Are Central Bank Independence Reforms Necessary for Achieving Low and Stable Inflation?*

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Abstract

Using data on the occurence of central bank independence (CBI) reforms in 131 countries during 1980-2005, we test whether they were important in reducing inflation and maintaining price stability. CBI reforms are found to have reduced inflation on average 3.31% when countries with historically high inflation rates are included. But countries with lower inflation have reduced it without institutional reforms granting central banks more independence, undermining the theoretical time-inconsistency case for CBI. There is furthermore no evidence that CBI reforms have helped reduce inflation variability.

Keywords: inflation; institutional reform; monetary policy; time-inconsistency

JEL-codes: E52; E58; P48

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1 Introduction

A major trend in international politics during recent decades is the dramatic increase in central bank independence (CBI) around the world. The theoretical background behind this development is the literature on time-inconsistency in monetary policy (Kydland and Prescott, 1977; Barro and Gordon 1983; and Rogoff, 1985), suggesting that credibility for a low-inflation goal can only be achieved if essentially irreversible CBI reforms are implemented. According this theory, low inflation cannot be explained simply by a commitment to central bank autonomy. If announcement of a CBI-reform alters the inflation expectations of the public, then it is optimal for the policymakers to violate this promise when price stability is achieved (McCallum, 1997).

Two main approaches have been used to study the effect of CBI on inflation. The first uses indices reflecting the degree of CBI to study its relationship with inflation (Alesina, 1988; Grilli et al., 1991; Cukierman et al., 1992; Alesina and Summers, 1993; Campillo and Miron, 1997; and Eijffinger et al., 1998). However, CBI indices have been criticized for being arbitrarily constructed (Forder, 1996, 1998; Mangano, 1998).

The other approach (Acemoglu, 2008; Daunfeldt and de Luna, 2008; Landström, 2011) has been to assign a value of one to an indicator variable when a country has made a sufficiently large CBI reform, and study whether this reform is correlated with lower inflation. However, this approach has the drawback that two very different reforms could be assigned the value one, and thus treated as equal.

Empirical evidence on whether CBI matters for inflation is also rather mixed. Early cross-country studies (Alesina, 1988; Grilli et al., 1991; Cukierman et al., 1992; Alesina and Summers, 1993; Jonsson, 1995; and Eijffinger et al., 1998), used constructed CBI-indices and in general found a negative correlation with inflation. Grilli et al. (1991, p. 375), for example, concluded that: *"having an independent central bank is almost like having a free lunch, there are benefits, but no apparent costs in terms of economic performance"*.

More recent empirical studies have studied the relationship between inflation and CBI using other methods. Using data from 29 OECD-countries, Daunfeldt and de Luna (2008) focused on the change in CBI rather than its level. They found that price stability had usually been achieved before the central bank became more independent, suggesting that a low inflation goal can be credible without CBI reforms. Using multivariate regression analysis on cross-country data, Campillo and Miron (1997) could not reject the null hypothesis that CBI had no influence on inflation. But using a difference-in-difference methodology, Landström (2011) found that CBI reforms seem to have reduced inflation in high-inflation countries.

Using a data-set compiled by Daunfeldt et al. (2008) covering the possible occurence of CBI reforms in 131 countries during 1980-2005, we estimate a random-effects random-coefficients model to account for heterogeneity in the effects of CBI reforms on inflation. This method accounts for country-specific unobserved heterogeneity in inflation, while also allowing for unobserved heterogeneity in the effects of CBI reforms on inflation. We also study how CBI reforms affected price stability.

We find that CBI reforms have reduced inflation, but only when countries with historically high inflation rates are included. We also find a clear announcement effect, particularly strong for low-inflation countries and periods. This undermines the time-inconsistency case for CBI, which implies that announcement of a CBI reform is not sufficient for reducing inflation. We also find no evidence that CBI reforms have reduced inflation variability.

The next section reviews previous studies on the relationship between CBI and inflation, while Section 3 presents the data and the descriptive statistics. Section 4 develops the econometric specifications, while Section 5 presents the results. Section 6 summarizes and draws conclusions.

2 Previous studies on CBI and inflation

It is believed that CBI reforms will reduce the inflationary bias of monetary policy and make a low-inflation rule credible. Kydland and Prescott's (1977) and Barro and Gordon's (1983) work on time inconsistency in monetary policy, together with Rogoff's (1985) suggestion that a more inflation-averse central bank can make a low-inflation policy credible, constitute the theoretical rationale for this belief.

Klomp and De Haan (2010a) recently summarized the empirical literature on the relationship between CBI and inflation using meta-regression analysis. To identify relevant studies, they first used the surveys by Eijffinger and De Haan (1996) and Berger et al. (2001), then searched in Google Scholar and JSTOR. They stopped searching December 31, 2006, having identified 59 studies.

Most of these studies used different CBI indicies to analyze if CBI reduced inflation. Bade and Parkin (1988) is recognized as the first study that developed a CBI index for this purpose. Alesina (1988), Grilli et al. (1991), Cukierman (1992), and Cukierman et al. (1992) later developed modified CBI indicies that were supposed to better reflect the independence statues of central banks. However, besides the arbitrariness and subjectivity involved in the construction of CBI indicies (Forder, 1996, 1998; Mangano, 1998), Klomp and de Haan (2010a) found that the estimated relationship between CBI and inflation was sensitive to the choice of CBI index. Eijffinger and De Haan (1996), on the other hand, noted that the correlations between different CBI indicies were suprisingly low.

Early studies analyzed the correlation between the degree of CBI (measured by some CBI index) and average inflation for some industrialized countries (Alesina, 1988; Grilli et al., 1991; Cukierman, 1992; Alesina and Summers, 1993; and Jonsson, 1995). All found that inflation was negatively correlated with CBI.

However, the specification of empirical models was later critized for not being sufficient to establish a causal relationship (Campillo and Miron, 1997). Low inflation might lead to more CBI, rather than being caused by it. Or there might be omitted variables that caused both CBI and low inflation (Posen, 1993; Hayo, 1998). Early studies were also sensitive to the inclusion of high-inflation observations. For example, the statistically significant effect of CBI on inflation was found to disappear when high-inflation countries were included in the sample (Temple, 1998).

Almost all early studies mainly used data from just a few highly indus-

trialized countries, though Cukierman et al. (1992) studied 72 countries, finding that CBI contributed to lower inflation in industrialized countries but not in less developed countries. One explanation is that implementation of CBI reform is not sufficient to reduce inflation in less developed countries since policymakers can easily reverse it, which the public understands.

Results might thus differ between industrialized and less developed countries because of a greater difference between *de facto* independence, defined as independence of the central bank as actually implemented, and *de jure* independence, defined as CBI based on legal documents (Walsh, 2008). Turnover rates of central bank governors might better reflect *de facto* CBI than CBI indicies (Cukierman et al., 1992), since a central bank is not very independent if its governors are frequently replaced. But turn-over can also be low if governors are sufficiently responsive to government wishes, so the government would have no desire to change them. Nevertheless, higher turnover rates of central bank governors has been found to be associated with higher inflation in less developed countries, but not in industrialized ones.

Using multivariate regression analysis on data from 62 countries, Campillo and Miron (1997) found that inflation was unrelated to the degree of legal CBI once controlling for the degree of openess, political instability, initial inflation, and debt history. However, their data included many less-developed countries for which, as noted, legal status might not reflect actual independence. Sturm and De Haan (2001) used a similar model but instead analyzed whether high inflation was related to high turn-over of central bank governors, finding a statistically significant positive effect.

Since Klomp and de Haan's (2010a) search ended in 2006, we searched

in Google Scholar and JSTOR to find more recent studies, summarized in Table 1.[1]

[Table 1 about here]

Among the 10 studies we found published since 2007, results are mixed. Some found that CBI reduced inflation, others found no effect. But in general there was less optimistim about CBI lowering inflation in these latter studies. Most of the studies used CBI indicies to measure the legal independence of the central banks.

Using CBI indicies and turn-over rates for central bank governors in 24 Latin American and Caribbean countries during 1985-2002, Jácome and Vázquez (2008) found a negative relation between CBI and inflation, which confirms results from earlier studies. But when the possible endogenity of CBI reforms was taken into account, reduction in inflation was mainly attributed to other economic policies, with increases in CBI playing a secondary role.

Using both ordinary least squares and quantile regression techniques on data from 107 countries during 1990-2004, Siklos (2008) found no effect of CBI on inflation. But some components of the CBI index (e.g., clarity in central bank objective and the presence of explicit numerical targets) did have an effect, suggesting that more attention to such components might be fruitful. On the other hand, using index data on just 26 highly industrialized countries, Carlstrom and Fuerst (2009) found that CBI was negatively related to inflation, expaining nearly two-thirds of the change.

[1] We stopped searching June 14, 2012.

Recent studies have also evaluated the effect of CBI on inflation from other methodological perspectives. Using a random-coefficients model, Klomp and de Haan (2010b) analyzed how inflation was related to turn-over rates and a CBI index in over 100 countries during 1980-2005. They found no effect of CBI on inflation, concluding that (p. 453): "CBI may be less important than generally thought".

Daunfeldt and de Luna (2008) noted that the implementation dates of CBI-reforms might constitute a neglected source of information for investigating how CBI affects the credibility of a pre-commited goal of low inflation. Using trend decomposition to compare the transition process from high to low inflation with the implementation dates of CBI-reforms, they found that price stability had been achieved in most OECD-countries before their central banks actually became more independent, which questions whether CBI-reforms are necessary in order to achieve low and stable inflation.

Using a difference-in-difference method on data from 132 countries, Landström (2011) instead found that CBI-reforms had reduced inflation, but only in countries with high previous inflation.

Also using implementation years of CBI-reforms - with data from the Polity IV dataset - Acemoglu et al. (2008) found that CBI reforms reduced inflation in countries with intermediate constraints on politicians, whereas it had no (or little) effect on inflation in countries with strong or weak constraints .

All these studies assumed that CBI increases by the same magnitude in each country following a reform, which we know is not true (Acemoglu et al., 2008). Hielscher and Markwardt (2012) therefore analyzed changes in

a CBI-index from 1989 to 2003 for 63 countries, finding that a CBI-reform only reduced inflation if certain conditions were fulfilled. Specifically, greater CBI reduced inflation if the change was large, and the quality of institutions was high.

3 Data and descriptive statistics

Information on the dates when more independence was granted to central banks is necessary to investigate whether CBI reforms affect inflation. This information is available in the dataset obtained and used by Daunfeldt et al. (2008). To obtain the dates, they sent an e-mail questionnaire to all 162 central banks listed in Morgan Stanley's *Central Bank Directory* (2004), asking: (i) Has your country implemented any institutional reforms that grant your central bank more independence from elected policymakers? (ii) If yes, when? (iii) Where can we find more information about this?

Legal reforms that reduced the influence of politicians on monetary policy-making were thus defined as CBI reforms, whereas the mere statement that price stability is the only goal of monetary policy was not regarded as sufficient. According to time-inconsistency theory, price stability cannot be achieved by a commitment to central bank autonomy. If announcement of a CBI-reform was sufficient for achieving low inflation, then it would be optimal for politicians to violate the announcement once price stability was achieved (McCallum, 1997). Thus, time-inconsistency theory suggests that politicians need to implement irreversible CBI reform (or reversible only with great difficulty) to achieve low inflation.

Included in the definition of CBI-reforms are legal reforms that safeguarded the low inflation goal in the legislation; reduced the possibility for governments to override central bank decisions on operating targets; reduced governments' opportunities to use central bank credits to finance budget deficits; and reduced the possibility of dismissing central bank governors, or increasing their term in office or their number.

Ninety-five central banks (59%) responded to the questionnaire. Other sources (central bank publications, legislative acts, and scientific articles) were used to validate the e-mail answers and to obtain the dates of any CBI reforms for the rest. This data were then used to create a dummy variable taking the value one after a country had implemented a CBI reform, otherwise zero. The countries for which information on CBI-reforms was missing, years when CBI reforms occurred in the other countries, and sources, can be found in Daunfeldt et al. (2008, Tables A1 and Table A2).

Inflation is measured by the annualized percentage change in consumer prices, from *IMF Financial Statistics*. Following Campillo and Miron (1997), we omitted observations with inflation in excess of 100%[2] and included previous inflation, GDP per capita, degree of openess, political stability, and foreign debt as control variables.[3] The independent variables are also interacted with the introduction of CBI reforms to capture possible interaction effects.

[2] We also tried excluding observations with inflation in excess of 50%, 75%, and 125%. Results are presented in Tables A1-A3 in the Appendix.

[3] These are the same variables used by Campillo and Miron (1997), though they estimated a multivariate regression model on cross-section data, using a index to measure the degree of CBI. As described above, we instead use data on the occurence of CBI reforms to estimate a panel data model.

GDP per capita, obtained from the World Bank's *World Development Indicators* and measured in US dollars, is included as a control variable since high-income countries may have more developede tax - and financial systems, so that their optimal inflation tax is lower than in less developed countries (Grilli et al., 1991).

More open countries may have lower inflation rates than others, because openness promotes efficiency and productivity through specialization in producing goods with comparative advantage (Romer, 1993). Openess is measured by the ratio of exports plus import to GDP from *Human Development Reports*.

It is expected that the credibility of a low inflation policy is lower, and thus inflation higher, in politically unstable countries. Political stability is proxied by an exponential weighted moving average (EWMA, 20 years) of the number of coups in the country, obtained from the *Coup Data Codebook* (Marshall and Marshall, 2007).[4] The weights for successive past observations in the moving average were calculated as $(1-\lambda)\lambda^0$, $(1-\lambda)\lambda^1, (1-\lambda)\lambda^2, ...,$ where λ is 0.75.[5]

Foreign debt is measured by the use of fund and credits from the IMF - with data obtained from the World Bank's *Global Indicators Database* - assuming that countries with large debts produce inflation to reduce them.

Means and standard deviations of the variables included in the empirical analysis are presented in Table 2.

[Table 2 about here]

[4] http://www.systemicpeace.org/inscr/CSPCoupsCodebook2008.pdf

[5] The values $\lambda = 0.94$, and $\lambda = 0.5$ gave similar results.

4 Empirical model

To analyze how CBI-reforms have affected inflation, while also accounting for possible heterogeneity in effects across countries, we estimated:

$$\begin{aligned}\pi_{it} &= \sum_{p=1}^{5}\mu_p\pi_{it-p} + \beta_0 + \beta_1 DCBI_{it} + \beta_2 GDP_{it} \\ &+\beta_3(DCBI_{it} * GDP_{it}) + \beta_4 OPENNESS_{it} \\ &+\beta_5(DCBI_{it} * OPENNESS_{it}) + \beta_6 DEBT_{it} \\ &+\beta_7(DCBI_{it} * DEBT_{it}) + \beta_8 STABILITY_{it} \\ &+\beta_9(DCBI_{it} * STABILITY_{it}) + \beta_{10} DCBI_{it-2} \\ &+\beta_{11} DCBI_{it-5} + \sum_{j=1}^{6}\beta_j CONTINENT_j \\ &+\sum_{tj=1}^{6}\beta_{tj}(CONTINENT_j * TREND_t) + \sum_{t=1}^{26}\beta_t t + u_{it},\end{aligned} \tag{1}$$

where π_{it} is inflation in country i during year t; $DCBI_{it}$ is a indicator variable taking value one after a CBI reform has been implemented; GDP_{it} is gross domestic product per capita; $OPENNESS_{it}$ is openness for trade with other countries; $DEBT_{it}$ is the level of foreign debt administered by the IMF; and $STABILITY_{it}$ measures political stability.

To account for a possible announcement effect, i.e., that inflation was reduced by low-inflation policy statements before a CBI-reform was actually implemented, we also include the indicator variables $DCBI_{it-2}$, with value equal to one two years before implementation of the CBI-reform (zero other-

wise), and $DCBI_{it-5}$, with value equal to one five years before implementation of the reform (zero otherwise). $CONTINENT_j$ and $CONTINENT_j * TREND_t$ account for continent-specific fixed effects and continent-specific time trends, while t are time-specific fixed effects, and u_{it} is the residual term.

The residual is specified as

$$u_{it} = v_i + \gamma_i DCBI_{it} + \varpi_i DCBI_{it-2} + \phi_i DCBI_{it-5} + \varepsilon_{it} \tag{2}$$

where $v_i \sim iid\ N(0, \sigma_v^2)$ is a country-specific random effect, while $\gamma_i \sim iid\ N(0, \sigma_\gamma^2); \varpi_i \sim iid\ N(0, \sigma_\varpi^2)$;and $\phi_i \sim iid\ N(0, \sigma_\phi^2)$ are country-specific random coefficients related to the three indicator variables for CBI reforms; and $\varepsilon_{it} \sim iid\ N(0, \sigma_\varepsilon^2)$ is the within-country residual. Specific random effects are assumed independent of each other, so the most general model can be written:

$$
\begin{aligned}
\pi_{it} \quad = \quad & \sum_{p=1}^{5} \mu_p \pi_{it-p} + \beta_0 + v_i + (\beta_1 + \gamma_i) DCBI_{it} + \beta_2 GDP_{it} \qquad (3) \\
& + \beta_3 (DCBI_{it} * GDP_{it}) + \beta_4 OPENNESS_{it} \\
& + \beta_5 (DCBI_{it} * OPENNESS_{it}) + \beta_6 DEBT_{it} \\
& + \beta_7 (DCBI_{it} * DEBT_{it}) + \beta_8 STABILITY_{it} \\
& + \beta_9 (DCBI_{it} * STABILITY_{it}) + (\beta_{10} + \varpi_i) DCBI_{it-2} \\
& + (\beta_{11} + \phi_i) DCBI_{it-5} + \sum_{j=1}^{6} \beta_j CONTINENT_j \\
& + \sum_{tj=1}^{6} \beta_{tj} (CONTINENT_j * TREND_t) + \sum_{t=1}^{26} \beta_t t + \varepsilon_{it}
\end{aligned}
$$

The main advantages of this type of model is that it accounts for unobserved continental and country-specific unobserved heterogeneity in inflation (via the fixed and random effects), and for continent-specific differences in inflation trends, while also allowing for unobserved country-specific heterogeneity in the effects of CBI-reforms due perhaps to differences in the design and magnitude of the reform, to differences in de facto and de jure CBI, to the competence of the central banks directors, to external shocks to the economy, etc., all of which are unobservable for the researcher. This estimation strategy thus addresses potential problems with the estimation strategies previously used (arbitrary indicies, and comparing reforms that are very different using indicator variables), while also making it possible to create a country-ranking of how successful CBI reforms have been.

We treat the indicator variable for the introduction of CBI-reforms as

exogenous, first because we found no instruments highly correlated with the potentially endogenous variable, but uncorrelated with the error term; and, second because using instruments for variables that are dichotomous is not simple (Heckman et al., 2006). Instead we discuss how endogeneity might affect our results. Basically, if the indicator for the introduction of CBI reform is endogenous, we would expect estimators related to it to be positively biased, that is less negative than the true values. This is because, since we included country-specific effects, parameter estimates for β_1 measure how CBI reform affected inflation within countries. If inflation in countries that introduced CBI reform would otherwise have been higher than in other countries, the expected bias for β_1 is positive, that is, the true effect of the reform was likely more negative, larger, so that our estimates are lower bounds.

Because interaction variables are included, the marginal effects of $DCBI$, GDP, etc., must be calculated after taking into account interaction effects, which requires using the derivative of the dependent variable, π_{it}, with respect to the independent variable of interest. Using $DCBI_{it}$ as an example, the following equation is evaluated at the mean of its independent variables:

$$\begin{aligned} \partial \pi_{it} / \partial DCBI_{it} &= \beta_1 + \beta_3 GDP_{it} + \beta_5 OPENNESS_{it} \\ &\quad + \beta_7 DEBT_{it} + \beta_9 STABILITY_{it} \end{aligned}$$

Marginal effects calculated are presented at the bottom of each results table.

We also evaluated whether countries that implemented CBI reforms were better at maintaining low inflation using the same type of empirical model. We measured price stability (PS_{it}) using an index consisting of the squared deviation from average inflation during the study period:

$$PS_{it} = \left[\frac{\pi_{it} - Average\ \pi_i}{Average\ \pi_i}\right]^2 * 100,$$

and estimated using the same independent variables as above. However, our most general model, including the country-specific random coefficients did not converge despite trying several algorithms and starting values. Thus, this less general model, excluding country-specific random coefficients, was estimated:

$$\begin{aligned} PS_{it} \quad = \quad & \sum_{p=1}^{5} \mu_p \pi_{it-p} + \beta_0 + v_i + \beta_1 DCBI_{it} + \beta_2 GDP_{it} \\ & + \beta_3 (DCBI_{it} * GDP_{it}) + \beta_4 OPENNESS_{it} \\ & + \beta_5 (DCBI_{it} * OPENNESS_{it}) + \beta_6 DEBT_{it} \\ & + \beta_7 (DCBI_{it} * DEBT_{it}) + \beta_8 STABILITY_{it} \\ & + \beta_9 (DCBI_{it} * STABILITY_{it}) + \beta_{10} DCBI_{it-2} \\ & + \beta_{11} DCBI_{it-5} + \sum_{j=1}^{6} \beta_j CONTINENT_j \\ & + \sum_{tj=1}^{6} \beta_{tj} (CONTINENT_j * TREND_t) + \sum_{t=1}^{26} \beta_t t + \varepsilon_{it} \end{aligned} \tag{4}$$

5 Results

Two models are estimated to analyze whether the CBI reforms reduced inflation, first without announcement effects (Model I) and then allowing for them (Model II).

[Table 3 about here]

The marginal effect of the introduction of a CBI reform, $\partial \pi_{it} / \partial DCBI_{it}$, is negative and statistically significant in both models. This suggests that CBI reforms did indeed reduce inflation, which has not always been clear before (Berger et al., 2001; Hayo and Hefeker, 2002). The reduction in inflation due to the CBI reforms is, on average, 5.04% according to the point estimate from Model I. As discussed above, this should be considered a lower bound of the true reform effect.

Despite time-inconsistency theory, the effect of CBI reform on inflation is only 3.31% when announcement effects are allowed (Model II), and the estimates for the announcement effect variables are both negative and statistically significant (although only at the 10% level for the 5 year variable). Thus, part of the reduction in inflation occured before reforms were actually implemented.

Among control variables, countries with high GDP per capita and a high degree of openess had lower inflation. On the other hand, debt and political instability had no discernible effect. F-tests also clearly show that the continent-specific and time-specific fixed effects, as well as continent-specific time trends, should be included in the model. Taken together, time-specific fixed effects and continent-specific time trends show a clear trend

of reduced inflation during the study period (1980-2005). Our results for CBI-reform are in addition to that trend.

Using our estimates for the random-coefficient terms and the average effect of introducing CBI-reforms,$(\gamma_i + \beta_2)$,we ranked countries by how succesful CBI reforms had been in reducing inflation (Table 4). The estimated random-coefficient term indicates considerable heterogeneity among countries in the effect of CBI-reform, not including these would lead to biased estimates. Though CBI reform, on average, led to reduced inflation, in some countries (20%) it led to higher inflation.

[Table 4 about here]

CBI reform seems to have had the most effect in bringing down inflation in Peru, Argentina, and Uruguay, but in Hungary, Madagascar, and Venezuela it led to substantially higher inflation, perhaps because it coincided with some exogenous shock, or the reform (or its management) might have been insufficient to affect the underlying problem causing inflation, such as deficit spending. Policymakers might also have increased *de jure* independence of the central bank, while *de facto* independence remained unchanged or was reduced.

As noted, in obtaining these results we excluded observations with yearly inflation over 100%. To study the extent to which the effect of CBI reform on inflation depends on previous inflation, we tried alternate exclusions of 50%, 75%, and 125%. The results are presented in Tables A1-A3 in the Appendix, and the estimates regarding the effect of CBI reforms on inflation are summarized in Table 5.

[Table 5 about here]

The negative effect of CBI reform on inflation is clearly driven by high-inflation observations, elimination of which yields much lower estimates. As noted, CBI-reform also led to reduced inflation before it was actually implemented, an effect seen most strongly among low-inflation observations with cut-off of 50%. In this case, there was no negative effect at the time of the reform, yet inflation was reduced 3.7% two years before and 1.42% five years before.

To investigate whether countries that implemented CBI reform were better at maintaing low inflation, Equation (4) is estimated and the results are presented in Table 6.

[Table 6 about here]

Variation in inflation is not statistically significantly different for countries that had implemented CBI reform compared to others. However, time-specific fixed effects and continental time-specific trends (not shown) are negative and highly significant. Recent lower variation in inflation is thus due to global and continental trends, not to CBI reforms.

6 Summary and conclusions

A major international trend in recent decades is increased central bank independence (CBI). Independent central banks are widely believed to be better at achieving and maintaing low inflation than are those controlled by politicians. The theoretical background is the literature on time-inconsistency in

monetary policy (Kydland and Prescott, 1977; Barro and Gordon, 1983; Rogoff, 1985). Empirical studies have also supported this hypothesis (Alesina, 1988; Grilli et al., 1991; Cukierman et al., 1992; Alesina and Summers, 1993; Jonsson, 1995; Eijffinger et al., 1998).

However, these studies have been criticized for many reasons. Correlation analysis is not sufficient for establishing a causal relationship. An omitted variable could cause both CBI and low inflation (Posen, 1993; Campillo and Miron, 1997; Hayo, 1998). Determining the level of CBI is also very subjective, and results seem sensitive to small plausible changes in CBI indicies (Forder, 1996, 1998; Mangano, 1998) .

More recent studies have therefore used other methods. Acemoglu et al. (2008), Daunfeldt and de Luna (2008), and Landström (2011) all analyzed changes in CBI using the years of CBI-reforms. However, very different CBI-reforms were then treated as equal.

We therefore used a random-effects and random-coefficients model to study whether CBI reforms have reduced inflation. This approach has the advantage of accounting for country-specific unobserved heterogeneity in inflation, while also allowing for unobserved heterogeneity in the effects of CBI reforms. We also investigated whether CBI reform reduced inflation, or whether CBI reforms were implemented in countries that had already achieved low inflation. The analysis is based on a data-set compiled by Daunfeldt et al. (2008), covering the possible occurrence of CBI reforms in 131 countries.

CBI-reforms, on average, reduced inflation by 3.31% when countries with historically high inflation rates were included, but not otherwise. CBI re-

forms were thus not necessary for achieving low and stable inflation in low inflation countries. It even seems that the negative effect of CBI reform on inflation occured before the reform was actually implemented, supporting Daunfeldt and de Luna's (2008) findings. This is especially noticeable in low-inflation countries, where CBI reform seems to have been implemented when low inflation had already been achieved, perhaps because politicians wanted to tie the hands of incoming governments. The time-inconsistency case for CBI, that politicians must implement CBI reform to achieve low and stable inflation, can thus be quesitoned.

There was considerable heterogeneity among countries in the effect of CBI reform, which were highly effective in reducing inflation in (for example) Peru, Argentina, and Uruguay, but resulted in higher inflation in (for example) Hungary and Venezuela.

Countries with high GDP per capita had lower inflation. All else equal, reforms that induce GDP-growth may thus also help reducing inflation. Countries open to trade also generally had lower inflation, probably because openness increases specialization and thus boosts productivity (Romer, 1993).

There might still be a role for CBI reform if it promotes price stability, i.e., if countries with more independent central banks are better at maintaining low inflation. However, we find no evidence that CBI reform led to lower inflation variability.

There are many possible reasons why CBI reform does not seem to have been necessary for achieving low and stable inflation. High inflation in many countries during the 1970s might have led policymakers to become more inflation-averse, so that the transition from high to low inflation might be

explained by shifting preferences. The time-consistency problem in monetary policy, after all, relies on the assumption that politicians' unemployment target is lower than the natural rate of unemployment. If this is no longer the case, politicians might be able to reduce inflation merely by declaring that low and stable inflation is the primary goal for economic policy.

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Table 1: Summary of studies on the relationship between CBI and inflation, 2008-2012.

Study	# Countries	Period	CBI measure	Method[a]	Results
Acemoglu et al. (2008)	52	1972-2005	Reform	OLS	CBI-reforms reduced inflation only in countries with intermediate constraints on the executive.
Copelovitch and Singer (2008)	23	1975-1999	Index	OLS	No statistically significant effect of CBI on inflation.
Daunfeldt and de Luna (2008)	29	1975-2005	Reform	Loess	Most OECD countries achieved price stability before a CBI-reform was implemented.
Jácome and Vázquez (2008)	24	1985-2002	Index, TORs	FGLS, G2SLS, EC2SLS	CBI is negatively related to inflation, but endogenously determined.
Siklos (2008)	107	1990-2004	Index	OLS, QR	No relation between CBI and inflation, although some components of CBI reduced inflation.
Carlstrom and Fuerst (2009)	26	1989,2000	Index	OLS	Nearly 2/3 of the decline in inflation was explained by increased CBI.
Klomp and de Haan (2010b)	128	1980-2005	TORs, Index	RC	No relation between CBI and inflation.
Chrigui et al. (2011)	40	1971-2004	TORs	LSDV	No statistically significant effect of TORs on inflation.
Landström (2011)	128	1980-2005	Reform	DD	CBI reforms reduced inflation, but only in countries with high initial inflation.
Hielscher and Markwardt (2012)	69	1989-2003	Δ Index	OLS	More CBI led to lower inflation only if the change was large and the quality of institutions was high.

Note: [a] OLS = Ordinary Least Square; Loess =Locally weighted regression; FGLS = Feasible Generalized Least Squares; G2SLS = Generalized Two-Stage Least Squares; EC2SLS = Error correction Two-Stage Least Squares; QR = Quantile regression; RC = Random coefficient model ; LSDV = Least Squares Dummy Variables; DD = Difference-in-Difference

Table 2: Descriptive statistics

Variable	Mean	St.dev.
π_{it}	11.55	15.34
π_{it-1}	30.34	511.78
π_{it-2}	149.17	2810.55
π_{it-3}	245.63	3414.44
π_{it-4}	272.84	3569.81
π_{it-5}	319.75	4318.91
$DCBI_{it}$	0.228	0.42
GDP_{it}	9290.73	8581.49
$DCBI_{it} * GDP_{it}$	2280.29	6111.60
$OPENESS_{it}$	93.82	86.04
$DCBI_{it} * OPENESS_{it}$	23.40	59.27
$DEBT_{it}$	10.56	13.49
$DCBI_{it} * DEBT_{it}$	2.67	7.80
$STABILITY_{it}$	0.27	0.51
$DCBI_{it} * STABILITY_{it}$	0.06	0.13
Number of observations	2965	

Table 3: Estimation results, without and with announcement effects

	Model I		Model II	
Variable (parameter)	Estimate	Std. err.	Estimate	Std. err.
$DCBI_{it}$ (β_1)	-8.052***	2.994	-6.158**	2.971
GDP_{it} (β_2)	-0.001***	0.000	-0.000***	0.000
$DCBI_{it} * GDP_{it}$ (β_3)	0.000	0.000	0.000***	0.000
$OPENESS_{it}$(β_4)	-0.021***	0.008	-0.021***	0.008
$DCBI_{it} * OPENESS_{it}$ (β_5)	-0.000	0.012	-0.002	0.011
$DEBT_{it}$ (β_6)	0.056*	0.033	0.048	0.033
$DCBI_{it} * DEBT_{it}$ (β_7)	-0.149*	0.080	-0.151*	0.081
$STABILITY_{it}$ (β_8)	0.305	0.566	0.422	0.561
$DCBI_{it} * STABILITY_{it}$ (β_9)	1.062	3.105	1.278	3.232
$DCBI_{it-2}$ (β_{10})			-2.996**	1.445
$DCBI_{it-5}$ (β_{11})			-2.394*	1.330
Constant (β_0)	22.164***	2.732	22.306***	2.764
Random-effects/random-coefficients parameters (variable)				
v_i	10.668***	0.782	10.919***	0.801
$\mu_i(DCBI)$	10.415***	1.209	9.333***	1.351
$\varpi_i(DCBI_{it-2})$			5.604***	1.662
$\phi_i(DCBI_{it-5})$			3.660***	1.629
E				ffects:
$\partial\pi_{it}/\partial DCBI_{it}$	-5.036***	1.539	-3.314**	1.555
$\partial\pi_{it}/\partial GDP_{it}$	0.000***	0.000	0.000***	0.000
$\partial\pi_{it}/\partial OPENESS_{it}$	-0.021***	0.0081	-0.020***	0.0082
$\partial\pi_{it}/\partial DEBT_{it}$	0.022	0.032	0.014	0.033
$\partial\pi_{it}/\partial STABILITY_{it}$	0.547	0.829	0.713	0.857

Note: ***, ** and * denote significance at the 1%, 5% and 10% levels.

Table 4. The effect of CBI reform on inflation ($\Delta\pi$) , country ranking

Ranking country	$\Delta\pi$	Ranking country	$\Delta\pi$	Ranking country	$\Delta\pi$
1. Peru	-30.34	30. Switzerland	-4.20	59. Croatia	-1.11
2. Argentina	-26.36	31. Latvia	-4.17	60. Romania	-1.09
3. Uruguay	-22.84	32. Spain	-3.94	61. Colombia	–0.81
4. Vietnam	-15.55	33. Albania	-3.86	62. Georgia	-0.68
5. Serbia	-14.23	34. Chile	-3.74	63. Macedonia	-0.45
6. Yemen	-13.17	35. Slovak Republic	-3.74	64. Cyprus	-0.35
7. Uganda	-13.05	36. Sweden	-3.67	65. Philippines	0.01
8. Iceland	-12.15	37. Tanzania	-3.67	66. Malta	0.16
9. Poland	-11.59	38. Nicaragua	-3.49	67. Netherlands	0.18
10. Lithuania	-10.34	39. Azerbaijan	-3.31	68. Sri Lanka	0.21
11. Mongolia	-9.19	40. Bulgaria	-3.31	69. Guatemala	0.25
12. New Zealand	-8.06	41. Djibouti	-3.31	70. Nepal	0.87
13. Czech Rep.	-7.63	42. Gambia	-3.31	71. Korea	1.06
14. Paraguay	-7.52	43. Iran	-3.31	72. Lesotho	1.13
15. Mexico	-7.47	44. Kazakhstan	-3.31	73. Ireland	1.43
16. El Salvador	-6.90	45. Namibia	-3.31	74. Malaysia	2.62
17. Turkey	-6.85	46. Seychelles	-3.31	75. Dominican Republic	2.97
18. Guyana	-6.83	47. Suriname	-3.31	76. Ecuador	4.54
19. Italy	-6.25	48. Australia	-3.31	77. Pakistan	5.47
20. Greece	-6.03	49. Luxembourg	-2.76	78. Indonesia	6.22
21. Ukraine	-5,76	50. United Kingdom	-2.68	79. Russia	6.68
22. France	-5.49	51. Mauritius	-2.52	80. Papua New Guinea	9.23
23. Nigeria	-5.46	52. Japan	-2.17	81. Honduras	9.40
24. Norway	-5.12	53. Bahamas	-2.17	82. Uzbekistan	10.44
25. Slovenia	-4.93	54. Finland	-1.96	83. Hungary	11.19
26. Bosnia	-4.53	55. Austria	-1.75	84. Madagaskar	11.35
27. Portugal	-4.33	56. South Africa	-1.33	85. Venezuela	11.60
28. Estonia	-4.33	57. Belgium	-1.28		
29. Bolivia	-4.25	58. Costa Rica	-1.15		

Table 5: The effect of CBI reforms on inflation at time*t*, *t-2*, and *t-5* for various inflation cut-offs. (Standard errors in parantheses)

	Inflation cut-off			
Variable	125%	100%	75%	50%
$\partial\pi_{it}/\partial DCBI_{it}$	-4.261**	-3.314**	-0.754	0.847
	(2.059)	(1.555)	(1.289)	(0.900)
$DCBI_{it-2}$	-2.646*	-2.996**	-3.461***	-3.704***
	(1.549)	(1.445)	(1.054)	0.987)
$DCBI_{it-5}$	-1.612	-2.394*	-1.548	-1.420*
	(1.484)	(1.330)	(1.012)	(0.832)

Note: ***, ** and * denote significance at the 1%, 5%, and 10% levels.

Table 6: Estimation results, inflation variance

	Model I		Model II	
Variable (parameter)	Estimate	Std. err.	Estimate	Std. err.
$DCBI_{it}$ (β_1)	0.225	0.268	0.203	0.262
GDP_{it} (β_2)	-0.000	0.000	-0.000	0.000
$DCBI_{it} * GDP_{it}$ (β_3)	0.000	0.000	0.000	0.000
$OPENESS_{it}$(β_4)	0.001	0.000	0.001	0.000
$DCBI_{it} * OPENESS_{it}$ (β_5)	-0.002**	0.001	-0.002**	0.011
$DEBT_{it}$ (β_6)	-0.000	0.005	-0.001	0.005
$DCBI_{it} * DEBT_{it}$ (β_7)	0.007	0.006	0.008	0.006
$STABILITY_{it}$ (β_8)	0.352	0.388	0.351	0.386
$DCBI_{it} * STABILITY_{it}$ (β_9)	-0.387	0.377	-0.404	0.385
$DCBI_{it-2}$ (β_{10})			0.053	0.076
$DCBI_{it-5}$ (β_{11})			-0.031	0.069
Constant (β_0)	2.206***	0.562	2.211***	0.563
Random-effects/random-coefficients parameters(variable)				
v_i	0.893***	0.083	0.893***	0.083
$\mu_i(DCBI)$	N/A	N/A	N/A	N/A
$\varpi_i(DCBI_{it-2})$	N/A	N/A	N/A	N/A
$\phi_i DCBI_{it-5})$	N/A	N/A	N/A	N/A
Effects:				
$\partial\pi_{it}/\partial DCBI_{it}$	0.052	0.099	0.022	0.106
$\partial\pi_{it}/\partial GDP_{it}$	-0.000	0.000	-0.000	0.000
$\partial\pi_{it}/\partial OPENESS_{it}$	0.000	0.000	0.000	0.000
$\partial\pi_{it}/\partial DEBT_{it}$	0.001	0.004	0.000	0.004
$\partial\pi_{it}/\partial STABILITY_{it}$	0.264	0.313	0.258	0.310

Note: ***, ** and * denote significance at the 1%, 5% and 10% levels.

7 Appendix

Table A1: Estimation results, inflation cut-off 50%

	Model I		Model II	
Variable (parameter)	Estimate	Std. err.	Estimate	Std. err.
$DCBI_{it}$ (β_1)	-2.532	1.674	-0.199	1.786
GDP_{it} (β_2)	-0.001***	0.000	-0.000***	0.000
$DCBI_{it} * GDP_{it}$ (β_3)	0.000**	0.000	0.000	0.000
$OPENESS_{it}$(β_4)	-0.014***	0.005	-0.015***	0.005
$DCBI_{it} * OPENESS_{it}$ (β_5)	-0.004	0.007	-0.005	0.006
$DEBT_{it}$ (β_6)	0.059***	0.022	0.048**	0.022
$DCBI_{it} * DEBT_{it}$ (β_7)	-0.057	0.049	-0.050	0.050
$STABILITY_{it}$ (β_8)	0.351	0.366	0.475	0.361
$DCBI_{it} * STABILITY_{it}$ (β_9)	2.932	1.965	3.206	2.044
$DCBI_{it-2}$ (β_{10})			-3.704***	0.987
$DCBI_{it-5}$ (β_{11})			-1.420*	0.832
Constant (β_0)	19.902***	1.604	20.169***	1.622
Random-effects/random-coefficients parameters(variable)				
v_i	5.849***	0.457	6.041***	0.472
$\mu_i(DCBI)$	4.917***	0.662	4.794***	0.780
$\varpi_i(DCBI_{it-2})$			4.546***	1.025
$\phi_i(DCBI_{it-5})$			2.038*	1.221
Effects:				
$\partial\pi_{it}/\partial DCBI_{it}$	-1.104	0.824	0.847	0.900
$\partial\pi_{it}/\partial GDP_{it}$	-0.000***	0.000	-0.000***	0.000
$\partial\pi_{it}/\partial OPENESS_{it}$	-0.016***	0.005	-0.016***	0.005
$\partial\pi_{it}/\partial DEBT_{it}$	0.046**	0.021	0.036*	0.021
$\partial\pi_{it}/\partial STABILITY_{it}$	1.033*	0.538	1.220**	0.556

Note: ***, ** and * denote significance at the 1%, 5% and 10% levels.

Table A2: Estimation results, inflation cut-off 75%

	Model I		Model II	
Variable (parameter)	Estimate	Std. err.	Estimate	Std. err.
$DCBI_{it}$ (β_1)	-4.985**	2.337	-3.721	2.373
GDP_{it} (β_2)	-0.000***	0.000	-0.000***	0.000
$DCBI_{it} * GDP_{it}$ (β_3)	0.000***	0.000	0.000***	0.000
$OPENESS_{it}$(β_4)	-0.021***	0.007	-0.021***	0.007
$DCBI_{it} * OPENESS_{it}$ (β_5)	-0.002	0.009	-0.001	0.009
$DEBT_{it}$ (β_6)	0.057**	0.028	0.051*	0.029
$DCBI_{it} * DEBT_{it}$ (β_7)	-0.075	0.065	-0.078	0.066
$STABILITY_{it}$ (β_8)	0.266	0.473	0.322	0.472
$DCBI_{it} * STABILITY_{it}$ (β_9)	1.231	2.585	2.004	2.586
$DCBI_{it-2}$ (β_{10})			-3.461***	1.054
$DCBI_{it-5}$ (β_{11})			-1.548	1.012
Constant (β_0)	21.171***	2.270	21.298***	2.276
Random-effects/random-coefficients parameters(variable)				
v_i	8.752***	0.631	8.811***	0.635
$\mu_i(DCBI)$	7.575***	0.918	7.651***	0.919
$\varpi_i(DCBI_{it-2})$			N/A	N/A
$\phi_i(DCBI_{it-5})$			N/A	N/A
Effects:				
$\partial\pi_{it}/\partial DCBI_{it}$	-2.603**	1.185	-0.754	1.289
$\partial\pi_{it}/\partial GDP_{it}$	-0.000***	0.000	-0..000***	0.000
$\partial\pi_{it}/\partial OPENESS_{it}$	-0.021***	0.007	-0.021***	0.007
$\partial\pi_{it}/\partial DEBT_{it}$	0.039	0.027	0.033	0.027
$\partial\pi_{it}/\partial STABILITY_{it}$	0.549	0.696	0.782	0.696

Note: ***, ** and * denote significance at the 1%, 5% and 10% levels.

Table A3: Estimation results, inflation cut-off 125%

	Model I		Model II	
Variable (parameter)	Estimate	Std. err.	Estimate	Std. err.
$DCBI_{it}$ (β_1)	-9.643***	3.654	-8.763**	3.692
GDP_{it} (β_2)	-0.001***	0.000	-0.000***	0.000
$DCBI_{it} * GDP_{it}$ (β_3)	0.000***	0.000	0.001***	0.000
$OPENESS_{it}$(β_4)	-0.032***	0.010	-0.032***	0.010
$DCBI_{it} * OPENESS_{it}$ (β_5)	0.006	0.015	0.007	0.015
$DEBT_{it}$ (β_6)	0.013	0.039	0.010	0.039
$DCBI_{it} * DEBT_{it}$ (β_7)	-0.120	0.098	-0.124	0.098
$STABILITY_{it}$ (β_8)	2.302***	0.676	2.352***	0.675
$DCBI_{it} * STABILITY_{it}$ (β_9)	-0.776	3.802	-0.247	3.810
$DCBI_{it-2}$ (β_{10})			-2.646*	1.549
$DCBI_{it-5}$ (β_{11})			-1.612	1.484
Constant (β_0)	24.205***	3.320	24.259***	3.325
Random-effects/random-coefficients parameters(variable)				
v_i	13.024***	0.956	13.060***	0.958
$\mu_i(DCBI)$	13.288***	1.453	13.270***	1.445
$\varpi_i(DCBI_{it-2})$			N/A	N/A
$\phi_i(DCBI_{it-5})$			N/A	N/A
Effects:				
$\partial\pi_{it}/\partial DCBI_{it}$	-5.701***	1.929	-4.261**	2.059
$\partial\pi_{it}/\partial GDP_{it}$	-0..000***	0.000	-0..000***	0.000
$\partial\pi_{it}/\partial OPENESS_{it}$	-0.031***	0.010	-0.031***	0.010
$\partial\pi_{it}/\partial DEBT_{it}$	-0.014	0.038	-0.018	0.038
$\partial\pi_{it}/\partial STABILITY_{it}$	2.128***	1.000	2.296**	1.001

Note: ***, ** and * denote significance at the 1%, 5% and 10% levels.