is the right definition of CBI. Its inconsistent measures, and defects in empirical investigations coupled with an autonomous central bank, make it problematic to determine if central bank independence really matters. This paper suggests that these problems can be overcome by using simple interest rules. A proposed method may answer the question whether a behaviour chosen by a central bank to make its policy decisions changes after it gains more autonomy.

Monetary rules can help to trace effects of shifts in monetary policy over time. By estimating and comparing the Taylor rule's coefficients in different points of time we can observe alterations to the central bank's priorities. We focus on monetary policy stances in two countries, Sweden and the United Kingdom and compare two subsamples, before central banks were granted higher degree of independence and after that. It is interesting for us to see if there is a structural break in the history of inflation of the country, which could be related to the introduction of a higher degree of CBI. The common understanding of central bank independence would lead one to formulate a hypothesis that greater independence allows a bank to put greater weight on controlling an inflation rate. In terms of the Taylor rule it means

[2]For example, The Treaty on European Union, chapter 3, article 7, specifies "Neither the ECB nor the national central banks (NCBs), nor any member of their decision-making bodies, are allowed to seek or take instructions from European Community institutions or bodies, from any government of an EU Member State or from any other body."

larger coefficients for inflation gap in the post-independence period. However, as it will be described later, both central banks recorded an independence improvement of a different kind. In our opinion, the Riksbank has made legal the process that had been effective for a long time. Both, for the market and the Bank, this change represented a "sealing of a deal", thus, in our analysis, we expect smaller differences between coefficients for inflation and output gap in two subperiods. Our expectations are different when it comes to the Bank of England. Granting an operational independence to the bank shifts the monetary power from the government to the monetary authority. What follows, it sends a strong signal to the market not only about political exclusion from the policy process but also about the change in the type of monetary policy. Such a strong shift in the degree of independence has to, in our mind, influence the whole monetary policy in a significant way.

The next section section describes a theory on central bank independence. It also includes a background information on the Taylor rule. Section 3 is an empirical part of this study, and hence includes a description of the data and summarizes the main results. Section 4 concludes the paper's objectives.

4.2 Theoretical Presentation

4.2.1 On Central Bank Independence

The initial spark that caused many researchers to consider the political and economic importance of CBI was the seminal article by Barro and Gordon (1983). Their paper, originating from earlier work of Kydland and Prescott (1977), describes a central banker as a social welfare maximizer. The public is fully informed about a central bank's control over inflation and output (employment). Monetary authority, however, may have incentives to deviate from its announced target by increasing inflation rate and causing inflationary bias. This deviation from a promise could be avoided if, as Rogoff (1985) suggests, an authority with known preferences about inflation and output is appointed. The Rogoff-conservative central bank has also become a way of describing the central bank independence in theoretical models. This type of conservatism is in accordance with the notion that the central bank's weight in inflation exceeds that of the elected government.

The theoretical and empirical discussion that started in the late 1980s with the work of Bade and Parkin (1988), and continued with the works of Grilli, Masciandaro and Tabellini (1991) and Cukierman, Webb and Neyapti (1992), focused on constructing measures of central bank autonomy and explaining relationships

between CBI and the whole economy. The measures' construction methodology have been under severe criticism, especially by Forder (1999, 2005), who points out that many CBI indices have, in fact, a different understanding of what could be the key issue of independence. Brumm (2000) criticizes the measure of *actual* independence (TOR) because it might not consider the possibility of a central bank governor holding the post for a long period (thus giving an impression of a high level of CBI) simply thanks to an agreement with political leaders. In a comparison of two indices - a legal proxy by Cukierman et al. (1992) and Grilli et al. (1991) - Mangano (1998) finds the two indices disagreeing with each other in nearly 60% of all countries included in the area of an attribute concerning the central bank's ability (legal permission) of purchasing government debt in the primary market. Finally, inconsistencies in measures have been underlined by de Haan, Eijffinger and Waller (2005, 175 - 176). The authors present an example of Poland and opposite directions of the degree of central bank independence calculated for this country when two different measures are used. According to measures of legal independence, prepared by Loungani and Sheets (1997) or Maliszewski (2001), for example, Poland has much higher CBI levels than other new European Union member countries. However, when another index of independence is calculated, such as the turnover rate of governors, Poland registers one of the highest values, which in this case means the lowest degree of independence.

Problems with proper CBI proxy and its justification as a solution for central banks continue in empirical studies. The common use of bi-variate models have been widely criticized in the relevant literature. The problem of omitted variables was underlined by Campillo and Miron (1997). Furthermore, de Haan and Sturm (2001) show rather insignificant results from regressions where the CBI is used as a proxy, unless the sample is enriched with high inflation countries.

4.2.2 On the Taylor rule

An alternative method of empirical investigation used in this study is the Taylor rule (Taylor 1993), which is a simple formula that describes how a central bank's interest rate should respond to changes in the inflation rate and output, given an economy's inflation target and level of potential output. The rule is used ex-post in a descriptive capacity, and provides in this study a view of how central banks historically changed the interest rate in response to inflation and output gaps developments. A central bank's policy response is additionally determined by the choice of institutions. Therefore, it could be related to the change in the degree of central

bank independence.

The well-known Taylor rule directs the central bank to react to deviations of the inflation rate from a target level. It does so without any relation to the absolute level that prices have reached. Such concern with the inflation rate rather than the price level, as Woodford (2003) explains, would seem to characterize policy in all advanced countries in recent years.

Despite its simplicity, the Taylor rule has stimulated much useful research on monetary policy. Clarida et al. (1998), Hetzel (2000) and Orphanides (2003), among others, provide some theoretical discussion on the rule along with some empirical evidence. Clarida et al. (1999) emphasize that "the rule is consistent with the main principles for optimal policy". This means that the rule (1) makes the nominal rate adjust more than one-for-one with inflation rate; (2) makes real rates adjust to engineer inflation back to target and, (3) calls for countercyclical response to demand shocks and accommodation of shocks to potential GDP that do not affect the output gap.

The general form of the Taylor rule, taken for example from Woodford (2003, 40), and later used in this study can be presented as:

$$i_t = \alpha + \beta_\pi(\pi_t - \pi^*) + \gamma_y y_t + \varepsilon_t \tag{4.1}$$

where i_t is the policy interest rate, π_t the rate of inflation, π^* the inflation target and y the output gap in period t. α is the long-run equilibrium interest rate and defined as $\alpha = r^* + \pi^*$, where r^* the equilibrium real rate. Additionally, β_π and γ_y are coefficients for inflation and output gaps respectively.

The major idea in the Taylor rule (the so-called *Taylor Principle* assumes that the nominal interest-rate is being adjusted by more than the amount by which inflation exceeds the target. In other words, the coefficient for inflation is expected to exceed the unity, in the case of optimal policy. Therefore, the key lesson drawn from the estimation of this policy reaction function concentrates on analyzing the coefficient for inflation gap.

If one assumes that the coefficient for the inflation gap is smaller than one $\beta_\pi < 1$, that is, on contrary to the Taylor Principle, the expectational difference equation for the inflation rate has an infinity of bounded solutions, so that the equilibrium inflation, in this case, is indeterminate, as in the pure interest-rate control (see Leeper 1991, for example, or Woodford 2003, for the analysis). Coefficients positive but smaller than the unity were recorded in the United States for the period 1960-1979. Taylor (1999) interpreted these as the instability of U.S. inflation and real activity during the 1970s. That is, they indicate passive interest-rate responses.

The Taylor rule has been modified to include various elements of modern central banking. A static relationship such as equation (1) cannot capture the serial correlation present in the data. Therefore, a modification to the rule leads to a dynamic specification. For example, Judd and Rudebusch (1998) estimate the Fed's reaction functions that describe how the fund-rate operating target adjusts in response to changes in an implicit desired level of the fund rate. The "actual" interest rate i_t is partially adjusted to the target, according to the form

$$i_t = \rho i_{t-1} + (1-\rho) i_t^* \tag{4.2}$$

where ρ is a parameter that measures the degree of interest rate smoothing and i_t^* is the target interest rate. This gives the following equation to be estimated:

$$i_t = (1-\rho)\alpha + (1-\rho)\beta_\pi(\pi_t - \pi^*) + (1-\rho)\beta_y y_t + \rho i_{t-1} + \varepsilon_t \tag{4.3}$$

where ε is an independent and identically distributed error term. The model with an interest rate smoothing parameter (or otherwise called a partial adjustment to the target) eliminates the concern that a simple rule could not capture the tendency of central banks to smooth changes in interest rates. Clarida et al. (1998) explains that the necessity to smooth interest rates is justified with the fear of disrupting capital markets, loss of credibility from sudden large policy reversal or the need for consensus building to support a policy change.

4.3 Empirical Analysis

Central banks have been chosen for this analysis according to one crucial criterion: the presence of the evolution of the legal system in the area of a central bank's organization and activity. The most prominent examples are the central banks of Sweden and the United Kingdom.[3]

The Riksbank, Sweden's central bank and one of the oldest in the world, has had a considerably high degree of independence for most of its operating time. An introduction of the inflation targeting in January 1993 brought a certain monetary discipline. The subsequent change of the legal act granting the bank a higher degree of independence was its natural consequence. New legislation, which we are

[3]It is also important to note that many European countries, which adjusted legal acts toward more independent monetary authority, could not be included here due to their membership in the monetary union. In many cases, law amendments were made shortly before their Economic and Monetary Union (EMU) membership, and hence the data series would have been too short for the analysis.

interested in, came into force on January 1, 1999. As the monetary authority explains in their report, the new legislation gave "a legal form to the independence that monetary policy already had in practice" (Sveriges Report 1999, 4). It is represented by the shift on monetary policy from the General Council to an Executive Board. Moreover, external communication also improved with the publishing of the minutes from the monetary policy meetings.

The history of the Bank of England has tied the Bank strongly to the HM Treasury and the Government itself. The first modern legal act from 1946 enabled the Treasury to give directions to the bank about monetary policy, which was clearly a part of government policy. After all, it had been the chancellor of exchequer who had been setting interest rates for years. Therefore, the 1996 amendment, crucial for the bank and for our analysis change in its legislation, shifted that major monetary responsibility from the Treasury to the Bank of England. This, and many other alterations of the bank's role, aimed to fulfill the Maastricht Treaty requirements, as well as create a modern style of central banking.

An example of the United States as a control country is added to our analysis. The Federal Reserve System did not record any institutional amendments leading to changes in its independence during the period in question. It is therefore interesting to compare how the central bank of the world leading economy reacted during that twenty year period.

Additionally, for the sake of comparison, one should include several other countries in the analysis, so we include the case of Economic and Monetary Union member states. Figure 1 shows scatter plots of inflation and interest rates in Italy and Portugal, countries with a history of high inflation rates. A breakpoint here is January 1999, when the European Central Bank started to determine common monetary policy and the data was published worldwide. Although these countries are not included in further analysis, it is worthwhile to describe the data. The period until 1999 is characterized with an obvious disinflationary process. Lower inflation rates in subsequent years can be tied to improvements in degrees of central banks independence. In Italy, the bank was given fully independent power to set official interest rates in 1992. The Portuguese central bank registered two crucial CBI improvements: the first in 1990, granting greater independence to the board of directors and the second in 1995, when the main mission of the bank was assigned to price stability. These important dates and the data on inflation confirm what many studies empirically showed: a lower inflation rate is correlated with a higher degree of CBI. According to the theory of an optimal currency area, one

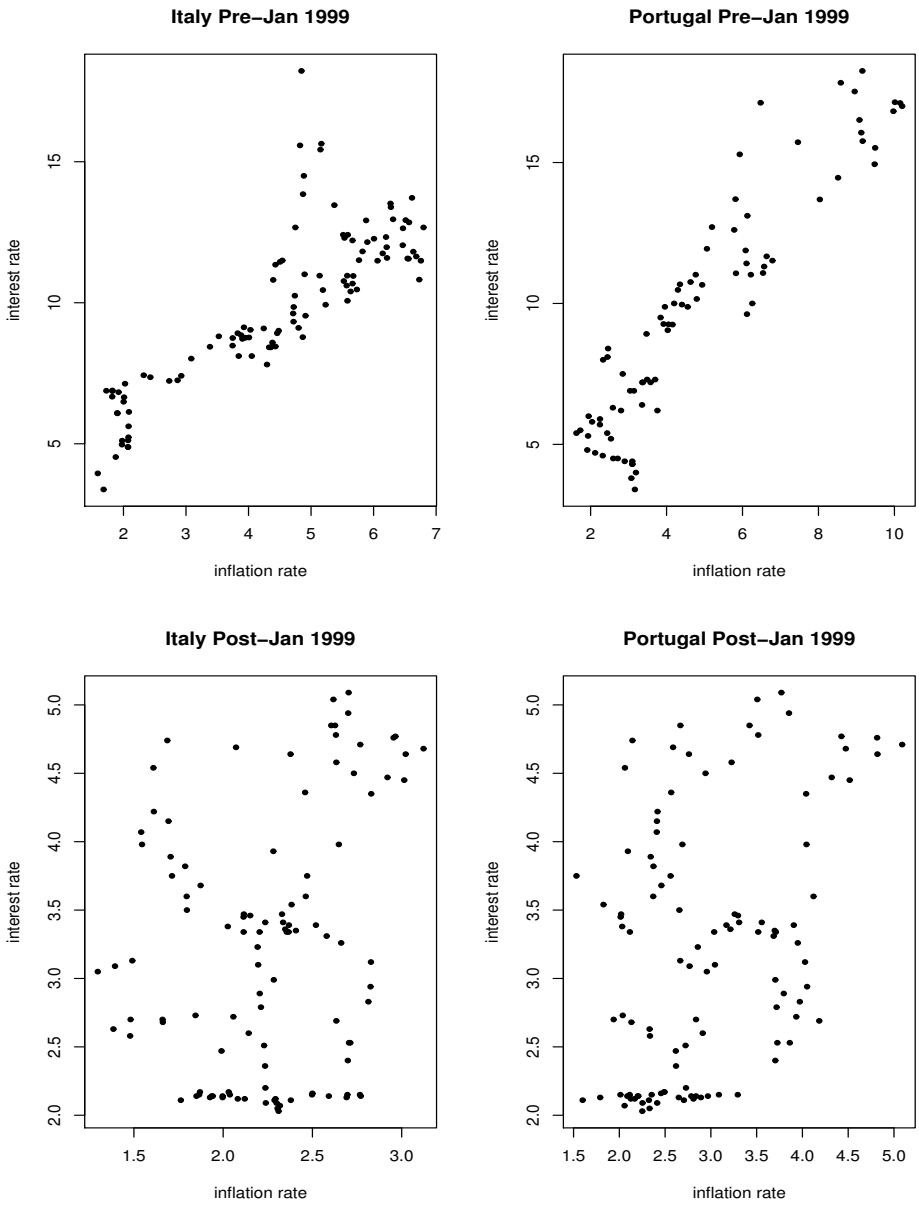

Figure 4.1: Inflation and interest rates in Italy and Portugal

could consider membership in the euro zone as a loss of monetary policy independence by many European countries. This is observed in the data, where the level of a country-specific inflation rate does not always seem to be as a result of the monetary policy run for that country.

4.3.1 Data

In his original study, Taylor used the federal funds rate, which was later replicated as the natural choice for the United States. In other papers, which include different samples, the short-term interest rate is represented by an interbank lending rate for overnight loans, or a three-month Treasury bill. Here, representation of this variable differs, depending on the country, but it is always the major monetary policy interest rate. Therefore, in Sweden, the repo rate is the rate of interest at which banks can borrow or deposit funds at the Riksbank for a period of seven days (four first quarters for repo rate is a marginal rate, which stopped being published after introducing repo). In the United Kingdom, the rate is the three-month interbank lending rate, also considered a three-month Treasury bill rate).

Based on the information from the Riksbank, the key inflation rate followed by the bank is the so-called "underlying inflation" (named CPIX in the country's statistical office). This variable is therefore chosen for our study. Following studies on monetary policy in the United Kingdom by Nelson (2000) and Mihailov (2006), the inflation rate is defined as the Retail Price Index, excluding the mortgage rate (RPIX). The Bank of England has been recently using a general CPI, which is also included in the data.

Of all three, the most difficult variable to quantify, and the most discussed in the literature is the output gap (see Billmeier 2004). This study follows the recent trend (see, for example, Sauer and Sturm 2007) that the output and the output gap are calculated using the industrial production index (IPI). Data are tested for seasonality using the standard Census X12 test, in order to apply a Hodrick-Prescott filter (with the smoothing parameter set at λ=14400 for monthly data). The actual output gap is calculated as the percentage deviation of real GDP or IPI from a target

$$y = 100 * \frac{Y - Y^*}{Y^*}$$

where Y is real GDP (or more often industrial production index), and Y^* is trend real GDP.

Both data descriptive statistics in Table 4.1 and box-plots in Figure 4.2 show a characterization of the data for the full period, but especially for the two subperi-

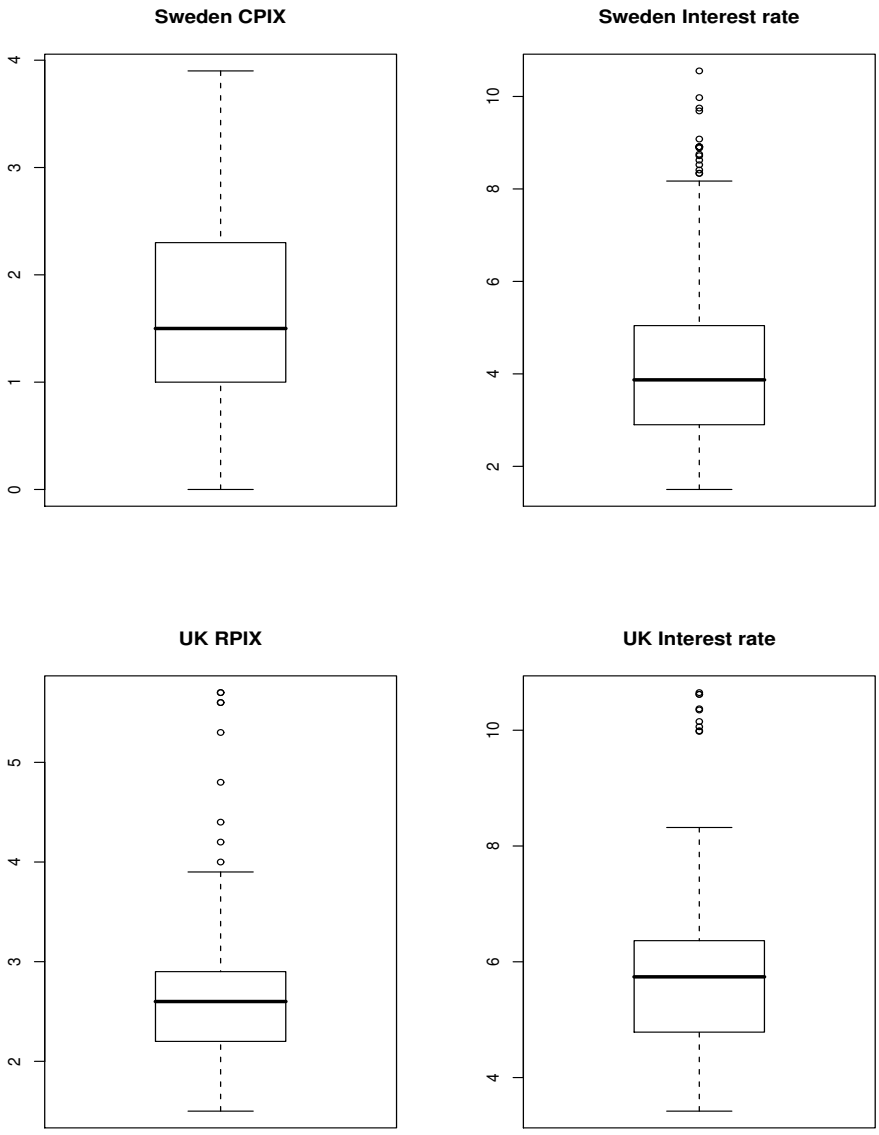

Figure 4.2: Data dispersion

Table 4.1: Data descriptives

Sweden	Long sample	Pre-independence	Post-independence
Average *r*	4.44	6.51	3.06
Average π	1.67	1.93	1.5
Stdev *r*	2.23	2.04	0.85
Stdev π	0.85	0.92	0.75
United Kingdom	Long sample	Pre-independence	Post-independence
Average *r*	5.76	6.86	5.34
Average π	2.71	3.19	2.53
Stdev *r*	1.47	1.69	1.13
Stdev π	0.7	0.96	0.46

ods divided by the date of the legislation change. It is clear that the feature of data for both countries is a large dispersion, lack of symmetry in a frequency distribution with several observations traditionally treated as "outliers" and a large range between the minimal and maximal data point.

A salient feature of economic time series like price indexes or interest rates, is inertia, otherwise referred to as sluggishness. This is one cause of the existence of serial correlation, which has been also detected in this data set[4]. Another cause for correlation in this time series is the use of lags in the Taylor rule. In the presence of autocorrelation, the ordinary least square (OLS) estimators are still linear and unbiased, as well as consistent and asymptotically normally distributed. However, they are no longer efficient (see Greene 2003, 226 and 253, for example). The implication of this finding for hypothesis testing leads to declaring a coefficient statistically insignificant, even though it may be significant (based on the correct procedure).

The use of OLS estimation is still possible if the standard errors are corrected for autocorrelation. It can be done using the procedure developed by Newey and West (1987). Then, the corrected standard errors are known as HAC (heteroscedasticity- and autocorrelation-consistent). Note that the Newey-West procedure can be used for large samples only. This Taylor rule analysis includes approximately 200 observations, which could be considered rather large. A similar analysis is performed for the United Kingdom. Theoretical justifications of econometric methods are the same as in the case of Sweden. Tests indicate the existence of autocorrelation in residuals, as well as the presence of autoregressive conditional heteroscedasticity[5].

[4]The Breusch-Godfrey test does not reject the null hypothesis of no correlation with Prob=0,000167.

[5]Checked with Breusch-Godfrey and Arch tests respectively.

A conventional proposition suggested while analyzing the kind of policy function considered here is to make an assumption about stationarity of the data (see Clarida et al. 2000). The usual tests (Augmented Dickey-Fuller and Kwiatkowski-Phillips-Schmidt-Shin, for example) were run with the general conclusion that it is hard to find conclusive evidence in favour or against stationarity among investigated variables. However, the Engle and Granger (1987) cointegration test rejects the non-stationarity of the residuals in tests performed for the full sample and subsamples. Furthermore, to cope with the possible non-stationarity of some of the data, the fully modified estimator of Philips and Hansen (1990) has been applied for the Taylor rule in its original form. The fully modified estimation results do not differ greatly from the ones obtained using the OLS.

4.3.2 Break-point in Time Series

Before any estimation is done, it is necessary to find a breakpoint in the time series, which divides samples into two significantly different subsamples. The breakpoint date is already known, and is based on the schedule of institutional changes in central banks legislation: May 1997 for the United Kingdom and January 1999 for Sweden. The significance of these dates is checked with the Chow breakpoint test (Chow 1960), which analyzes the null hypothesis of no structural break in the sample period. According to this test, the dates of interest clearly divide the sample into two subperiods. In Sweden, the probability of two subsamples being the same is the lowest "around" January 1999. Several other dates have also been tested. However, January 1999 (1999m1) appears to be the "best" point characterizing the structural break in time series.

Although the date of the Bank of England legislation change seems to confirm the existence of the structural break, the lowest probability that two subsamples are the same has been detected for January 1997. Moreover, none of the dates around May 1997 have proven to significantly differentiate the two periods from each other when the whole period extends to the 1980s, that is, including the time before the introduction of inflation targeting. Such a test has been done for the United Kingdom, for example, where the sample before 1992 is clearly different due to a different monetary regime. A Chow test performed for the period of January 1980 to December 2007 with the hypotheses of the existence of three subperiods (1980-1992, 1992-1997 and 1997-2007) indicates the breakpoint only for 1992, and treats the remaining one, from 1992 to 2007 as one unified sample.

As for the Chow test, results were mixed for control countries included in this

study such as the United States. Artificially, that is, without any reasonable explanation, a breakpoint date around 1999 was chosen to see if the results obtained for Sweden and the United Kingdom were really driven by changes in their central banks or by other worldwide economic conditions. Although no change in central banks legislation has been recorded, it is possible to detect a structural break in the United States around 2001. However, with the longer period, since 1980, it is the year 1990 that rejects the hypothesis of no structural break. These tests lead to the conclusion of performing two types of tests. First, regression coefficients are calculated for separate subsamples, and second the dummy-variable approach is used to compare two regressions.

An additional test based on unit roots procedure has been applied to detect the existence of a structural break in the data. Among the few available tests, a Zivot and Andrews (1992) test was chosen. This is a sequential test that utilizes the full sample and uses a different dummy variable for each possible break date. The break is selected where the t-statistic from the augmented Dickey-Fuller (ADF) test is at the minimum. Thus, a break is chosen where the evidence is least favourable for the unit root null. Due to low explanatory power of the ADF in the tests performed, a decision is made after a consult with the Kwiatkowski-Phillips-Schmidt-Shin (KPSS) test.

This test gives a clear-cut evidence that a structural break took place around January 1999 in Sweden. Therefore, it supports the decision to perform a Taylor rule analysis on the data broken into two subsamples exactly around this date. It is also additional proof that it is acceptable to justify an observed policy change with an institutional modification of the central bank. The unit root tests for structural break failed to confirm that the date of a central bank legislation change, leading to a higher degree of CBI in the United Kingdom, was significant. Based on the described procedure and the data since 1992, January 2001 was more distinctive for the country and its economic policy. However, an ADF test had a small explanatory power, whereas a KPSS test was able to reject the null of stationarity at the 10% level.

4.3.3 Diversity of Models

The main rule estimated here includes the interest smoothing element suggested by Judd and Rudebusch (1998). The relatively shorter period of analysis causes a smaller number of observations. The use of monthly, instead of quarterly, data multiplies the number of observation by three, allowing for sets of data that include

at least 50 observations in one period. The type of monetary policy held in the new millennium, however, characterized with very high interest rate inertia (i.e. small and rare changes in their levels) leads to small correlation between inflation and interest rate. This situation, which perhaps is also a special feature of the monetary policy in the 2000s, caused estimation problems, and had to be dealt with. Several analyses of simple cases, where the current interest rate is explained with a one-month lagged interest rate and inflation rate, show a very strong explanation power of only the lagged interest rate. This preliminary analysis suggests that the second-order partial adjustment model should be used with interest rate lagged at one and two periods as an explanatory variable.

$$i_t = \rho_1 i_{-1} + \rho_2 i_{-2} + (1 - \rho_1 - \rho_2)(TR_t) \tag{4.4}$$

where TR_t equals $[\alpha + \beta_\pi(\pi_t - \pi^*) + \beta_y y_t + \varepsilon_t]$. The second-order partial adjustment has been also used by Clarida et al. (1998, 1048), who write that it fits the US data significantly better than the first-order model in the sample, from October 1979 to December 1994.

Short periods, leading to a small sample of observations, may cause a problem with estimation results. Moreover, the Chow breakpoint test brings insufficient information needed in this analysis. The dummy variable approach (see Greene 2003, 116 for example) covers these problems. In recent applications, dummy variables are used to study the effects of treatment on some kind of response or to analyze structural change. A dummy variable takes the value one for some observations to indicate the presence of an effect in a group, and it takes value zero for the remaining observations. In our case, the dummy variable approach allows us to use a single regression for the whole period and to increase the degrees of freedom. This can result in improving the relative precision of the estimated parameters and in indicating which coefficient, intercept or slope is different. The model with the dummy variable is of the following form:

$$i_t = \rho_1 i_{-1} + \rho_2 i_{-2} + (1 - \rho_1 - \rho_2)(TR_t + TR_t * D_T) \tag{4.5}$$

where TR stands for Taylor rule and D_T is a time dummy. The whole model estimates first, values for the whole period, while the time dummy indicates the change in values of coefficients in the second period, as compared to the first one.

Table 4.2: Single regressions and || dummy variable approach for Sweden

Period	Pre-1999	Post-1999	Pre-1999	Δ in coefficients in period post-1999 (D_T)
Variable	(1)	(2)	(3)	(4)
Interest rate	0.95**	0.98**	0.983***	0.983***
($\rho_1+\rho_2$)	(0.35)	(0.55)	(0.15)	(0.15)
Inflation (β_π)	1.95***	0.28	2.42**	-2.15*
	(0.36)	(2.98)	(0.88)	(1.25)
Output gap(β_y)	0.67*	-0.31	1.79**	-2.07*
	(0.34)	(0.71)	(0.89)	(1.12)
Constant (α)	5.89***	3.42**	3.66**	0.05
	(0.64)	(1.12)	(1.49)	(1.6)
Adjusted R^2	0.99	0.98	0.99	
No. obs.	70	108	178	178

Notes: Single regressions for each seperate period according to a model:
$i_t = \rho_1 i_{-1} + \rho_2 i_{-2} + (1-\rho_1-\rho_2)(TR_t)$.
A dummy variable approach according to a model: $i_t = \rho_1 i_{-1} + \rho_2 i_{-2} + (1-\rho_1-\rho_2)(TR_t + TR_t * D_T)$.
Both models estimated with Least Squares. Standard errors in brackets, corrected with Newey-West HAC. Statistical significance at 1, 5, and 10% with ***, **, and * signs. Columns (1) and (2) report estimation results for seperate periods. So estimated coefficients represent values, the way they are reported by Taylor. A column (3) also reports exact values of coefficients, while a column (4) informs how the values of coefficients differ as compared with a column (3).

4.3.4 Empirical Results

Analysis of Data for Sweden

The first report relates to Sweden and consists of a table presentation of analysis, based on separate pre- and post-independence periods. Such a division of time series has been explained already with the Chow breakpoint test. Additionally, Figure 4.3 shows scatter plots of inflation and interest rates. Both graphs clearly present different situations - the first period (pre-1999) shows a clear negative relation between the two variables, whereas the post-1999 data are more dispersed.

The first conclusion drawn from Table 4.2, and the part for single regressions approach, relates to the value of constant α. According to the estimation results, the value of the interest rate is almost two times larger in the pre-independence period than in the period after the legislation change. This could be related to general global fall in the real interest rate. At the same time it is plausible that increased level of central bank independence reduced the risk of inflation outbreak caused by the political pressure on central bank. This strong disinflationary policy is also

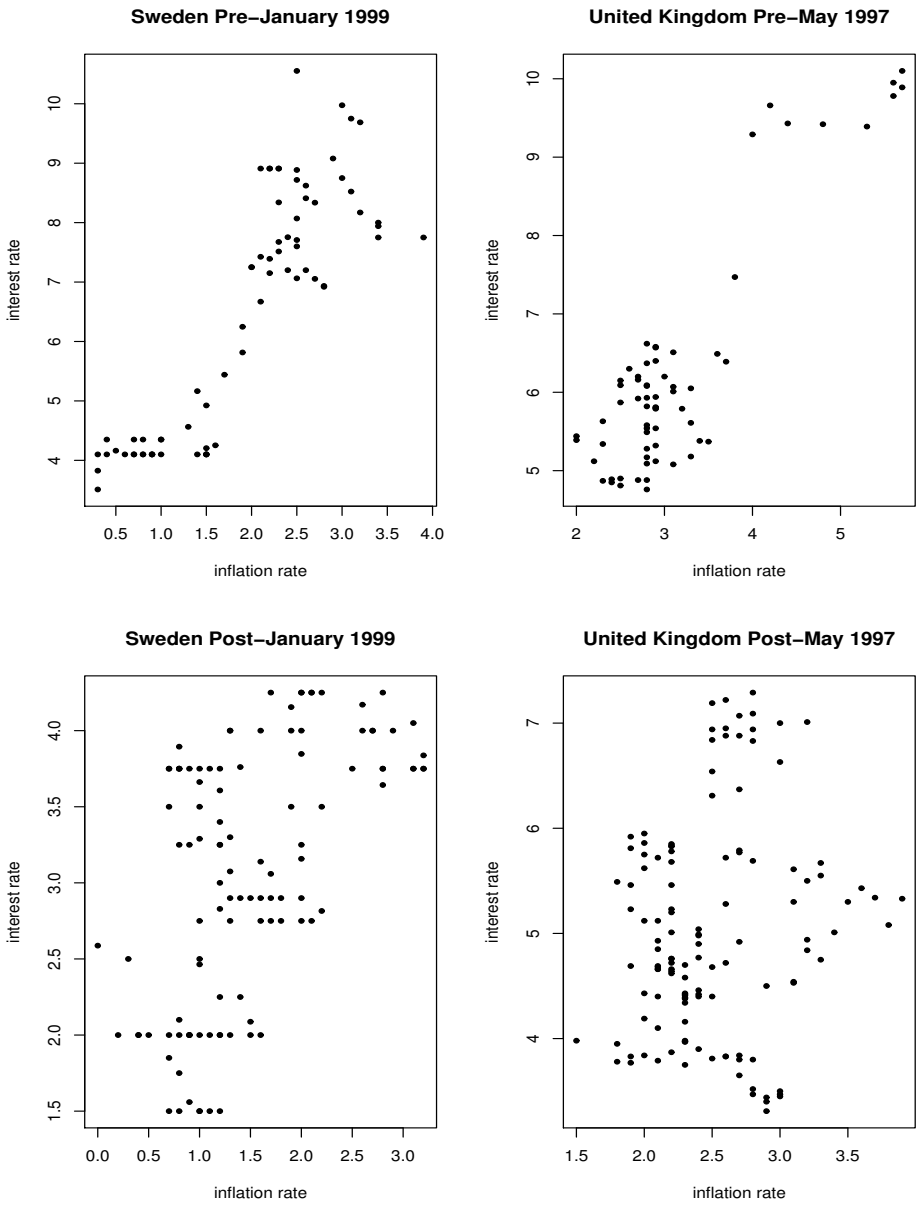

Figure 4.3: Inflation and interest rates in Sweden and the United Kingdom

visible when coefficients for inflation gap are compared. In the pre-independence period, their values are around two - hence, according to the Taylor rule. One may conclude that during this period the central bank incorporates the implicit inflation targeting feature. Coefficients are also significantly different from zero and thus the prediction that the Bank raises real rates in response to inflationary pressure is statistically significant. Although results in the second period are insignificant, a very low value of the inflation gap coefficient could indicate low response to inflation changes. Hence, we conclude that strengthening of the monetary power could allow the bank to react less aggressively to changes in inflation rate and focus on stabilizing the real economy.

Introducing a dummy variable results in variables that now stand for the differential intercept and differential slope coefficients. They indicate how much the slope coefficient of the first period's function differs from the slope coefficient of the second period's function. In the test for Sweden, the differential coefficients (the values for time dummy variables) are placed in the column for "post-1999 D_T" and indicate how much values differ from the first period (hence, they do not indicate the absolute value for the second period). This approach confirms stronger central bank's reaction to changes in inflation in the pre-independence period (inflation gap coefficient 2.42). The time dummy coefficient for inflation gap (-2.15) informs that in the period with increased level of CBI the Taylor rule is not satisfied and could represent the expansionary monetary policy of the Riksbank, as compared to the previous period. The estimated coefficient for an output gap gives a negative (wrong) sign with the use of a time dummy approach. As explained earlier, this results could be due to problematic exact estimation of output gap. Note, however, that negative signs of Taylor rule coefficients are not rare. These can be found in estimations of the rule for the European Central Bank and the Bundesbank (see for example Sauer and Sturm 2007) or estimations for the Bank of England (Nelson 2001). All in all, the dummy approach also indicates that types of monetary policy in these two periods are different.

Setting restrictions for coefficients in the Wald test, it is possible to test the null hypothesis that two coefficients from different periods are the same. For example, constant (α) in period one equals constant in period two (and similarly with other coefficients). The low probability values (Prob.=0.000) for constant and inflation rate (both calculated when inflation has 9 observation lead) indicate that the null hypothesis is strongly rejected. For a contemporaneous regression, probability values Prob.=0.02 and Prob.=0.05 for inflation and output gap, respectively, indicate

that the null hypothesis of equal coefficients may be rejected.

Analysis of Data for the United Kingdom

While it was possible to obtain consistent estimators using the Least Square estimation method in the case of Sweden, it was impossible to control for serial correlation in the data for the United Kingdom. Verbeek (2004, 125) and others explain that the OLS estimator can be saved if, in the case of autocorrelation, one uses the White or Newey-West estimates for the covariance matrix. Sometimes, however, there are statistical or economic reasons not to impose this condition. The scatter plots and the tests mentioned above characterize the data in the United Kingdom somewhat differently than in Sweden. Dispersion of observations is much more irregular in the case of the United Kingdom making estimation with OLS less plausible, even after correcting standard errors with the Newey-West procedure (checked for serial correlation with the Breausch-Godfrey Lagrange Multiplier test). If this is the case, then the Gauss-Markov conditions are not satisfied. Briefly, Gauss-Markov conditions require that the expected value of the error term is zero, regressors and error terms are independent from each other, all error terms have the same variance, and zero correlation between different error terms (Verbeek 2004, 16). The solution to the bias in the simple OLS estimator can be found by using the instrumental variable methods proposed by Anderson and Hsiao (1981, 1982) and Arellano and Bond (1991).

The Generalised Method of Moments (GMM) assumes the theoretical relation that the parameters should satisfy orthogonality conditions between some function of parameters and a set of instrumental variables. The GMM estimator selects parameter estimates so that the sample correlation between instruments and the function are as close to zero as possible (for more on GMM estimates, see Greene 2000, 476-491). To choose instruments, one can follow a general rule of choosing lagged values of independent variables. In this analysis, instruments chosen for the United Kingdom are interest rate lags (1, 2, 3, 6), inflation rate lags (1, 2, 3, 6, 9, 12), output gap lags (4, 5), U.S. Federal Reserve System main interest rate lags (1, 2, 3, 6) and three-month money growth lags (1, 2, 3). The use of U.S. interest rates is explained by the close international trade and financial relations between the two countries.

Estimations are based on the assumption that the inflation target is 2%. However, a replication of all estimations for the United Kingdom has been also done

Table 4.3: Dummy variable approach for the United Kingdom

Period	Pre-1997	Δ in coefficients in period post-1997 (D_T)	Pre-1997	Δ in coefficients in period post-1997 (D_T)
	OLS	OLS	GMM	GMM
Interest rate	0.92***		0.93***	
($\rho_1 + \rho_2$)	(0.1)		(0.11)	
Inflation rate (β_π)	1.17**	-0.74	2.26**	-1.43
	(0.57)	(0.67)	(1.14)	(2.08)
Output (β_y)	-0.01	0.11	1.61	0.44
	(0.57)	(0.51)	(1.21)	(2.03)
Constant (α)	2.78***	0.37	3.44*	0.46
	(0.63)	(0.58)	(1.86)	(1.95)
usafed	0.04*		0.01	
	(0.02)		(0.02)	
No of obs.	192	192	192	192

Notes: A dummy variable approach according to a model: $i_t = \rho_1 i_{-1} + \rho_2 i_{-2} + (1 - \rho_1 - \rho_2)(TR_t + TR_t * D_T)$. Test of overidentifying restrictions for the model (GMM) J=7.22, chi-squared (10) with p-value=0.70. The sample is 1992:1-2007:12. The instruments for GMM: interest rate lags (1, 2, 3, 6), inflation rate lags (1, 2, 3, 6, 9, 12), output gap lags (4, 5), Fed Treasury rate lags (1, 2, 3, 6), 3-month growth of M4 lags (1, 2, 3). Standard errors in brackets, corrected with White heteroskedasticity for OLS. GMM with Kernel: Bartlett and instruments as specified in the text. GMM estimates robust to heteroskedasticity and autocorrelation (HAC). Statistical significance at 1, 5, and 10% with ***, **, and * signs. usafed stands for the federal funds rate. Columns "Pre-1997" represent values of coefficients as in the Taylor rule. Columns "Post-1997" indicate changes compared to the previous period.

with the target for inflation at 2.5%. On its website,[6], the Bank of England explains that the inflation target was higher from June 1997 to December 2003, and was 2% after 10 December, 2003. Additionally, also corrected was the major inflation rate in the central bank's analysis, which was changed in 2003 from underlying inflation RPIX to CPI. The change in the inflation target has the greatest effect on equilibrium interest rates by making its value higher.

Estimated coefficients (reported in table 4.3) for inflation gap in the "pre-independence" period are in accordance to the Taylor principle, that is they are positive and above the unity (1.17 with OLS and 2.26 with GMM). Reaction to inflation, however, in the second period shows that the magnitude of the coefficient had declined to the levels below the unity. Even though results in the post-independence period are not significant, the direction of the change is confirmed by two estimation methods. Hence, these results confirm that the reaction to inflation has been weakened in the post-independence period. Again, as in the case of Sweden, this outcome is rather unexpected as one could suspect these values would increase.

It is rather undetermined how to analyze insignificant results for the long-term interest rate. Dummy values for this coefficient suggest that values of interest rate increased in the post-independence period, hence on contrary to our expectations. Again, despite insignificant results in the case of output gap, it is still possible to draw some conclusions as both estimation methods support the direction of changes. Simply speaking, the magnitude of coefficients for output gap has increased in the post-independence period (an increase from -0.11 by 0.11 with OLS and an increase from 1.66 by 0.44 with GMM). It is rather surprising that gaining greater independence would have effect on greater reaction to output gap changes. The Bank of England's weaker response to changes in inflation in the post-independence period can be explained by a decline in the inflation rate itself (from 5.6% in January 1992 to 2.1 in January 2000). As explained previously, we also notice a change in the inflation target that was lowered from 2.5% to 2.0%.

Analysis of Data for the Control Country

The same analysis as above was made for the United States. This country has been chosen due to its importance in the global market as well as because it did not record any changes in the central bank legislature in terms of the degree of independence (within the considered period). The historical data, mostly changes

[6] www.bankofengland.co.uk

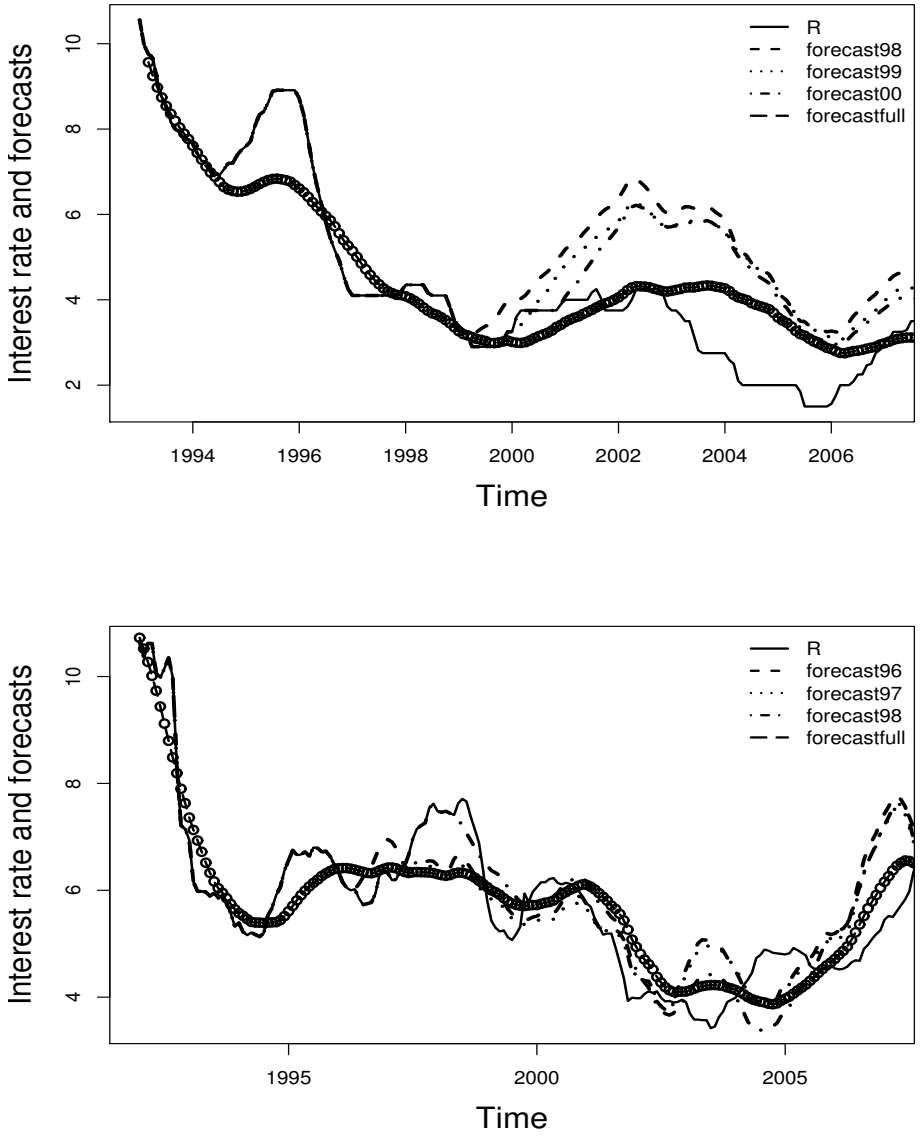

Figure 4.4: Forecasts of interest rates in Sweden and the United Kingdom

Table 4.4: Dummy variable approach for the United States

Period	Pre-2001	Δ in coefficients in period post-2001 (D_T)	Pre-2001	Δ in coefficients in period post-2001 (D_T)
	OLS	OLS	GMM	GMM
Interest rate	0.98***		0.82	
($\rho_1+\rho_2$)	(0.10)		(0.13)	
Inflation rate (β_π)	-0.27	0.49	0.25	0.13
	(0.77)	(1.10))	(0.92)	(1.29)
Output (β_y)	1.04**	0.91	-0.02	1.86*
	(0.51)	(1.00))	(0.33)	(1.04)
Constant (α)	5.25***	-2.34**	5.75***	-4.18***
	(0.66)	1.08	(0.54)	(0.85)
No of obs.	190		180	

Notes: A dummy variable approach according to a model: $i_t = \rho_1 i_{-1} + \rho_2 i_{-2} + (1-\rho_1-\rho_2)(TR_t + TR_t * D_T)$. Test of overidentifying restrictions for the model (GMM) J=12.06, chi-squared (13) with p-value=0.51. The sample is 1992:1-2007:12. The instruments for GMM in accordance to suggestion by Clarida et al. (1998): interest rate lags (1,...,6, 9, 12), inflation rate lags (1,..., 6, 9, 12), output gap lags (1,..., 5, 6). Standard errors in brackets, corrected with Newey-West (HAC) procedure . GMM with Kernel: Bartlett and instruments as specified in the text. GMM estimates robust to heteroskedasticity and autocorrelation (HAC). Statistical significance at 1, 5, and 10% with ***, **, and * signs. Columns "Pre-2001" represent values of coefficients as in the Taylor rule. Columns "Post-2001" indicate changes compared to the previous period.

in the levels of the Treasury fund rate, also suggest that monetary policy led by the Federal Reserve System (Fed) had two different subperiods: before and after year 2001. We notice a rapid fall in the fund rate starting around July 2000 from the level of 6.54% (effective funds rate) to 3.77% after a year and levels around 1% in 2003-2004.

The Taylor rule estimation results, though inconsistent when two estimation methods are compared, identify a regime change (table 4.4). It is characterized with a lower long-term interest rate, small reaction (below unity) to changes in inflation and increased focus of monetary policy to changes in output gap. When we compare these results with passed economic policy of the United States we notice a strong pressure on stimulating economic growth and job creation rather than focusing on stable prices.

Although Federal Reserve System leads a different type of monetary policy than the Riksbank or the Bank of England[7] making a direct comparison of these

[7]The Fed has three equally important goals of monetary policy: "promote effectively the goals of maximum employment, stable prices, and moderate long-term interest rates" (Federal Resrve Act, Section 2a).

three banks difficult, the example of the Fed illustrates that there have been many varying factors that have been affecting central banks around the world. Therefore, it is unclear if a shift in monetary regime in Sweden and the United Kingdom was caused only by a legislative change in central banks or by other factors, as well. As "other factors" one can understand a general decrease in inflation rates observed globally or an economic slowdown paired with economic crises observed in a few countries by the end of the previous century. Moreover, a simple correlation of interest rates can reveal that it is impossible to exclude effects of countries' monetary policies on other states (pairwise correlation matrix between countries interest rates: USA vs. UK - 0.55, UK vs. Sweden - 0.46, and US vs.Sweden - 0.26).

Further Analysis

Based on the historical data and Taylor rule specification, it is possible to find predictions of a dependent variable, interest rate r. This exercise helps to compare forecasts based on historical data with the actual decisions of central banks concerning the level of interest rates. In order to make such a comparison, forecasts were found (see Figure 4.4), first for the full period of analysis and later for the year of institutional change, as well as "around" the date (one year before and two years after). Model used for forecast analysis is of the form as in (4.6), with an exception that the one for the United Kingdom includes also the US federal funds rate. They were estimated using the Least Squares method. Forecasts have been made using the dynamic method (on forecasting see Clements and Hendry 1998, for example). A dynamic, as opposed to static, forecast calculates multi-step forecasts, starting from the first period in the forecast sample. Forecasted values for the lagged dependent variables are used in forming forecasts of the current value.

The largest discrepancies between predictions and data recorded can be noticed in the case of Sweden. In general, a higher degree of CBI should have helped keep the interest rate much higher, based on forecasts, than actually occurred. Shorter predictions suggest a rapid increase in the interest rate after the year 1999, with a decrease later, but not to the low levels recorded in past data. The full period forecast suggests that interest rates should have been kept higher after 2003. Forecasts for the United Kingdom are rather in accordance with actual time series, both with full period predictions and those starting around 1997.

4.4 Conclusions

The aim of this paper was to verify if central bank independence matter. Unlike many previous studies on CBI, this one proposes an alternative method of analysis, namely estimating coefficients for the Taylor rule. It has been expected that a greater degree of CBI will have a visible effect on central banks' reactions to variability of inflation and output.

Data analysis for the case of Sweden allowed us to see a clear cut in the time series. Both the Chow and the unit-root tests, aiming to identify breakpoints in the data, showed a distinctive change around January 1999. Therefore, they confirmed not only the existence of two different regimes, but also that these regimes relate to legal status of the central bank. Results of the Taylor rule estimations indicate that the adjustment of interest rate to changes in inflation was much stronger in the pre-independence period. Independently from the Taylor specification type (simple or modified), coefficients for inflation gap were much higher in the first period, even close to 2.0. Although results for the output gap did not give such an obvious distinction between the two periods, the analysis of the equilibrium interest rate proved again the existence of two varying regimes. The rate, a constant term, being composed of nominal interest rate and inflation target, is much higher in the pre-independence period. This was confirmed with the simple Taylor rule specification estimated with the OLS and cointegration tests, as well as with the modified Taylor rules, as indicated. Wald tests supported the results that coefficients in two periods are different from each other.

Our results show that also in the case of the Bank of England we can conlude that two subperiods are characterized with different monetary policy types. We notice a weaker response to inflation and a stronger one to the output gap in the post-independence period. This direction in the bank's monetary policy can be already understood from the bank's decision of lowering the inflation target from 2.5% to 2.0% in December 2003. British economy is very dependent on international economic relations with the United States. We considered that fact in this analysis by including the U.S. federal funds rate in the equation. All in all, these estimations were in few cases insignificant. Moreover, traditional tests of identifying the breakpoint date were rather inconclusive. Although the Chow test confirmed the hypothesis of the breakpoint in the data around the time of the new legislation for the Bank of England (1997), the unit root test did not support this hypothesis. The latter test suggested the year 2001 as a break indication, although the test had a low explanatory power.

In this analysis it is difficult to exclude effects of other economic phenomena on interest and inflation rates, as well as on output. The dummy variable approach and inclusion of the United States, the country without any important change in the Fed legal status, was expected to correct for these unobservable variables. The analysis of the data suggest that there was a policy change around 2001 in the United States. Therefore, the example of the Fed illustrates that there have been many varying factors that have been affecting central banks around the world. It is unclear if a shift in monetary regime in Sweden and the United Kingdom was caused only by a legislative change in central banks or by other factors, as well.

This paper enriches the discussion on whether "central bank independence matters", suggesting new methodology and presenting new results. Our expectations that increased level of CBI would allow central banks to put greater weight on inflation were verified by the new perspective. Now, we understand that once greater independence is granted to the bank, it can focus on other goals, as well, being legally protected from political pressure. Therefore, the answer to the main question is again the same as in previous studies. Yes, independence of the central bank, the legal foundations of its existence in the market and relations with the public do matter. More precisely, they matter for some countries. In other cases, however, the general, domestic and international economic conditions of the country are the main prerequisites of a sound economic policy.

4.5 Appendix

4.5.1 Data descriptives

Table 4.5: Descriptive statistics

Variable	Obs	Mean	Std Dev.	Min	Max
Sweden					
Inflation rate	180	1.67	0.85	0.00	3.9
Interest rate	180	4.44	2.23	1.5	10.55
Production index	180	95.25	14.67	62.76	120.53
the United Kingdom					
Inflation rate	192	2.71	0.70	1.5	5.7
Interest rate	192	5.76	1.47	3.42	10.65
Production index	192	98.73	4.20	86.70	104.60

4.5.2 Data source

Table 4.6: Data sources

Variables	Source
Inflation rate	Statistics Sweden $http://www.scb.se/$
	Office for National Statistic $http://www.statistics.gov.uk/rpi$
	Bureau of Labor Statistics $www.bls.gov/cpi/$
Interest rate	Riksbank *www.riksbank.com*
	Bank of England
	Federal Reserve System
Production index	Statistics Sweden
	Office for National Statistic $http://www.statistics.gov.uk$
	OECD

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Glossary

Bretton Woods system The international monetary system established at the end of the Second World War is commonly known as the Bretton Woods system. It iakes its name from the conference held at Bretton Woods, New Hampshire, USA, in 1944, which adopted the Articles of Agreement of the International Monetary Fund and thus put in place the rules and arrangements that would govern international monetary relations in the post-war world.

central bank independence Central bank independence refers to the freedom of monetary policymakers from direct political or governmental influence in the conduct of policy. The historical, legal, and de facto relationship between a country's government and its central bank is very complex, involving many difference aspects. These include, but are not limited to, the role of the government in appointing (and dismissing) members of the central bank governing board, the voting power (if any) of the government on the board, the degree to which the central bank is subject to budgetary control by the government, the extent to which the central bank must lend to the government, and whether there are clearly defined policy goals established in the central bank's charter. Most discussions have focused on two key dimensions of independence. The first dimension encompasses those institutional characteristics that insulate the central bank from political influence in defining its policy objectives. The second dimension encompasses those aspects that allow the central bank to freely implement policy in pursuit of monetary policy goals. Debelle and Fischer (1994) called these two aspects "goal independence" and "instrument independence". Goal independence refers to the central bank's ability to determine the goals of policy without the direct influence of the fiscal authority. Instrument independence refers only to the central bank's ability to freely adjust its policy tools in pursuit of the goals of monetary policy.

certainty equivalence In order to take a decision in an uncertainty context, it is necessary, from a theoretical point of view, to build a model and specify all the consequences in evry possible state of the world. In applied work this method is much too involved. Consequently, for applied purposes, it would be interesting to have a model where uncertainty is treated in such a way that the decision problems are as simple as the equivalent ones in a certainty framework. The identofication of the conditions under which such an isomorphism between the optimal decisions under uncertainty and the optimal decisions in an equivalent certainty conext holds is called the certainty equivalent problem.

credibility In a world of perfect information and no commitment, a policy announced today for some future period is either fully credible or not credible at all. It is fully credible if it is dynamically consistent. The reason is that in each period policy-makers reoptimize and choose the policy that is best for them in that period. Under asymmetric information it is still the case that only dynamically consistent strategies are credible. However, due to the fact that the public is not fully informed about the (moving) objectives of policymakers, there is normally a divergence between the rate of monetary expansion planned by the central bank and what the public believes about this rate. (Cukierman, 1992, p.205). A central bank is credible if people believe it will do what it says (Blinder, 1999).

euro The currency of the ECB member countries for which banknotes and coins first went into circulation on 1 January 2002.

European Central Bank The European Central Bank (ECB) was established on 1 June 1998 and since 1 January 1999 has been responsible for the conduct of a single monetary policy for its member countries. The establishment of the ECB and with it the launch of the euro was the culmination of a process of monetary and economic integration.

expectations Most decisions that economic agents must take involve uncertainty about the future. Thus, any economic model that is intended to be descriptive of human behaviour is likely to involve human expectations about uncertain future economic variable.

Federal Reserve System The Federal Reserve System of the United States was established in 23 December 1913, when President Woodrow Wilson signed the Federal Reserve Act.

gold standard All gold standards involve (a) a fixed gold content of the do-

mestic monetary unit, and (b) the monetary authority both buying and selling gold at the mint price, whereupon the mint price governs in the marketplace.

inflation Inflation is a process of continuously rising prices, or equivalently, of a continuously falling value of money. The most commonly used measures of inflation in the modern world are the percentage rate of change in a country's Consumer Price Index or in its Gross Domestic Product deflator. Inflation has been a feature of human history for as long as moneya has been used as a means of payment, and as Milton Friedman (1970, p. 24) famously wrote, " inflation is always and everywhere a monetary phenomenon, in the sense that it cannot occur without a more rapid increase in the quantity of money than in output". *Anticipated inflation* is an idealized situation in which prices are rising at a rate at which all economic agents expect them to rise.

inflation bias A situation that can arise under discretion. Monetary policymakers care about both price stability and employment. Their preferred level of employment is higher than the natural level. Under discretion policymakers try to create inflationary surprises in order to push employment above its natural level. Individuals are able to trace this temptation and correctly forecast inflation inflation, neutralizing any effect of inflation on employment. As a consequence, monetary policy is subject to a suboptimal inflationary bias.

inflation expectations From a steady-state perspective it is natural to presume that actual and expected rates of inflation coincide, so it is common to discuss the welfare cost of inflation, superneutrality, and so on, in terms of actual tather than expected inflation. Most of allocation effects are, however, attributable in principle to expected rather than realized inflation. A relatively high expected inflation rate will induce indivudual to hold (*ceteris paribus*) relatively small shares of their wealth in the form of money. Consequently, agents are required to devote relatively more time to the activity of 'shopping'. In terms of dynamic effects, there are three ways in which expectations of future inflation affect period-by-period equilibria: (1) first, intertemporal decisions depend significantly on real rates of interest, which are nominal rates adjusted for expected inflation; (2) second, expected inflation rates are important determinants of price-setting behaviour in most models in which there is some form of nominal price stickiness; (3) third, monetary policy decisions may be based on expected inflation rates, as with the strategy of 'inflation forecast targeting'.

inflation measurement Inflation measurement is the process through which changes in the prices of individual goods and services are combined to yield a measure of general price change. In formal terms, we may specify the time-t rate of aggregate inflation P_t as

$$P_t = F(p_t^1, p_t^2, ..., p_t^I), \qquad (4.5)$$

where $F(\dot{})$ is a function that aggregates a set of I individual time-t price changes p_t^i. Writing the problem in this manner highlights three basic issues associated with inflation measurement: First, we must decide what collection of price changes we wish to include (or, more generally, what should be the measure's scope); second, we must ensure that the individual price changes are correctly measured; and finally, we must choose a method for combining those changes into a measure of aggregate inflation.

inflation targeting Inflation targeting is a monetary-policy strategy that was introduced in New Zealand in 1990, has been very successful, and as of 2007 had been adopted by more than 20 industrialized and non-industrialized countries. It is characterized by (a) an announced numerical inflation target, (b) an implementation of monetary policy that gives a major role to an inflation forecast and has been called 'inflation-forecast targeting', (c) and a high degree of transparency and accountability.

monetary policy A policy is said to be *monetary* if the relevant actions are those generally undertaken by a central bank. These may include the size of monetary injections, reserve requirements, the discount rate, or the scale of interventions in bond or foreign exchange market.

optimal monetary and fiscal policy without commitment "Optimal fiscal and monetary policy" is a policy of choosing taxes and transfers or monetary instruments to maximize social welfare. "Absence of commitment" refers to inability of a policymaker to make binding policy choices.

policy rule A rule can be defined as "nothing more than a systematic decision process that uses information in a consistent and predictable way" (Meltzer, 1993). The concept of a policy rule is the application of this principle in the implementation of economic (monetary and fiscal) policy by central bank and a government. (Poole, 1999).

rational expectations 'Rational expectations' is an equilibrium concept that can be applied to dynamic economic models that have elements of 'self-reference', that is, models in which the endogenous variables are influenced by the expectations about future values of those variables held by the agents in the model.

reputation (of a central bank) Reputation is one solution to an inflationary bias. The central bank may affect the degree of its reputation through its past behaviour and demonstrate that it will deliver zero inflation despite the apparent incentive to inflate. If the central bank deviates from the low-inflation solution, its credibility is lost and the public expects high inflation in the future. (Walsh 2003, p. 379)

targeting rules Targeting rules, one of solutions that acts to reduce the problems arising from discretion by restrict policy flexibility, are the rules under which the central bank is judged in part on its ability to achieve a prespecified value for some macro variable. A wide variety of rules designed to restrict the flexibility of the central bank have been proposed and analyzed. Inflation targeting is currently the most commonly discussed form of targeting. Fixed or target-zone exchange-rate systems are also interpreted as targeting regimes. (Walsh 2003, p. 406)

Taylor principle Central bank should respond to inflation above the target rate by raising the nominal interest-rate operating target by more than the amount by which inflation exceeds the target (Woodford 2003, p.40). John Taylor was the first to stress the importance of interest-rate rules that called for responding more than one for one to changes in inflation (Walsh 2003, p.247).

Taylor rules Taylor rules are simple monetary policy rules that prescribe how a central bank should adjust its interest rate policy instrument in a systematic manner in response to developments in inflation and macroeconomic activity. They provide a useful framework for the analysis of historical policy and for the econometric evaluation of specific alternative strategies that a central bank can use as the basis for its interest rate decisions. The classic Taylor rule, according to Woodford (2003, p.21) prescribes setting an interest-rate operating target at each decision point as a function of current estimates of inflation and the output gap.

time consistency of monetary and fiscal policy A (possible time- and state-contingent) strategy is said to be time inconsistent if an agent finds it optimal from the point of view of some initial period 0 but finds it suboptimal in some subsequent period t. Time inconsistency can obviously arise if the government has time-varying preferences because of alternations of government. As Kydland and Prescott (1977) discovered, the time-inconsistency problem is a pervasive feature of environments with a single benevolent policymaker taking de-

cisons over time.

transparency (of central banks) The degree of genuine understanding of the monetary policy process and policy decisions by the public (Winkler, 2000)

type of a central bank A central bank's type is usually identified either as it preference between output and inflation stabilization or as its ability to commit (Walsh 2003, p. 385). A "dry" or a "hard-nosed" central banker prefers a zero-inflation target; a "wet" central banker optimizes between the two targets.

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