Central bank financial strength and inflation: an empirical reassessment considering the key role of the fiscal support

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Central bank financial strength and inflation: an empirical reassessment considering the key role of the fiscal support

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"The Bundesbank profit is a residual issue for me and my colleagues... I don't enter into any strategic considerations about Bundesbank profits, neither in the morning, afternoon or evening"[2] *(Bundesbank President Axel Weber, 2004)*

"We, the central bank, have a negative net worth...and this remains our greatest challenge"[3] *(Central Bank of Costa Rica President Gutiérrez, 2004)*

ABSTRACT:

This paper re-examines whether weak central bank finances affect inflation by scrutinizing the key rationale for such a relationship: that the absence of Treasury support makes central bank finances relevant for price stability. Specifically, I ask whether central banks which are not likely to enjoy fiscal support when needed experience higher inflation as their financial situation deteriorates. I find this to be true among a large sample of 82 countries between 1998 and 2008. *De facto* potential fiscal support appears relevant, while *de jure* fiscal support, which I survey analyzing 82 central bank laws, does not appear to matter. No link is found in a general context. The results bring forward an explanation for the conflicting results of the previous empirical studies, which neglected this key component.

Keywords: Central bank financial strength; Central bank capital; Central bank balance sheet; Inflation; Fiscal space; Central bank law. JEL classification: E58; E52; E42; E63

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[2] Reuters (2005)

[3] Francisco de Paula Gutiérrez, President of the Central Bank of Costa Rica (*Central Banking*, Vol. XV No.4, May 2005, page 82)

1. Introduction

A growing literature emphasizes the negative influence that a weak central bank financial strength[4] (CBFS henceforth) can have on price stability. Recent important theoretical studies such as Benigno and Nisticò (2015), Del Negro and Sims (2015) and Hall and Reis (2015) emphasize the key role of the fiscal support for this link to arise. Essentially, the argument is that *when fiscal support is absent*, a central bank can be expected to let inflation grow in order to increase seigniorage profits and thus reinforce its financial situation[5]. Current empirical works on the link between CBFS and inflation neglect this key component of the relationship. These studies indeed essentially focus on the link between CBFS and inflation in a general context, thereby mainly answering the question *"does CBFS always matter for inflation?"*. Consequently, different studies lead to different results depending on the sample used: studies such as Klüh and Stella (2008) or Perera *et al.* (2013) find a link between CBFS and inflation, while Benecká *et al.* (2012) do not find any significant link. This apparent inconsistency has not been explained in the existing literature yet.

In this paper, I examine the empirical link between CBFS and inflation by considering the theoretical underpinning of this link, namely, the absence of fiscal support. Doing so, I aim at two objectives. First, I want to test empirically whether CBFS can indeed have an effect on inflation when fiscal support is absent. Second, I want to see whether the negligence of this key factor can explain the inconsistency of previous empirical results. I deal with the first aspect by taking into account the conditionality of the relationship in my empirical model. I distinguish between the *de jure* absence of fiscal support, that is the absence of guaranteed fiscal support in the law (the "legal view"), and *de facto* potential absence of fiscal support, that is the possibility that fiscal support does not actually arise because of structurally weak government finances (the "pragmatic view"). *De jure* absence of fiscal support is evaluated by creating a new database, going manually through each central bank law, while *de facto* potential absence of fiscal support is identified with governments' creditworthiness indicators. I firstly identify the countries likely to be in such situations among a large sample of 82 countries, and then test for a link between CBFS and inflation for these countries. In order to compare my results with the ones of previous studies, I use similar empirical methods (Panel System-GMM), a similar indicator for CBFS and a similar time period sample (1998-2008) to those used in the most recent empirical studies.

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[4] Financial strength could be defined as *"the extent to which an entity is constrained by its financial situation in pursuing its strategic goals or policies"* (Stella, 2008).

[5] Agents' expectations or the central bank behavior in itself could then lead to higher inflation.

My results suggest that CBFS indeed doesn't automatically matter for inflation, but matters in the case of *de facto* absence of fiscal support. The results appear robust when considering alternative econometric methods, alternative controls, and alternative proxies for *de facto* potential fiscal support. They also hold when using a newly built alternative variable for CBFS. The results suggest an explanation for the apparent inconsistency of the results of the previous literature, in that the significant results of previous studies were based on samples mostly containing countries that shared the characteristics which are found relevant here.

This study contributes to the existing literature in this area in three dimensions. First, the results suggest a clear answer on whether a central bank financial situation empirically matters for inflation: it doesn't always matter, but it does when fiscal support is absent. To the extent that this study borrowed on many aspects from the previous studies, while proposing improvements on important aspects such as the sample selection and the robustness checks, it arguably cuts off the debate on the empirical link between CBFS and inflation. Second, this study provides a new database on the presence of fiscal support guarantee in the law, useful for further studies. Third, as the paper finds *de facto* potential support rather than *de jure* fiscal support to be empirically relevant, it sheds light on the channels at work in the relationship between CBFS and inflation. While it cannot be inferred from my results that *de jure* fiscal support is irrelevant, it can be nonetheless argued that *de facto* potential fiscal support is at least as relevant and should thus be considered accordingly.

The rest of the paper is structured as follows: section 2 reviews the related literature and explains the baseline test; section 3 introduces the data and the estimation technique; section 4 presents the baseline results and section 5 the robustness checks; section 6 concludes.

2. Related literature and the baseline test

2.1: Why CBFS does matter and how it can affect inflation

Sound finances are important for central banks for many different reasons. Solvency considerations are probably the most commented motive in recent studies: a central bank faces limits on the long run if it spends more than it earns without letting its policy unchanged (Del Negro and Sims, 2015; Reis, 2013). In countries in which the expenses of the central bank are particularly significant relative to their income, such a budget constraint can be especially difficult to satisfy[6]. This can in turn force the central bank to tolerate higher inflation in order to increase seigniorage income (Reis, 2013; Buiter, 2008). Central bank finances are also important for the credibility of the institution. Weak central bank finances could make the public and the market believe that the central bank will review the policy it committed to in order to improve its financial situation, thereby indeed impacting inflation (Klüh and Stella, 2008; Cargill, 2005). The lender of last resort role of the central bank could likewise be severely questioned by weak central bank finances, in particular by a weak equity position, to the extent that such operations generally require undertaking large balance-sheet risks (Sims, 2013; Miller and Vallée, 2009; Stella, 2005; Pringle, 2003). A weak financial situation might also create unnecessary and potentially damaging interferences with the Treasury, thereby eroding the independence of the institution (Williamson, 2014; Cukierman, 2011; Jeanne and Svensson, 2007). Since central banks have become more independent and more transparent in the last decades, all these motives have become increasingly relevant.

When a central bank wants to improve its financial position, it essentially faces three ways. The most straightforward procedure is to ease monetary policy to generate further profits. Former Bank of Japan policy board member Kazuo Ueda for example only referred to this possibility in his speech (Ueda, 2004). For many academics, this solution is implicitly considered as the main leeway the central bank has. Del Negro and Sims (2015), Reis (2013) and Buiter (2008) detail the theoretical mechanisms through which monetary policy easing translates into higher seigniorage income, thereby bringing higher profits. Easing monetary policy can also increase profits by lowering sterilization costs[7]. Another possibility for the central bank is to decrease the level of its expenditure. Most studies however consider that

[6] See Ize (2005) for empirical examples.
[7] See Adler *et al.* (2012) and Kletzer *et al.* (2004) for a discussion. Unexpected easing is particularly relevant here.

this is likely to provide only little leeway (Hall and Reis, 2015) while requiring a non-negligible amount of time (Buiter, 2008), making this possibility often neglected. We will follow this practice in this study. Finally, the central bank could ask for the fiscal support of the Treasury. Stella (2005), Stella and Lönnberg (2008), Jácome and Parrado (2007) discuss historical examples when fiscal support to the central bank took place. The most straightforward mechanism for fiscal support is the recapitalization of the central bank by the Treasury, which can either be done through the transfer of bonds to the central bank, or through the direct debit of cash from the government account at the central bank. All in all, as Reis (2013) summarizes, the central bank has two possibilities to improve its financial situation: rely on the Treasury support or tolerate higher inflation[8]. That the central bank does tolerate higher inflation or that economic agents do expect it should in both cases make a link between CBFS and inflation existent.

2.2: Review of the previous empirical studies

The first attempt to investigate the relationship between CBFS and inflation econometrically was the innovative work of Klüh and Stella (2008). The authors find a negative and significant link between inflation and CBFS through two empirical studies. In the first one, they consider a sample of 15 Latin American and Caribbean countries[9] between 1987 and 2005 and use panel estimation methods with yearly observations. In the second one, they consider a sample of 97 countries between 1992 and 2005 and show that the average values for CBFS on that period are significantly negatively correlated with the average inflation values across countries. In contrast with their panel result, this cross-section analysis includes few controls and appears limited by essence.

The study of Benecká *et al.* (2012) copes with the weaknesses of the cross-section analysis of Klüh and Stella (2008). The authors apply a wide range of panel econometric methods with different covariates in order to test for the robustness of the link previously found. Using a notable sample of 105 countries between 2002 and 2009, they conclude that the link between CBFS and inflation is weak and not robust. However, some technical aspects appear as limits

[8] With this assertion we deliberately disregard the possibility that the central bank either changes its investment policy or resorts to financial repression to boost profits. The former possibility can provide some leeway only when the current investment policy is not efficient (or not constrained by law): when it is, it cannot be considered as a straightforward solution anymore, which is why I will ignore this possibility as in the connected literature. The latter is likely to face limits and can hardly be considered as a long-run solution (Klüh and Stella, 2008) in contrast with the possibilities we mentioned here.

[9] The choice of focusing on Latin America is not explicitly defended but implicitly justified by the particularities of these countries: central banks in this region experienced severe losses and the issue of central bank independence is presented as an historically controversial issue for these countries.

to this general conclusion: the observations for the years corresponding to the global financial crisis as well as the observations for countries belonging to a currency union are not put aside or controlled for, while it is arguable that their inclusion can severely affect the measured link (see section 3).

More recently, the study of Perera *et al.* (2013) enriches the debate by partly dealing with the limits of the two previous studies by accounting for heterogeneity between different groups of countries while using robust estimation methods similar to Benecká *et al.* (2012). With Pooled OLS, Within-Group and System GMM estimations considering yearly moves in the corresponding variables[10], they find a robust link between CBFS and inflation. Their findings however rely on a relatively small sample, consisting of 18 heterogeneous countries for the period 1996-2008. When their sample is split according to different criteria, their results suggest that the link between CBFS and inflation is particularly important for central banks with a low degree of independence and for countries with fixed exchange rate regimes. The number of countries selected is certainly the most important limit of their findings, as the authors state. On the one hand, the small N-dimension is likely to be detrimental when using IV-methods with a short T dimension such as System GMM. This is arguably the case when estimates for a group of 5 countries with flexible exchange rates are performed. On the other hand, the small number of countries makes it difficult to draw general conclusions.

2.3: The baseline test

The assumption of this paper is that the empirical link between CBFS and inflation, if there is, is conditional on the absence of fiscal support. The goal is thus to know: a) if, when paying more attention to the sample selection than previously done, a link between CBFS and inflation still arise in a general context; b) if we can find a specific link between CBFS and inflation where it makes sense to have one, that is, in the case of no fiscal support. Accordingly, I use the following methodology. I first test for the presence of a link between CBFS and inflation for my whole sample (82 countries). Then, to test for b), I build a dummy variable equal to 1 when the fiscal support is indeed absent (0 otherwise) and interact this dummy with the CBFS variable to test for its significance. If my above assumption is correct, I should not find any significant link between CBFS and inflation in the former case, while the link could appear in the latter case.

[10] They take a 3-years moving average for their CBFS variable but consider yearly moves.

I will follow the literature by considering the lag of the variable for CBFS (CBFS1) instead of its contemporaneous value in the relationship between CBFS and inflation, mainly because the data for the key explanatory variable CBFS1 are end-of-year figures, as it will later be detailed. Consequently, taking into account the so-called inflation inertia (Calderon and Schmidt-Hebbel, 2008), the first model to be estimated is the following:

$$\mathrm{Y_{i,t}} = \alpha \mathrm{Y_{i,t-1}} + \beta X_{\mathrm{i,t}} + \delta\ \mathrm{CBFS1}_{i,t-1} + \mathrm{v_i} + \mathrm{u_{i,t}} \quad (1)$$

and the second one, which takes into account the conditionality of the link, is just a particular case of the first:

$$\mathrm{Y_{i,t}} = \alpha \mathrm{Y_{i,t-1}} + \beta X_{\mathrm{i,t}} + \delta_N\ (\mathrm{I_i^N} *\ \mathrm{CBFS1_{i,t-1}}) + \mathrm{v_i} + \mathrm{u_{i,t}} \quad (2)$$

where Y is the measure of inflation (INF), X represents the set of control variables other than lagged inflation, CBFS1 the indicator for CBFS in level[11], v is an unobserved country-specific effect, u the error term. $i = 1, \ldots, \mathrm{N}$ are the cross section units (N=82) and $\mathrm{t} = 1, \ldots, \mathrm{T}$ the time periods (T=11). The difference between (1) and (2) is simply the presence of an interaction term with $\mathrm{I_i^N}$ in (2). $\mathrm{I_i^N}$ is a dummy variable equal to 1 if the country i has no fiscal support (0 otherwise). Interacting this dummy with CBFS1 allows us to test for the conditionality of the link[12]. Note that model (2) does not include CBFS1 outside the interaction term: we do not assume that the effect of CBFS is *potentially different* when $\mathrm{I_i^N} = 1$, but that the effect *becomes potentially present* when $\mathrm{I_i^N} = 1$. N is simply a subscript to differentiate between the different fiscal support indicators I will use[13]. In essence, model (1) is similar to the model estimated in the previous literature, model (2) is the novelty of the approach of this paper.

[11] Note that initially I also included a square term for CBFS1 (demeaned to avoid collinearity) to take into account potential non-linearity effects. The square term was never significant when CBFS1 was not significant, and when CBFS1 was significant, only in one case the square term was significant (at a 10% threshold). For this reason this specification was not judged worth being reported.

[12] An alternative approach would be to perform subsamples estimates for countries for which $\mathrm{I_i^N} = 1$. The method I use here has the relative benefit of increasing the precision of the estimates given the larger number of observations resulting, which is why it is preferred. Subsamples estimates however led to the same conclusions.

[13] Note that if the fact that country i shares the characteristics N has *per se* an effect on inflation, this effect is in theory captured by the fixed effects present in equation (2).

3. Data and estimator

3.1: Data for CBFS

For the baseline estimates, I take the indicator of CBFS that was used in all the previous studies: the ratio of the sum of capital and "Other Items Net"[14] (OIN) to total assets (CBFS1), which is more likely to be close to the effective equity[15] of a central bank. Adding to the capital item the OIN component of the central bank balance sheet as identified by the IMF indeed allows us to take into account revaluation accounts, reserves not included in the reported capital item, and potential accounts reflecting "hidden" reserves or losses, thus making it of high conceptual relevance, although this item is on average quite small in our sample[16]. The use of this proxy comes with the advantage of using a balance sheet indicator, which might be an important focal point. This variable is also potentially close to central bankers' preoccupations: Jeanne and Svensson (2007) indeed report that several central banks have explicitly defined an objective in terms of capital-adequacy ratio. The use of this proxy however comes with the disadvantage of not directly taking into account the net present value of future income, which affects CBFS. As the net present value of future income is most of the time presented as a structural component of the balance sheet (Reis, 2013; Buiter, 2008; Ize, 2005), the presence of fixed effects in my model potentially alleviates these concerns. Later I will also consider an alternative index built from central banks reports for robustness checks: the average net income of the central bank over the last 3 years scaled by the respective nominal GDP (CBFS2), available for fewer countries.

3.2: Data on the absence of fiscal support

De jure absence of fiscal support:

De jure absence of fiscal support is defined here as the absence of any legal statement binding the Treasury to recapitalize the central bank if the capital falls below a certain threshold or to

[14] The OIN account is the residual item after taking into account the asset items (foreign assets, claims on central bank government, claims on other levels of government, claims on financial institutions, claims on the private sector, etc.) and the liability items (reserve money, foreign liabilities, central government deposits, monetary authority securities, etc.) that are explicitly identified.

[15] "Effective equity" refers to the difference between assets and liabilities of the balance sheet valued at market prices (Buiter, 2008). Due to different accounting treatments it can differ from the equity figures found in financial reports.

[16] see Perera *et al.* (2013), Stella (2008) and Stella (2003) for further discussions on the OIN item. In our sample the OIN item accounts on average for less than 0.7% of the total assets, when the capital item accounts for 9% on average.

make up for central bank losses in case these materialize. In many countries, the law requires that the Treasury recapitalizes the central bank if the capital falls below a certain threshold (Stella and Lönnberg, 2008). For example, one can read in the Central Bank of Peru organic law of 1993 that *"In the case of a loss, the reserve fund referred to in subsection b) of the preceding article shall be applied. If the reserve is insufficient, within thirty days of the approval of the balance sheet, the Public Treasury shall issue and deliver to the Bank nonnegotiable and interest-bearing debt titles equivalent to the outstanding amount."*. In contrast, the law of the central bank of Estonia mentions that *"Eesti Pank shall not to be held liable for the financial obligations of the State, nor shall the State be held liable for the financial obligations of Eesti Pank*". There is no public database on fiscal support in central bank laws, even though Stella and Lönnberg (2008) release some fifty central bank law extracts relevant for that purpose. To know whether fiscal support is guaranteed by the law for the central banks in my sample, I analyze one by one each central bank law for the central banks of the sample. In cases similar to the central bank of Peru, I consider that fiscal support is guaranteed by the law ($I_i^N = 0$ in Equation (2)), while in cases similar to Estonia, I consider that there is no legal guarantee for fiscal support ($I_i^N = 1$ in Equation (2)). Where no reference to the arrangement in case of loss or capital depletion could be found, in most cases I find the relevant information on *ad hoc* reports or studies, and where no information can be found I consider that there is no fiscal support[17]. In total, in 37 cases out of 82 (around 45% of the cases), fiscal support is not guaranteed by the law. Table A3 in Appendix 1 shows the country-level database obtained.

De facto absence of fiscal support:

Legal obligations for fiscal support may in some cases not be enough for the Treasury to actually stand behind the central bank when needed. Based on several case studies, Stella and Lönnberg (2008) document that Treasuries have often not been in practice the funding backup they were supposed to be. The actual transfer of resources from the Treasury to the central bank usually requires legislative approval and thus can involve a high degree of political effort. This may in turn refrain the Treasury from indeed provide fiscal support. Jácome and Parrado (2007) note in particular that the Treasury mandate has not materialized in the case of Dominican Republic and Nicaragua despite significant losses. The authors explain that the weak ability of the Treasury to engage in further expenses and the political burden associated

[17] These cases are double-checked, and in some cases, central banks confirmed me by email that there was no such mention in the law.

with it seem to have been the main reason for the absence of Treasury support in such cases. Consequently, the ability of the Treasury to engage in further expenses could be of better relevance than what the law says. Fiscal support also arose in cases in which the law was not binding while the government had room for further expenses (Stella and Lönnberg, 2008).

Based on these pragmatic considerations, we can thus hypothesize that where the Treasury's room for further expenses is structurally weak, the central bank will not firmly be able to rely on fiscal support. The relevant concept here is the one of a country's structural fiscal space[18]. As this concept is closely linked to the sustainability of government finances, I will proxy the structural fiscal space of a country by this country's average sovereign rating[19] over the sample period. Ratings used are the ones from the main rating agencies[20]. As we are interested in the countries where fiscal support is likely to be absent, only the countries with a *low* fiscal space are of interest. A key but controversial term here is the adjective *"low"*: there is no objective criterion to qualify the fiscal space of a country as *"low"*. To minimize discretionary judgment, I use an objective benchmark commonly employed in other studies (see for example Rajan and Zingales (1998)): I classify as "low" fiscal space countries the countries for which fiscal space is lower than the first quartile value for fiscal space in my sample. For these countries the dummy variable I_i^N in Equation (2) will take the value 1 (0 for the others). For the sake of simplicity, later these cases will be referred to as "no potential *de facto* fiscal support" cases.

In order to minimize discretionary judgment, I use two other proxies for fiscal space and use the same method as before: the average Debt-to-GDP ratio (following World Bank Group (2015)) and the average Debt-to-Revenue ratio (which appears as a relevant complement of the Debt-to-GDP ratio, see International Monetary Fund (2000) *eg*) on the sample time period [21].

[18] Fiscal space can be defined as *"the availability of budgetary room that allows a government to provide resources for a desired purpose without any prejudice to the sustainability of a government's financial position"* (Heller, 2005). I follow this definition in the rest of the paper. The adjective "structural" here is meant to emphasize that what is seen as relevant here is the mean to long term position of the Treasury, not the short term one.

[19] More specifically, I take the rating on foreign currency debt, which is available for a larger number of countries in the sample. Note that it is widely correlated with the local currency rating (98% on average).

[20] To minimize the weight of discretionary judgments, for each country I take an average of the ratings provided. For a small number of countries there are no rating provided by any of the rating agency: I chose to generate missing ratings relying on the main studies documenting the determinants of sovereign ratings. In total I have generated ratings for 18% of the observations. See Appendix 3 for details.

[21] Here countries with low fiscal space are the ones for which the value for these variables exceeds the third quartile value of my sample. In so far as comparing Debt-to-GDP ratios or Debt-to-Revenue ratios between countries with different fundamentals might be misleading, when using this proxy I put aside advanced economies. Those are indeed likely to be able to run sustainable fiscal policies at significantly higher debt thresholds than developing or emerging economies. The results are not dependent upon this choice.

3.3: Dependent and control variables

I use as a dependent variable the normalized measure of inflation INF = π / (1 + π) (where π is the rate of change of CPI) in order to limit heteroscedasticity issues resulting from the presence of countries with relatively high inflation rates, in line with the connected literature (Benecká *et al.*, 2012; Calderon and Schmidt-Hebbel, 2008; Klüh and Stella, 2008; Cukierman *et al*, 1992)[22]. INF can thus be interpreted as the real depreciation of a given amount of money.

The control variables are selected considering the connected literature and the specificities of this study[23]. Real GDP per capita (GDP_PC) is included to capture factors related to economic development influencing inflation (Romer, 1993) and the so-called Balassa-Samuelson effect (Mihaljek and Klau, 2008). A variable for the output gap (GAP) is added to capture cyclical domestic demand shocks meant to affect inflation through medium-run Philips curve considerations (see also Calderon and Schmidt-Hebbel (2008) and Campillo and Miron (1997))[24]. The growth rate of oil price (OIL_g) is included both to control for cyclical supply shocks (Calderon and Schmidt-Hebbel, 2008; Loungani and Swagel, 2001) and to capture contemporaneous cross-sectional dependence. A dummy variable to control for the occurrence of currency crisis (CRIS) is built from the database of Valencia and Laeven (2012), taking the value of 1 when a currency crisis occurred (0 otherwise), and added to limit endogeneity and heteroscedasticity issues, insofar as currency crisis are often associated with huge increases in inflation while the other control variables do not experience such moves. A trend (TREND) is included to capture the deflationary tendency in world inflation associated with globalization since the beginning of the 1990's (Klüh and Stella, 2008; Jácome and Vázquez, 2008)[25] and to control for the potential remaining cross-sectional contemporaneous dependence (similarly to Perera *et al.* (2013)). All the variables used here were present in previous empirical studies, with the exception of the dummy for the occurrence of currency crisis. We expect inflation to be negatively linked with GDP_PC and TREND and positively linked with GAP, OIL_g, and CRIS. Table A1 (Appendix) presents descriptive statistics.

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[22] Using the log(1 + π) instead yields similar results. When doing so, CBFS1 was also taken in log values, and I considered the logarithm of (1+CBFS1) in order to take the observations for which CBFS1 was negative.

[23] I use the variables I judge the most relevant for this study in order to keep the model parsimonious and to avoid potential multicollinearity issues. Initially I also considered openness and money growth. As the former variable barely entered with the expected sign and in a significant way in the regressions, I didn't consider it. Money growth was highly correlated with inflation (>0.5) so that I didn't include it. The inclusion of these variables didn't change the main result though.

[24] It is computed as the residuals of the regression of real GDP on a trend normalized by the corresponding fitted values.

[25] As CBFS also has had a tendency to decline in the 2000's (Klüh and Stella, 2008), this also allows us to avoid any bias in the estimates.

3.4: Sample

The sample consists of 82 countries on the period 1998-2008. Following the literature, the data are yearly. The beginning of the period corresponds to the first year of data availability in the Bankscope database. As an objective of this study is to explain the inconsistency of the previous results, the sample period goes until 2008, as in Perera *et al.* (2013). The sample deliberately stops in 2008 as in Perera *et al.* (2013) in order to exclude the impact of the global financial crisis. As many central banks adopted unconventional monetary policies from 2009 on, the baseline CBFS indicator used here, with central bank assets in the denominator, is likely to lose part of its relevance as a proxy for CBFS after 2008, with central banks' assets exceptionally skyrocketing. The sample period has the advantage of covering almost entirely the periods analyzed in Perera *et al.* (2013) and in Benecká *et al.* (2012), thus facilitating comparisons. Countries are first selected in function of the availability of the data for CBFS in the International Financial Statistics database of the IMF (IMF IFS henceforth) and in Bankscope. The countries using a foreign currency or belonging to a currency union are then removed insofar as in these countries central banks can generally not decide independently to ease their monetary policy if their individual financial situation deteriorates, thus certainly making the link between CBFS and inflation either inexistent or very different from the link in other countries. By doing so[26], I chose a different approach from Klüh and Stella (2009), Benecká *et al.* (2012) and Perera *et al.* (2013), where the formers included many Euro area countries and the latter included Germany, but a similar approach to the one of Adler *et al.* (2012), who only selected economies with "some degree" of exchange rate flexibility when studying the link between CBFS and interest rates. Other adjustments are carried out in order to make the sample homogeneous [27].

3.5: Estimator

To estimate the coefficients in (2), the System GMM method (see Appendix 4) appears to be the most relevant method for our case. In contrast with the Within-Group estimation method,

[26] This makes us exclude from the sample the European countries using the Euro, Saint Kitts and Nevis, the African countries members of the CFA (Colonies Francaises d'Afrique) Franc zone, and the countries belonging to the Common Monetary Area in the South African region (South Africa, Lesotho, Swaziland and Namibia).

[27] I remove the observations which can naturally be considered as outliers and bias the estimates and the conclusions: the hyperinflationary observation for Belarus in 1999, where inflation reached 293%; observations for "Dominican Republic" and "Costa Rica", as these 2 central banks suffered from unusually severe problems (Stella and Lonnberg, 2008) and have CBFS values in the sample sometimes going below -100%; Serbia is ignored because it split during the sample period. I chose to keep a panel as balanced as possible in order to have a number of observations roughly similar when splitting the sample, therefore countries for which only few observations (less than 5) are available are not included.

System GMM allows us to take into account dynamic despite the small T-dimension and to deal with the potential endogeneity of the regressors (Roodman, 2009a). In comparison with the alternative Difference GMM approach, it is expected to produce more precise estimates when the dependent variable exhibits a high degree of persistency (Blundell and Bond, 1998), what could be assumed in our case (Calderon and Schmidt-Hebbel, 2008). The method is also employed in Benecká *et al.* (2012) and Perera *et al.* (2013).

With System GMM, I instrument CBFS1 in order to deal with the endogeneity of its contemporaneous values with inflation: inflation may impact CBFS, thus making the residuals u_{it-1} potentially correlated with the lag of CBFS in the "difference part" of the System GMM if the later if not instrumented. Similarly, the lag of inflation is treated as a pre-determined variable (i.e. influenced by the past shocks as u_{it-1} but not by the contemporaneous ones u_{it}). Other control variables are instrumented by themselves[28]. I use the two-step GMM procedure with Windmeijer correction as a baseline method as this method has been shown to perform better than the one-step GMM procedure in estimating coefficients and allows us to avoid any downward bias in the two-step standard errors (Roodman, 2009a, 2009b; Windmeijer, 2005). To avoid the large instrument problem (Roodman, 2009b) the number of instruments is limited first by using a collapsed instrument matrix (Roodman 2009a; 2009b). In addition, I also limit the number of instrumenting lags used in this way: I start by using one lag for the instrumented variables in each regression and then cautiously extend the number of lags used as instruments (starting by the variable of interest CBFS1) until the related test statistics indicate warning signals (taking at the maximum 3 lags). The tests used here are the Difference-in-Hansen test of exogeneity of instrument subsets, which tests separately for the validity of each instrument, the Hansen test of overidentification, which tests for the joint validity of the instrument set[29], and the Arellano and Bond (1991) test of second-order serial correlation in the differenced error terms.

In parallel I also perform Within-Group estimates as a robustness check and in order to compare the results with the ones of the previous studies. I use a cluster-robust variance/covariance matrix for the standard errors in order to correct for serial correlation and heteroscedasticity, a method particularly adapted when T is greater than 3 (Stock and Watson,

[28] Similar to Perera *et al.*. (2013) the control variables are lagged one year in order to limit potential endogeneity issues.

[29] As Roodman (2009a) explains, the usual Sargan statistic is inconsistent when one suspects nonsphericity in the errors, thus making the Hansen overidentification test superior to the Sargan test in such cases. Also, Roodman (2009a) notes that, in the context of System GMM, conventional significance levels of 0.05-0.10 are "liberal" and states that a p-value of 0.25 "should be viewed with concern". On the other hand, a p-value close to 1 is said to suggest that the number of instruments is too high, making the test unreliable. Accordingly when possible I select the number of lags so that the p-value of the Hansen test lies between 0.3 and 0.9 (threshold arbitrarily fixed).

2006). I do not include the lag of inflation here to avoid the resulting bias (Nickell, 1981) and thus expect a downward bias in the CBFS coefficient estimates given the assumed positive impact of inflation on both CBFS and future inflation.

4. Baseline Results

4.1: General estimation not taking into account conditionality (model (1))

I first perform estimations for the whole sample, in effect estimating the coefficients of model (1), which I repeat here for convenience:

$$\mathrm{Y_{i,t}} = \alpha \mathrm{Y_{i,t-1}} + \beta X_{\mathrm{i,t}} + \delta\ \mathrm{CBFS1}_{i,t-1} + \mathrm{v_i} + \mathrm{u_{i,t}} \quad (1)$$

Column 1 and 2 of Table 1 report the results. As it can be seen, no significant effect is detected for CBFS1. The same statement holds with the log specification of Perera *et al.* (2013) or with fewer instrumenting lags[30]. The general result of Perera *et al.* (2013) therefore doesn't hold in my sample. In contrast the results go in the same direction as the result of Benecká *et al.* (2012): CBFS doesn't seem to be relevant to maintain price stability under general conditions.

The outcome is similar when we consider only advanced, emerging or developing economies, using the classification of IMF (2010). As Table 1 shows, CBFS1 remains non significant in each case. In Appendix 2 I also repeated the approach of Perera *et al.* (2013) to test for a link in countries with fixed exchange rate regime and countries where the central bank has a low level of independence: in no case do I find any significant effect of CBFS on inflation.

Control variables enter significantly in most of the regressions and with the expected sign, with the exception of the trend and GDP per capita, probably due to the fact that these two variables may capture many different factors in link with inflation. Inflation appears persistent, and the impact of currency crisis as well as oil price moves on inflation appears evident in all estimates. Because controls are not a focal point here I will not comment further in the rest of the paper.

[30] Results are available on request.

Table 1: Central Bank Financial Strength and inflation: baseline, groups of countries with similar level of economic development, Within-Group and System GMM estimates

	Full sample		Advanced countries		Emerging countries		Developing countries	
	Within-Group	SGMM (1-2)	Within-Group	Syst GMM	Within-Group	Syst GMM	Within-Group	Syst GMM
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
INF_{t-1}	-	0.5456***	-	0.1896	-	0.6294***	-	0.4978***
		(0.0782)		(0.2793)		(0.1183)		(0.1025)
$CBFS1_{t-1}$	**0.0546**	**-0.0369**	**0.0063**	**0.0541**	**0.1783**	**-0.0402**	**-0.0244**	**-0.0535**
	(0.0515)	**(0.0325)**	**(0.0120)**	**(0.0363)**	**(0.1258)**	**(0.0275)**	**(0.0344)**	**(0.0518)**
GDP_PC_{t-1}	0.0004	-0.0004*	0.0017**	-0.0004	-0.0037	0.0001	0.0024	-0.0001
	(0.0015)	(0.0002)	(0.0006)	(0.0006)	(0.0077)	(0.0006)	(0.0021)	(0.0004)
GAP_{t-1}	0.1235**	0.1068**	0.2067***	0.3358***	0.1500	0.0398	0.1096*	0.1350*
	(0.0616)	(0.0455)	(0.0573)	(0.0977)	(0.1671)	(0.0365)	(0.0583)	(0.0701)
$CRIS_t$	0.0799***	0.1021***	0.0478***	0.0567***	0.0741	0.0806***	0.0903***	0.1139***
	(0.0227)	(0.0170)	(0.0020)	(0.0082)	(0.0522)	(0.0246)	(0.0240)	(0.0252)
OIL_g_t	0.0010***	0.0007***	0.0003***	0.0006***	0.0012***	0.0009***	0.0010***	0.0007***
	(0.0002)	(0.0002)	(0.0001)	(0.0001)	(0.0003)	(0.0003)	(0.0002)	(0.0002)
$TREND_t$	-0.0001	0.0022***	-0.0018*	0.0007	-0.0006	0.0011	0.0012	0.0031***
	(0.0014)	(0.0005)	(0.0010)	(0.0013)	(0.0035)	(0.0008)	(0.0014)	(0.0007)
Constant	0.0472***	0.0167***	0.0409***	0.0147**	-0.0213	0.0120	0.0823*	0.0100
	(0.0137)	(0.0060)	(0.0149)	(0.0062)	(0.0123)	(0.0102)	(0.0454)	(0.0136)
Number of observations	792	789	140	140	206	205	446	444
Hansen test (pvalue)	-	0.452	-	0.159	-	0.811	-	0.208
AR(2) test (pvalue)	-	0.901	-	0.090	-	0.577	-	0.479

Notes: the dependent variable is the rescaled measure of the inflation rate $d = \pi / (1 + \pi)$, where π is the rate of change of CPI; INF_{t-1} refers to the lag of the dependent variable; CBFS1 is Central Bank Financial Strength, measured by (capital + OIN) scaled by total assets; GDP_PC is the GDP per Capita at Purchasing Power Parity; GAP is the output gap; CRIS is a dummy variable taking the value of 1 when a currency crisis occurs; OIL_g is the growth rate of the average price of oil; TREND is the trend. Within-Group estimates use a cluster variance/covariance standard errors matrix robust to heteroscedasticity and serial correlation. System GMM estimates are performed using the two-step Windmeijer correction procedure, robust to heteroscedasticity and serial correlation, where INF and CBFS1 are treated as exogeneous. In (x-y), x corresponds to the number of lags instrumenting INF_{t-1} and y corresponds to the number of lags instrumenting $CBFS1_{t-1}$. Hansen test corresponds to the test of overidentifying restriction which tests for the joint validity of instruments. AR(2) test corresponds to the autocorrelation test developed by Arellano and Bond (1991) which tests for the absence of serial correlation of order 2 in the first-difference residuals. Statistical significance levels are based upon t-stats. * Statistical significance at 10% level ** Statistical significance at 5% level *** Statistical significance at 1% level

4.2: Estimation taking into account the conditionality on fiscal support (model (2))

I now logically implement the approach at the core of this paper. That is, I take into account the conditional nature of the link by estimating model (2), which I repeat here for convenience:

$$\mathrm{Y}_{\mathrm{i,t}} = \alpha \mathrm{Y}_{\mathrm{i,t-1}} + \beta X_{\mathrm{i,t}} + \delta_N \left(\mathrm{I}_{\mathrm{i}}^{\mathrm{N}} * \mathrm{CBFS1}_{\mathrm{i,t-1}}\right) + \mathrm{v}_{\mathrm{i}} + \mathrm{u}_{\mathrm{i,t}} \quad (2)$$

Table 2 presents the results, first for the countries with no *de jure* fiscal support (Columns 1 and 2) and then for the countries with no *de facto* fiscal support, as proxied in turn with "Low Sovereign rating" (Column 3 and 4), "High Debt-to-GDP" (Column 5 and 6), "High Debt-to-revenues" (Column 6 and 7). No link arises where there is no *de jure* fiscal support. The coefficient enters even with a positive sign, opposite from what we could expect. In contrast, clearly a link arises in the context of no *de facto* fiscal space. For each estimation technique and for each proxy considered for low fiscal space, in each case weaker central bank finances (lower value of CBFS1) are associated with higher inflation. As expected, System GMM estimates lead to coefficients of higher magnitude than Within-Group estimates, indicating that the theoretical downward bias in Within-Group regressions discussed in section 3 might be important in practice. Control variables appear once again relevant in most cases.

Next sections tests for the robustness of this result.

Table 2: Central Bank Financial Strength and inflation: no *de jure* and no *de facto* fiscal support, Within-Group and System GMM estimates

	N = no *de jure* fiscal support (Legal indicator)		N = no potential *de facto* fiscal support (Sovereign Rating)		N = no potential *de facto* fiscal support (Debt / GDP)		N = no potential *de facto* fiscal support (Debt / Revenue)	
	Within-Group	SGMM (1-2)	Within-Group	SGMM (2-2)	Within-Group	SGMM (2-2)	Within-Group	SGMM (2-2)
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
INF_{t-1}	-	0.5379***	-	0.5287***	-	0.5129***	-	0.5138***
		(0.0600)		(0.0676)		(0.0682)		(0.0665)
I_i^N*CBFS1 $_{t-1}$	**0.1614**	**0.0782**	**-0.1340*** **	**-0.2635*** **	**-0.1608** **	**-0.2972** **	**-0.1237** **	**-0.2621*** **
	(0.1025)	**(0.0513)**	**(0.0451)**	**(0.0728)**	**(0.0614)**	**(0.1158)**	**(0.0553)**	**(0.0777)**
GDP_PC_{t-1}	0.0006	-0.0007***	0.0002	-0.0007***	0.0003	-0.0006***	0.0003	-0.0007***
	(0.0015)	(0.0003)	(0.0016)	(0.0002)	(0.0016)	(0.0002)	(0.0016)	(0.0002)
GAP_{t-1}	0.1220*	0.1130***	0.1168*	0.1070**	0.1186*	0.1152***	0.1152*	0.1029**
	(0.0652)	(0.0416)	(0.0624)	(0.0420)	(0.0621)	(0.0432)	(0.0616)	(0.0415)
$CRIS_t$	0.0814***	0.0896***	0.0789***	0.0951***	0.0786***	0.0925***	0.0788***	0.0927***
	(0.0230)	(0.0187)	(0.0212)	(0.0147)	(0.0203)	(0.0148)	(0.0212)	(0.0149)
OIL_g_t	0.0010***	0.0008***	0.0009***	0.0007***	0.0009***	0.0007***	0.0009***	0.0007***
	(0.0002)	(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0002)	(0.0001)
$TREND_t$	0.0002	0.0026***	-0.0001	0.0025***	-0.0003	0.0021***	-0.0002	0.0023***
	(0.0014)	(0.0006)	(0.0015)	(0.0004)	(0.0015)	(0.0005)	(0.0015)	(0.0005)
Constant	0.0335**	0.0084	0.0509***	0.0171***	0.0499***	0.0188***	0.0501***	0.0193***
	(0.0152)	(0.0051)	(0.0151)	(0.0051)	(0.0150)	(0.0055)	(0.0149)	(0.0051)
Number of observations	792	789	792	789	792	789	792	789
Hansen test (pvalue)	-	0.654	-	0.623	-	0.444	-	0.574
AR(2) test (pvalue)	-	0.809	-	0.997	-	0.959	-	0.989

Notes: see Table 1. I_i^N is a dummy variable taking the value of 1 if the country shares the characteristic N, 0 otherwise.

5. Robustness checks

5.1: Alternative estimation methods

In this subsection I check the robustness of the result to alternative estimation methods, using in turn one-step System GMM and Difference GMM methods.

I first check the robustness of the results to the one-step System GMM method, using the same method as before to select the optimal number of instrumenting lags. Results are displayed in Table 3. The coefficients as well as their standard errors broadly remain similar: the results do not appear dependent upon the two-step method choice.

It is important to notice that the coefficients, in particular the coefficient for CBFS1, are not affected by the specific moment conditions related to the "level part" of the System GMM (see Appendix 4). To see whether or not this is the case, I perform the same estimates as the initial ones (two-step method with Windmeijer correction) with a Difference-GMM estimator. As it can be seen on Table 3, the coefficient estimates for CBFS1 remain quite similar and, although their standard errors got logically larger in almost every case, they remain all significant at the 5% threshold.

Table 3: Central Bank Financial Strength and inflation: no *de facto* fiscal support case, one-step System GMM and Difference GMM estimates:

	N = no potential *de facto* fiscal support (Sovereign Rating)		N = no potential *de facto* fiscal support (Debt / GDP)		N = no potential *de facto* fiscal support (Debt / Revenue)	
	SGMM (1-1) one-step (1)	Diff GMM (2-2) (2)	SGMM (1-2) one-step d (4)	Diff GMM (2-2) (5)	SGMM (1-2) one-step d (7)	Diff GMM (2-2) (8)
INF_{t-1}	0.5844***	0.5531***	0.5539***	0.5408***	0.5754***	0.5477***
	(0.0775)	(0.0648)	(0.0787)	(0.0717)	(0.0747)	(0.0645)
$\mathbf{I_i^N}$*CBFS1 $_{t-1}$	**-0.2550*** **	**-0.2542*** **	**-0.2153** **	**-0.2735** **	**-0.2387*** **	**-0.2329** **
	(0.0823)	**(0.0820)**	**(0.0974)**	**(0.1315)**	**(0.0889)**	**(0.0896)**
GDP_PC $_{t-1}$	-0.0006**	-0.0018*	-0.0006***	-0.0016	-0.0006***	-0.0017*
	(0.0002)	(0.0011)	(0.0002)	(0.0010)	(0.0002)	(0.0010)
GAP $_{t-1}$	0.1258***	0.2223***	0.1262***	0.2148***	0.1239***	0.2170***
	(0.0444)	(0.0590)	(0.0439)	(0.0625)	(0.0432)	(0.0598)
CRIS $_t$	0.0889***	0.0792***	0.0884***	0.0791***	0.0889***	0.0804***
	(0.0186)	(0.0173)	(0.0182)	(0.0175)	(0.0182)	(0.0180)
OIL_g $_t$	0.0006***	0.0006***	0.0006***	0.0006***	0.0006***	0.0006***
	(0.0002)	(0.0001)	(0.0001)	(0.0001)	(0.0002)	(0.0001)
TREND $_t$	0.0026***	0.0045***	0.0022***	0.0044***	0.0024***	0.0046***
	(0.0005)	(0.0009)	(0.0005)	(0.0009)	(0.0005)	(0.0009)
Constant	0.0137**	-	0.0143**	-	0.0147**	-
	(0.0062)		(0.0056)		(0.0060)	
Number of observations	789	707	789	707	789	707
Hansen test (pvalue)	0.413	0.886	0.320	0.293	0.730	0.353
AR(2) test (pvalue)	0.993	0.961	0.963	0.884	0.972	0.804

Notes: see Table 1 and 2.

5.2: Alternative controls

In this section I check the robustness of the result robust to other econometric specifications. In particular, I control for additional *ad hoc* variables which may become relevant for no *de facto* fiscal support countries (central bank independence and government deficit) and which could be relevant here but are available for less countries (nominal effective exchange rate).

I first perform robustness checks by controlling explicitly for central bank independence (CBI). I didn't include this variable in a first stage because of the potential important problems that such a time-invariant variable could create in System GMM regressions, given that it is potentially correlated with the fixed effects[31]. Because weak balance sheets have sometimes been the result of government interferences with the monetary institution (Klüh and Stella, 2008; Muñoz, 2007; Hawkins, 2003) while independence is expected to matter for inflation, it can however be important to control for this factor. I therefore include a variable for central bank independence, CBI, in the regressions, and logically use the same number of lags as before when instrumenting the variables. Central bank independence is proxied here by the turnover index[32]. On the grounds that less independent central bank governors can be fired more easily (Cukierman *et al.*, 1992), a higher turnover rate should be associated with lower independence, and thus with higher inflation. Results are displayed in Table 4. In almost each of the regression CBI enters significantly and with the expected positive sign: lower independence implies higher inflation. The CBFS1 coefficient is only slightly affected by the inclusion of CBI: its value slightly decreases each time in comparison with the estimates in Table 2 and the associated standard errors mostly slightly decrease.

Given that the core result is based on a sample in which countries with low structural fiscal space were selected, I control for the fiscal surplus / deficit for these estimates to see whether fiscal considerations played a role in these results. I naturally treat this variable as endogeneous. As we can see in Table 4, the results are robust when we control for the stance of fiscal policy, which even enters significantly in the regressions (Columns 3, 6 and 9). The effect of CBFS on inflation thus doesn't seem to be due to any omitted fiscal consideration[33].

[31] Including a time-invariant variable such as CBI can be problematic in System GMM regressions if the cross-country moves of CBI are correlated with the fixed effects (see Appendix 4).

[32] I use the turnover index as it has been shown to be more relevant for non-advanced economies than a legal index (Cukierman *et al.*, 1992), and non-advanced economies are in majority in my sample. In addition, legal index public data I could find were only available for 60 out of the 82 countries of the sample (Crow-Meade index for year 2003). I compute the turnover index on 14 years (1996-2009), corresponding to the length of two seven-years mandates, from the database of Dreher *et al.* (2010).

[33] Separately I also performed regressions including an interaction term between the government surplus / deficit and CBFS1, to see whether the relationship I obtained would reflect a broader context of integrated budget constraint of the central bank

In addition, I control for exchange rate developments, more specifically for the percentage change in the nominal effective exchange rate (quoted at the "certain" method). Exchange rates may have a direct impact on inflation through imported products and may also have an impact on the central bank balance sheet, thus making it relevant here. This variable was not included before as it is available for fewer countries in our database (69) and only since 1999 from the World Bank[34]. Including it in the model shows exchange rates changes are indeed relevant for inflation (it enters significantly and with the expected sign) but this does not result in any loss of significance for the coefficient of CBFS (Columns 3, 6 and 9).

I also include time dummies instead of OIL_g and TREND in the System GMM estimates in order to better capture contemporaneous cross-sectional dependence. In the estimates I consistently include the same number of lags as before. Results are displayed in Table A9 (Appendix 2). The coefficients for CBFS1 are only slightly affected by the inclusion of time dummies, being now always significant at the 1% threshold. Results are thus unchanged.

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and the Treasury (see Del Negro and Sims (2015) for a discussion). Interaction terms were not significant while not affecting the results, suggesting that the effect of CBFS I obtain here is distinct from any potential consolidated budget consideration.

[34] We are not aware of any database which would cover more countries than the World Bank database (169 countries). The BIS database for example only covers about 70 countries, while the IMF IFS database covers 101 countries. Initially, a specification with the exchange rate change vis-à-vis the dollars was also tested (including more countries but being less relevant), but the coefficient associated with this variable was most of the time not clearly significant.

Table 4: Central Bank Financial Strength and inflation: no *de facto* fiscal support case, estimates with Central Bank Independence / Government Deficit / Exchange Rates

	N = no potential *de facto* fiscal support (Sovereign Rating)			N = no potential *de facto* fiscal support (Debt / GDP)			N = no potential *de facto* fiscal support (Debt / Revenue)		
	SGMM (2-2)	SGMM (2-2)	SGMM (2-2)	SGMM (2-2)	SGMM (2-2)	SGMM (1-1)	SGMM (2-2)	SGMM (1-1)	SGMM (1-1)
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
INF_{t-1}	0.4704***	0.4742***	0.2611**	0.4753***	0.4767***	0.2267**	0.4820***	0.4814***	0.2508**
	(0.0650)	(0.0500)	(0.0988)	(0.0671)	(0.0504)	(0.0950)	(0.0645)	(0.0459)	(0.1112)
$\mathbf{I_i^N}$***CBFS1** $_{t-1}$	**-0.2486*** **	**-0.2081** **	**-0.2156*** **	**-0.3363*** **	**-0.3067*** **	**-0.2347*** **	**-0.2574*** **	**-0.2514*** **	**-0.2091*** **
	(0.0832)	**(0.1036)**	**(0.0708)**	**(0.0969)**	**(0.0927)**	**(0.0645)**	**(0.0906)**	**(0.0825)**	**(0.0593)**
GDP_PC_{t-1}	-0.0007**	-0.0005*	-0.0008*	-0.0007**	-0.0004	-0.0006	-0.0007**	-0.0004	-0.0006
	(0.0003)	(0.0003)	(0.0005)	(0.0003)	(0.0003)	(0.0004)	(0.0003)	(0.0003)	(0.0004)
GAP_{t-1}	0.1194**	0.1367**	0.2029**	0.1186**	0.1378**	0.2009**	0.1080**	0.1156**	0.2036**
	(0.0550)	(0.0610)	(0.0868)	(0.0548)	(0.0581)	(0.0840)	(0.0523)	(0.0546)	(0.0870)
$CRIS_t$	0.0811***	0.0747***	0.0849***	0.0803***	0.0829***	0.0839***	0.0828***	0.0824***	0.0880***
	(0.0139)	(0.0148)	(0.0147)	(0.0106)	(0.0131)	(0.0149)	(0.0124)	(0.0139)	(0.0184)
OIL_g_t	0.0007***	0.0007***	0.0006***	0.0007***	0.0006***	0.0006***	0.0007***	0.0006***	0.0006***
	(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0002)	(0.0001)	(0.0001)
$TREND_t$	0.0027***	0.0031***	0.0031***	0.0022***	0.0028***	0.0030***	0.0023***	0.0030***	0.0030***
	(0.0004)	(0.0004)	(0.0006)	(0.0005)	(0.0005)	(0.0007)	(0.0005)	(0.0005)	(0.0007)
CBI_t	0.0696**	0.0553	0.0630**	0.0896***	0.0709**	0.0674**	0.0725**	0.0578**	0.0625**
	(0.0305)	(0.0354)	(0.0291)	(0.0336)	(0.0340)	(0.0307)	(0.0300)	(0.0280)	(0.0292)
DEF_{t-1}	-	-0.0010**	-0.0010	-	-0.0013***	-0.0012	-	-0.0014***	-0.0012
		(0.0004)	(0.0006)		(0.0005)	(0.0007)		(0.0005)	(0.0007)
$EXCH_{t-1}$	-	-	-0.0847***	-	-	-0.0920***	-	-	-0.0859***
			(0.0190)			(0.0210)			(0.0205)
Constant	0.0059	0.0014	0.0133	0.0058	-0.0027	0.0108	0.0080	-0.0007	0.0119
	(0.0066)	(0.0057)	(0.0088)	(0.0073)	(0.0065)	(0.0093)	(0.0068)	(0.0061)	(0.0096)
Number of observations	751	713	572	751	713	572	751	713	572
Hansen test (pvalue)	0.228	0.516	0.546	0.293	0.683	0.275	0.353	0.786	0.250
AR(2) test (pvalue)	0.857	0.635	0.778	0.873	0.559	0.905	0.800	0.532	0.759

Notes: see Table 1. CBI_I is central bank independence proxied by the central bankers' turnover rate, DEF_{I-1} is the government surplus/deficit, $EXCH_{I-1}$ is the percentage change in the nominal effective exchange rate. In (x-y), x now corresponds to the number of lags instrumenting INF_{t-1}, DEF_{I-1} and $EXCH_{I-1}$.

5.3: Is low fiscal space really the key characteristic behind the observed link?

Are there other characteristics correlated with "low fiscal space" which could explain the empirical link observed between CBFS and inflation? I discuss and rule out some other possibilities below.

Until now I have assumed that *de facto* fiscal support depends on the availability of extra resources from the Treasury. Another potential argument which could be advanced is that the country's institutional context determines *de facto* fiscal support. The institutional quality, and in particular the credibility of the government's commitments, could be suspected to play a role. If the proxy for the absence of *de facto* fiscal support is correlated with institutional quality, I would still be able to conclude on the key role of the absence of *de facto* fiscal support but not be able to identify exactly which factor causes this absence. To tackle this question, I build an index to indentify the governments with low commitment credibility. I use the Government Effectiveness Index of the Word Bank, which proxies in particular for the credibility of governments' commitments, and build an index taking the value of "1" when the average value on my sample period exceeds the 75% quartile value (low commitment credibility), 0 otherwise. The correlation between this variable and the dummy for the absence of *de facto* fiscal support is 44%. I then use this newly built dummy instead of I_i^N in model (2) and run the baseline regressions. The results (Table A7) do not indicate that low credibility of governments' commitments is a conditional factor lying behind the empirical link between CBFS and inflation: in none of the regressions the coefficient for CBFS is significant.

Until now I have assumed that the likelihood of *de facto* fiscal support was dependent on the Treasury's behavior. It could be the case however that *independent* central banks would not be willing to rely on the Treasury support, even if the latter is present, if the institution judges that doing so would put its independence at risk. In this case, we could also see a link between CBFS and inflation in countries with *independent* central banks. If the proxy for *de facto* potential absence of fiscal support also captures central bank independence, I could then not distinguish between the above channel and the effect of the absence of fiscal support. I show this is not the case in the same way as before. First, I build a dummy variable taking the value of "1" when the central bank can clearly be said to be "independent" using the same methodology as before (thus using the 75% quartile value for CBI as a threshold to infer independence), 0 otherwise. The correlation between this variable and the dummy for the absence of *de facto* fiscal support is only 4%, making it clear that the dummy for the absence of fiscal support is not capturing central bank independence. Using this newly built dummy instead of I_i^N in model (2) and running the baseline regressions, I find mixed support for the relevance of central bank independence (Table A7)[35]. One out of the two regressions gives a significant coefficient for CBFS, but the result disappears with a time dummy specification (Table A9).

5.4: Is the CBSF variable a proxy for other variables?

Does the CBFS variable proxy for something else? As a balance-sheet indicator, it could be the case that the variable for CBFS proxies for other variables important for inflation, for example base money. My results, tough, cannot be explained unless the CBFS indicator is strongly correlated with such variables and the absence of fiscal support proxies for the relevance of such central bank balance sheet variables for inflation. I rule out such possibilities below.

First, I perform estimates to control for a base money factor. The estimates, including in turn base money growth (BM_g) and the ratio of base money to total assets (BM_ta), didn't lead to changes in the key result (Table A8). The precision of the coefficients for CBFS1 was actually even slightly improved with the addition of this extra control in some cases.

Second, I use the alternative indicator for CBFS discussed in subsection 3.1: the average net income of the central bank over the last 3 years scaled by nominal GDP (CBFS2). Taking an average on 3 years allows us to diminish the problems posed by peculiar accounting rules when it comes to profit calculations, but comes at the price of breaking the independence between observations. This indicator is available for less countries than CBFS1 (68 versus 82) and with fewer data per country but gives us a unique opportunity to see whether our results are dependent on the indicator used. As we can see on Table 5, CBFS2 also appears as significant and with the expected sign in the context of low fiscal space: decreases in central bank profitability are associated with higher inflation. Only when sovereign rating is used as a proxy the CBFS coefficient does not appear significant, but the coefficient is quite similar and clearly significant when we consider the net income over GDP (income) on the past year instead of a moving average (Column 2), making it arguable than the averaging in itself and its consequences (loss of independence between observations) played a role in this result.

[35] Separately I performed the same estimates with the Crow-Meade legal indicator of independence: in none of the estimates was the coefficient for CBFS significant.

Table 5: Central Bank Financial Strength and inflation: no *de facto* fiscal support case, robustness checks estimates with the alternative indicators CBFS2 / net income

	N = no potential *de facto* fiscal support (Sovereign Rating)		N = no potential *de facto* fiscal support (Debt / GDP)		N = no potential *de facto* fiscal support (Debt / Revenue)	
	SGMM (3-3)	SGMM (2-2)	SGMM (1-1)	SGMM (1-1)	SGMM (3-3)	SGMM (3-3)
	(1)	(2)	(3)	(4)	(5)	(6)
INF_{t-1}	0.5636***	0.5314***	0.5780***	0.6065***	0.5648***	0.6037***
	(0.0781)	(0.0696)	(0.0650)	(0.0814)	(0.0641)	(0.0973)
I_i^N*CBFS2 $_{t-1}$	**-0.0032**	-	**-0.0030*** **	**-0.0038*** **	**-0.0034** **	**-0.0043** **
	(0.0163)		**(0.0010)**	**(0.0013)**	**(0.0016)**	**(0.0021)**
I_i^N*income $_{t-1}$	-	**-0.0011** ** **(0.0004)**	-	-	-	-
GDP_PC $_{t-1}$	-0.0007***	-0.0007***	-0.0007***	-0.0006***	-0.0007***	-0.0007***
	(0.0002)	(0.0002)	(0.0002)	(0.0002)	(0.0002)	(0.0002)
GAP $_{t-1}$	0.1637***	0.1211***	0.1682***	0.2669***	0.1570***	0.2616***
	(0.0518)	(0.0435)	(0.0529)	(0.0691)	(0.0523)	(0.0831)
CRIS $_t$	0.0725***	0.0926***	0.1006***	0.1051***	0.0861***	0.0746***
	(0.0172)	(0.0201)	(0.0214)	(0.0256)	(0.0121)	(0.0184)
OIL_g $_t$	0.0011***	0.0009***	0.0012***	0.0011***	0.0011***	0.0011***
	(0.0002)	(0.0001)	(0.0002)	(0.0002)	(0.0002)	(0.0002)
TREND $_t$	0.0006	0.0021***	0.0001	0.0001	0.0003	0.0002
	(0.0007)	(0.0005)	(0.0007)	(0.0007)	(0.0007)	(0.0008)
CBI $_t$	-	-	-	-0.0079	-	0.0049
				(0.0234)		(0.0253)
DEF $_{t-1}$	-	-	-	-0.0011*	-	-0.0008
				(0.0006)		(0.0009)
Constant	0.0227***	0.0147***	0.0264***	0.0228***	0.0257***	0.0218***
	(0.0060)	(0.0045)	(0.0059)	(0.0064)	(0.0062)	(0.0067)
Number of observations	533	685	533	506	533	506
Hansen test (pvalue)	0.509	0.668	0.883	0.271	0.837	0.202
AR(2) test (pvalue)	0.195	0.486	0.969	0.379	0.163	0.435

Notes: see Table 1 and 2. CBI $_t$ is central bank independence proxied by the central bankers' turnover rate, DEF $_{t-1}$ is the government surplus/ deficit. CBFS2 $_{t-1}$ is central bank financial strength proxied by the average on (t-1) (t-2) and (t-3) of the net income (income) of the central bank scaled by GDP. In (x-y), x now corresponds to the number of lags instrumenting both INF_{t-1} and DEF $_{t-1}$.

6. Conclusion

I develop a new approach in this paper to investigate whether impairments in the financial situation of a central bank have an influence on inflation, conditional on the absence of fiscal support. In doing so, the paper first aims at finding out whether a link can arise when fiscal support is absent, and second at finding an explanation for the conflicting results of the previous studies.

Using a large and consistent sample of 82 countries, the results first suggest that central bank financial strength doesn't always matter for inflation. Testing then for a link conditional on the absence of fiscal support, I find that weaker central bank finances induce higher inflation when fiscal support is arguably absent. *De facto* potential absence of fiscal support, defined as the context in which it is arguable that fiscal support will likely not arise because of weak government finances, appears to be the only relevant context for a link between CBFS and inflation to arise. *De jure* absence of fiscal support, which I measure creating a new database on the absence of fiscal support guarantee in the central bank law, does not appear relevant here for a link between CBFS and inflation to arise.

My results provide an explanation for the apparent inconsistency of the results of the previous studies, to the extent that past significant results rely on samples containing many countries where potential fiscal support was arguably absent. The non-refuted empirical result of Klüh and Stella (2008) for example is based upon a sample of Latin American countries and covers the end of the 20th century, a period in which these countries were clearly known for their weak fiscal balances (Collyns and Kincaid, 2003). Moreover, Perera *et al.* (2013) found a relatively important effect of CBFS on inflation in samples in which several countries which arguably had low fiscal space were included.

A critical contribution of this paper is to give empirical grounds to the recent theoretical works emphasizing the relevance of the fiscal support for central bank balance sheet impairments not to result into higher inflation. From a policy perspective, this means that central banks for which fiscal support is likely to be absent should particularly try to avoid large impairment of their balance sheet if they are willing to support a low inflation outcome. Policies containing a particular level of inherent risk should accordingly be weighted consistently *ex ante*. Improving the understanding of the public, political as well as financial actors on the subject of CBFS could also help alleviating the –possibly unwarranted- worries of such actors, thereby indirectly promoting low inflation. Also, as previously pointed out by

Sweidan and Widner (2008), the benefits of central bank transparency should be appropriately weighed against the potential costs of balance sheet concerns.

My analysis also emphasizes the need for further research on CBFS and its interaction with monetary policy. Further work on CBFS measures is needed to improve empirical investigations. The lack of alternative indicators for CBFS is indeed probably the main limit of my analysis and that of previous studies. In addition, all the current studies focus on the impact of CBFS considering CBFS as it appears *ex-post* on the balance sheet. A useful complementary approach would be to look at the potential impacts of CBFS on policy decisions from an *ex-ante* perspective with alternative indicators. Further measures would also maybe help analyze non-linearities in the intensity of the effect of CBFS, for which we didn't find any evidence here but could nonetheless be relevant. It would also be interesting to look deeper at agents' anticipations towards CBFS, especially at the current time of unconventional monetary policies triggering numerous debates on the risks of losses (Del Negro and Sims, 2015; Benigno and Nisticò, 2015; Hall and Reis, 2015). These issues appear as important areas for future research.

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APPENDIX

Appendix 1: variables and statistics

Variable	Description	Source
***<u>CBFS variable</u>* (CBFS1 = Capital+OIN / total assets; CBFS2 = average net income / GDP)**		
Capital + OIN	"Shares and Other equities" + "Other Items Net"	IMF IFS database
Total assets	"Total assets"	Bankscope Bureau van Dijk database, central banks' websites[36]
Central bank net income	"Net income" of the central bank at the end of the calendar year (in millions)	Bankscope Bureau van Dijk database, central banks' websites[49]
GDP (scaling variable)	Gross domestic product, current prices in national currency (in billions)	IMF IFS database
<u>Control variables</u>		
GDP_PC	Gross domestic product based on purchasing-power-parity (PPP) per capita GDP, current international dollar (in thousands)	IMF IFS database
GAP	Cyclical component of Real GDP (%), as measured by the residuals of the regression of Real GDP (GDP, constant local currency units) on a trend normalized by the corresponding fitted values.	World Bank World Development Indicators database
OIL_g	West Texas Intermediate crude oil spot average annual price (growth rate)	Energy information Administration

[36] I take data on central banks' websites when Bankscope data do not correspond to the end of the calendar year, when they correspond to data related to one department of the central bank only (*eg* for UK) or when data are not available on Bankscope. In case of misalignment, I also took the data on central banks websites (I didn't consider the observations in case I could not access the data).

CRIS	Currency Crisis (dummy taking the value of 1 if a crisis occurred, 0 otherwise)	Valencia and Laeven (2012)
CBI	De facto indicator of Central Bank Independence, based on the governors' turnover rate between 1996 and 2009 (computed from the database)	Dreher *et al.* (2010)
EXCH	Nominal effective exchange rate growth rate, computed from an index with 2000 as a base year. Exchange rates are weighted according to the intensity of the trade with the corresponding countries.	World Bank database
Variables used to split the sample and give a value to I_i^N:		
Fiscal Space	- Sovereign debt rating: average of the ratings on sovereign foreign currency debt provided by the three main rating agencies (Standard and Poor's, Moody's and Fitch). Each rating has been converted to a number ranging from 1 (best rating) to 17 (ranks after the "highly speculative" category, starting with CCC+ / Caa1).	- Afonso *et al.* (2009), completed and corrected by rating agencies' websites. Missing ratings have been generated through Mundlak-specification regressions, see Appendix 3.
	- Average of the Gross government debt scaled by GDP between 1998 and 2008	- See here-below
	- Average of the Gross government debt scaled by total general government revenue	- See here-below. General Government revenue is taken from the IMF IFS database
De jure absence of fiscal support	Dummy taking the value of 1 if there is no guarantee for fiscal support in the central bank law	Manual analysis of central bank laws. Central bank laws were accessed through central bank websites. In some cases Stella and Lönnberg (2008) observations were

		used.
Central Bank Independence	- Turnover index (CBI)	- Dreher *et al.* (2010)
	- Crowe-Meade Legal index measure for year 2003	- Crowe and Meade (2008)
Credibility of government's commitments	Government effectiveness index	World Bank Worldwide Governance Indicator database
Exchange rate regime	Dummy variable taking the value of 1 if the country has a fixed exchange rate (from no legal tender to managed float), 0 otherwise	Annual Report on Exchange Arrangements and Exchange Restrictions database (IMF), central banks websites
Data specific to sovereign ratings' estimates		
GDP_G	Annual percentage growth rate of GDP at market prices based on constant local currency	World Bank World Development Indicators
DEBT	Government gross debt in percent of GDP	IMF IFS database Data taken from the IMF Historical Public Debt database for Sri Lanka, Tonga, Mongolia
DEF	General Government net lending / borrowing in percent of GDP	IMF IFS database
GOVEFF	Government effectiveness index	World Bank Worldwide Governance Indicator database
SCRIS	Sovereign crisis dummy	Valencia and Laeven (2012)
RES	Foreign reserves and gold scaled by total exports	Computed from: total reserves including gold in dollars (World Bank), exports of good and services in percent of GDP (World Bank) and Gross Domestic Product current prices in dollars (IMF IFS database)

Table A1: Descriptive statistics and correlations (full sample, regressors)

Variables	Descriptive statistics					Correlation coefficients								
	N. of obs	Mean	S.d.	Min	Max	INF	CBFS1	CBFS2	GDP_PC	GAP	CRIS	OIL_g	CBI	DEF
INF	898	0.062	0.06	-0.09	0.63	1.00								
CBFS1	872	0.095	0.15	-0.44	0.59	-0.08	1.00							
CBFS2	604	0.135	0.56	-1.79	6.30	0.05	0.11	1.00						
GDP_PC	901	12.147	12.96	0.43	77.08	-0.26	0.32	-0.10	1.00					
GAP	901	0.002	0.06	-0.25	1.02	0.02	-0.03	-0.04	0.00	1.00				
CRIS	902	0.020	0.14	0.00	1.00	0.20	0.05	0.01	-0.05	-0.03	1.00			
OIL_g	820	8.525	8.23	-4.43	27.33	0.07	-0.09	-0.01	0.14	0.05	-0.11	1.00		
CBI	858	0.159	0.09	0.00	0.43	0.15	-0.02	0.09	-0.20	-0.01	0.13	0.00	1.00	
DEF	853	-0.961	5.91	-23.63	43.30	-0.06	0.19	-0.14	0.44	0.03	-0.05	0.17	-0.19	1.00

Notes : INF is the rescaled measure of the inflation rate d = $\pi / (1 + \pi)$, where π is the rate of change of CPI ; CBFS1 is the Central Bank Financial Strength measured by (capital + OIN) over total assets ; CBFS2 is the Central Bank Financial Strength measured by the average of central bank net income scaled by GDP over the last 3 years ; GDP_PC is the GDP per Capita at Purchasing Power Parity ; GAP is the output gap ; CRIS is a dummy variable taking the value of 1 when a currency crisis occurs, 0 otherwise ; OIL_g is the growth rate of the average price of oil (WTI crude oil); CBI is central bank independence proxied by the central bankers' turnover rate between 1996-2009; DEF is the government surplus/ deficit. All variables are yearly; contemporaneous correlations are displayed.

Table A2: Descriptive statistics and correlations (full sample, variables used to split the sample)

	Descriptive statistics					Correlation coefficients						
	N. of obs	Mean	S.d.	Min	Max	LAW	RATING	DEBT_GDP	DEBT_REV	CBI	CBI_leg	GOV_cred
LAW	902	0.451	0.50	0.00	1.00	1.00						
RATING	902	10.692	4.67	1.00	17.80	-0.31	1.00					
DEBT_GDP	902	54.551	32.61	5.80	165.82	-0.00	0.27	1.00				
DEBT_REV	902	2.213	1.78	0.20	10.49	-0.01	0.44	0.84	1.00			
CBI	858	0.159	0.09	0.00	0.43	-0.05	0.22	0.03	0.05	1.00		
CBI_leg	660	0.593	0.21	0.17	0.98	-0.12	0.36	-0.19	-0.17	0.10	1.00	
GOV_cred	902	0.159	0.90	-1.44	2.18	0.30	-0.92	-0.10	-0.30	-0.12	-0.33	1.00

Notes: All the variables -except when specified- correspond to average values between 1998-2008. LAW is a dummy variable taking the value of 1 when there is no fiscal support guarantee in the central bank law, 0 otherwise; RATING is the average sovereign rating provided by the three main rating agencies (Standard and Poors, Fitch, Moody's) encoded from 1 (best rating) to 17 (worst rating, see variable description); DEBT_GDP is the Gross Government Debt scaled by GDP ; DEBT_REV is the Gross Government Debt scaled by Government Total Revenue ; CBI is central bank independence proxied by the central bankers' turnover rate between 1996-2009; CBI_leg is central bank independence as proxied by the legal index indicator for the 2003 year developed by Crowe and Meade (2008); POL; GOV_cred is the government effectiveness index developed by the World Bank.

Table A3: Sample statistics

Country	LAW	RATING	DEBT_GDP	DEBT_REV	CBI	CBI_leg	GOV_cred
Albania	0	14,27	62,68	2,52	0,21	0,71	**-0,55***
Algeria	**1***	12,73	44,32	1,30	**0,07***	-	**-0,63***
Argentina	**1***	**15,30***	**81,99***	**3,08***	0,43	**0,79***	-0,02
Australia	**1***	1,66	15,06	0,42	0,14	0,29	1,78
Azerbaijan	0	12,33	16,80	0,68	-	-	**-0,82***
Barbados	0	8,59	44,97	1,32	0,21	0,41	1,36
Belarus	**1***	13,77	13,78	0,28	0,21	0,29	**-0,99***
Belize	0	14,45	**91,54***	**3,75***	0,21	-	-0,24
Bolivia	**1***	**15,00***	63,65	2,29	0,21	**0,78***	-0,44
Bosnia and Herzegovina	0	**15,73***	32,82	0,67	**0,08***	0,98	**-0,77***
Botswana	0	6,51	8,71	0,20	0,14	0,52	0,59
Brazil	0	13,09	69,66	2,03	0,21	0,46	-0,04
Bulgaria	0	11,82	41,23	1,12	0,21	**0,83***	0,04
Canada	**1***	1,58	78,25	1,88	0,14	0,47	1,91
Cape Verde	0	13,92	**76,28***	**2,75***	0,11	-	0,07
Chile	**1***	6,79	10,17	0,44	0,21	**0,79***	1,18
China	0	6,82	16,95	1,06	**0,07***	0,60	0,01
Colombia	0	11,43	37,29	1,50	**0,07***	0,69	-0,17
Croatia	0	9,91	34,79	0,89	0,14	**0,88***	0,40
Czech Republic	**1***	6,64	24,54	0,62	**0,07***	**0,80***	0,89
Denmark	**1***	1,27	44,87	0,80	0,14	0,27	2,18
Fiji	0	11,99	45,38	1,79	0,29	-	-0,32
FYR Macedonia	0	11,98	36,23	1,04	0,15	**0,86***	-0,33
Georgia	**1***	14,17	30,80	1,19	0,21	-	-0,38
Ghana	0	14,50	**67,63***	**5,01***	0,21	0,56	-0,06
Guatemala	0	12,05	20,42	1,64	0,21	0,78	**-0,55***
Guyana	0	**15,10***	**110,19***	**4,18***	0,14	-	-0,20
Haiti	**1***	**16,75***	46,33	**4,59***	0,29	-	**-1,44***
Honduras	0	**15,00***	52,91	2,44	0,29	0,67	**-0,59***
Hungary	0	7,27	60,94	1,40	0,14	**0,82***	0,88
Iceland	**1***	4,27	40,96	0,91	0,14	0,73	1,96
India	**1***	11,21	**77,13***	**4,20***	0,21	0,28	-0,06
Indonesia	0	**14,82***	57,00	**3,15***	0,29	**0,84***	-0,38
Israel	**1***	6,64	85,55	1,97	0,21	0,46	1,21
Jamaica	0	14,45	**112,20***	**4,34***	0,14	0,42	0,14
Japan	**1***	2,34	164,13	5,54	0,21	0,38	1,31
Jordan	0	12,45	**90,96***	**2,87***	0,14	-	0,14
Kazakhstan	**1***	11,03	10,20	0,40	0,36	0,54	**-0,64***
Korea	0	7,30	23,18	1,05	0,21	0,37	0,90
Kuwait	0	5,24	27,62	0,44	**0,00***	0,41	0,06
Kyrgyz Republic	**1***	**15,76***	**88,88***	**3,89***	**0,00***	**-**	**-0,65***
Latvia	**1***	7,94	12,81	0,37	**0,07***	**0,90***	0,51

Lebanon	0	**15,15***	**165,82***	**7,59***	**0,00***	0,46	-0,24
Lithuania	**1***	8,36	19,72	0,65	**0,07***	**0,86***	0,58
Madagascar	0	**15,05***	**81,04***	**5,42***	0,14	-	-0,54
Malaysia	**1***	8,06	41,02	1,69	0,14	0,47	1,10
Maldives	0	11,90	34,25	1,22	0,29	-	0,14
Mauritius	0	9,00	49,91	2,58	0,21	-	0,61
Mexico	**1***	9,76	41,47	2,16	**0,07***	0,64	0,20
Moldova	0	**16,18***	**69,48***	2,09	-	-	**-0,70***
Mongolia	0	**14,51***	**67,85***	2,35	0,29	-	-0,37
Morocco	**1***	11,36	64,26	2,58	**0,07***	0,31	-0,12
Mozambique	0	**14,91***	**86,95***	**3,96***	**0,07***	-	-0,47
New Zealand	0	2,00	26,04	0,72	**0,07***	0,38	1,73
Nicaragua	0	**16,09***	**115,34***	**5,05***	0,21	**0,79***	**-0,77***
Nigeria	**1***	**14,52***	46,93	1,28	0,21	0,53	**-0,98***
Norway	**1***	1,00	43,50	0,77	0,14	0,32	1,94
Oman	0	8,27	18,40	0,42	**0,00***	0,55	0,39
Peru	0	12,18	38,51	2,08	0,21	**0,89***	-0,36
Philippines	**1***	11,88	56,26	**3,09***	0,14	0,74	-0,05
Poland	**1***	7,60	43,15	1,10	0,14	**0,88***	0,51
Qatar	0	6,45	36,06	1,00	**0,07***	0,28	0,48
Romania	**1***	12,76	20,68	0,68	**0,00***	0,59	-0,32
Russia	**1***	11,85	33,91	0,95	0,14	0,62	-0,48
Rwanda	0	**15,55***	**75,81***	**3,83***	0,14	-	**-0,59***
Singapore	**1***	1,27	90,54	3,90	0,14	0,17	2,12
Sri Lanka	**1***	**14,85***	**93,00***	**5,64***	0,14	0,50	-0,24
Sudan	**1***	**17,80***	**123,65***	**10,49***	0,14	-	**-1,21***
Sweden	**1***	1,67	52,00	0,93	0,14	**0,85***	1,99
Switzerland	**1***	1,00	62,07	1,75	0,14	0,63	2,01
Syria	**1***	**15,37***	**104,55***	**3,93***	**0,07***	-	**-0,95***
Tanzania	0	13,75	46,92	2,74	0,14	0,53	-0,40
The Bahamas	**1***	7,00	27,72	1,90	0,14	0,40	1,19
Tonga	0	12,14	41,88	1,77	-	-	**-0,56***
Turkey	**1***	13,85	56,66	1,75	0,21	**0,85***	0,08
Uganda	0	14,39	51,54	**2,82***	**0,07***	0,52	-0,43
Ukraine	0	14,79	**31,27***	0,87	0,20	-	**-0,66***
United Arab Emirates	0	5,09	5,80	0,20	-	0,52	0,79
United States	**1***	1,00	61,19	1,90	**0,07***	0,48	1,69
Uruguay	0	12,94	83,11	**2,74***	0,36	0,43	0,47
Venezuela	0	14,48	38,49	1,23	0,21	**0,80***	**-0,96***
Yemen	0	15,09	**54,66***	1,67	**0,08***	-	**-0,84***

Notes: See Table A2. The presence of "*" near the statistic value indicates that $I_i^N = 1$ in equation (2) for this country (no fiscal support or high central bank independence cases, see section 1, 2 and 4).

Descriptive statistics and correlations for countries categorized as no de facto fiscal support countries:

Table A4: Descriptive statistics and correlations, no *de facto* fiscal support countries (proxy used: sovereign rating)

Variables	Descriptive statistics					Correlation coefficients							
	N. of obs	Mean	S.d.	Min	Max	INF	CBFS1	GDP_PC	GAP	CRIS	OIL_g	CBI	DEF
INF	230	0.082	0.06	-0.04	0.37	1.00							
CBFS1	217	0.054	0.13	-0.44	0.36	0.02	1.00						
GDP_PC	231	3.351	2.70	0.43	14.50	-0.25	0.26	1.00					
GAP	230	0.001	0.04	-0.18	0.22	-0.01	0.01	0.04	1.00				
CRIS	231	0.026	0.16	0.00	1.00	0.39	0.06	-0.03	-0.03	1.00			
OIL_g	210	8.525	8.24	-4.43	27.33	0.28	-0.02	0.14	0.36	-0.06	1.00		
CBI	220	0.171	0.11	0.00	0.43	0.17	0.33	0.16	0.00	0.14	0.00	1.00	
DEF	221	-2.928	4.33	-23.63	12.98	0.15	-0.04	-0.29	0.10	-0.12	0.19	0.22	1.00

Notes: INF is the rescaled measure of the inflation rate d = π / (1 + π), where π is the rate of change of CPI ; CBFS1 is the Central Bank Financial Strength, measured by (capital + OIN) over total assets ; GDP_PC is the GDP per Capita at Purchasing Power Parity ; GAP is the output gap ; CRIS is a dummy variable taking the value of 1 when a currency crisis occurs, 0 otherwise ; OIL_g is the growth rate of the average price of oil (WTI crude oil); CBI is central bank independence proxied by the central bankers' turnover rate between 1996-2009 ; DEF is the government surplus/ deficit. All variables are yearly; contemporaneous correlations are displayed.

Table A5: Descriptive statistics and correlations, no *de facto* fiscal support countries (proxy used: Debt-to-GDP)

Variables	Descriptive statistics					Correlation coefficients							
	N. of obs	Mean	S.d.	Min	Max	INF	CBFS1	GDP_PC	GAP	CRIS	OIL_g	CBI	DEF
INF	231	0.072	0.05	-0.04	0.28	1.00							
CBFS1	215	0.022	0.12	-0.44	0.36	-0.12	1.00						
GDP_PC	231	4.154	3.20	0.43	14.50	-0.18	0.17	1.00					
GAP	230	0.001	0.05	-0.18	0.16	-0.03	0.07	0.06	1.00				
CRIS	231	0.022	0.15	0.00	1.00	0.23	0.04	0.04	-0.21	1.00			
OIL_g	210	8.525	8.24	-4.43	27.33	0.25	-0.03	0.14	0.34	-0.08	1.00		
CBI	220	0.170	0.10	0.00	0.43	0.08	0.28	0.39	0.00	0.15	-0.00	1.00	
DEF	220	-4.220	3.83	-23.63	7.59	0.08	-0.37	-0.16	0.04	-0.12	0.17	0.18	1.00

Notes: see Table A5

Table A6: Descriptive statistics and correlations, no *de facto* fiscal support countries (proxy used: Debt-to-revenue)

Variables	Descriptive statistics					Correlation coefficients							
	N. of obs	Mean	S.d.	Min	Max	INF	CBFS1	GDP_PC	GAP	CRIS	OIL_g	CBI	DEF
INF	231	0.06	-0.04	0.37	0.072	1.00							
CBFS1	214	0.13	-0.44	0.36	0.046	-0.06	1.00						
GDP_PC	231	2.91	0.43	14.50	3.484	-0.19	0.17	1.00					
GAP	230	0.04	-0.18	0.16	0.001	0.01	0.02	0.05	1.00				
CRIS	231	0.15	0.00	1.00	0.022	0.34	0.07	-0.03	-0.08	1.00			
OIL_g	210	8.24	-4.43	27.33	8.525	0.25	-0.04	0.13	0.31	-0.05	1.00		
CBI	231	0.10	0.00	0.43	0.158	0.19	0.42	0.23	-0.00	0.15	0.00	1.00	
DEF	221	-3.969	3.72	-23.63	2.31	0.10	-0.22	-0.33	0.13	-0.07	0.16	0.16	1.00

Notes: see Table A5

Appendix 2: Other regression results

In **Table A7**, columns (1) (2) (3) and (4), I repeat the approach of Perera *et al.* (2013) to test for a link between CBFS and inflation for countries with a fixed exchange rate regime and countries where the central bank enjoys low independence. That is, I select the countries with fixed and managed-floating regimes based on the IMF *de jure* exchange rate regime classification, and the countries where central bank independence, as measured by the turnover index, is lower than the sample average. This leads us to select 32 countries in the first case and 31 in the second case (against 13 and 9 respectively for Perera *et al.* (2013)). As Table A3 shows, I do not find any robust link in the resulting sample[37].

Tables A7 and **A8** also show the robustness tests results discussed in section 5.

[37] The same holds with a log-specification and with a one-step estimator (available on request).

Table A7: Central Bank Financial Strength and inflation: fixed exchange rate regime, low central bank independence and low credibility of governments' commitments cases, Within-Group and System GMM estimates

	Fixed Exchange rate		Low central bank independence		N = High central bank independence (Turnover index)		N = Low credibility of government's commitments (World Bank Indicator)	
	Within-Group	SGMM (2-2)	Within-Group	SGMM (1-1)	Within-Group	SGMM (1-2)	Within-Group	SGMM (2-2)
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
INF_{t-1}	-	0.4007**	-	0.5268***	-	0.4848***	-	0.5092***
		(0.1857)		(0.0909)		(0.0734)		(0.0634)
I_i^N*CBFS1 $_{t-1}$	**0.0052**	**-0.0325**	**0.0499**	**-0.0785**	**-0.0142**	**-0.1118****	**-0.0433**	**-0.0313**
	(0.0316)	**(0.0281)**	**(0.0910)**	**(0.0644)**	**(0.0556)**	**(0.0480)**	**(0.0463)**	**(0.0405)**
GDP_PC $_{t-1}$	0.0027**	-0.0001	-0.0061	-0.0014***	0.0003	-0.0005	0.0003	-0.0006***
	(0.0013)	(0.0003)	(0.0054)	(0.0003)	(0.0016)	(0.0003)	(0.0016)	(0.0002)
GAP $_{t-1}$	0.0190	0.0056	0.0336	0.0176	0.0958	0.1086**	0.1106*	0.1033**
	(0.0465)	(0.0355)	(0.1175)	(0.0430)	(0.0664)	(0.0517)	(0.0628)	(0.0401)
CRIS $_t$	0.0292***	0.0599***	0.0813**	0.0890***	0.0714***	0.0867***	0.0815***	0.0917***
	(0.0048)	(0.0028)	(0.0301)	(0.0220)	(0.0231)	(0.0203)	(0.0225)	(0.0196)
OIL_g $_t$	0.0010***	0.0009***	0.0011**	0.0007**	0.0009***	0.0007***	0.0010***	0.0007***
	(0.0002)	(0.0002)	(0.0004)	(0.0003)	(0.0001)	(0.0001)	(0.0002)	(0.0001)
TREND $_t$	-0.0062**	-0.0033*	-0.0054	-0.0019	-0.0004	0.0022***	-0.0003	0.0023***
	(0.0027)	(0.0018)	(0.0033)	(0.0021)	(0.0015)	(0.0005)	(0.0015)	(0.0005)
Constant	0.0152	0.0185**	0.0985**	0.0287***	0.0492***	0.0167***	0.0496***	0.0156***
	(0.0148)	(0.0076)	(0.0362)	(0.0086)	(0.0159)	(0.0053)	(0.0147)	(0.0051)
Number of observations	306	304	298	297	754	751	792	789
Hansen test (pvalue)	-	0.713	-	0.791	-	0.417	-	0.647
AR(2) test (pvalue)	-	0.481	-	0.071	-	0.830	-	0.998

Notes: see Table 1. For columns (1) (2) (3) and (4) $I_i^N = 1$ for all the countries in the sample (subsamples estimates).

Table A8: Central Bank Financial Strength and inflation: no *de facto* fiscal support case, robustness checks estimates with base money variables

	N = no potential *de facto* fiscal support (Sovereign Rating)		N = no potential *de facto* fiscal support (Debt / GDP)		N = no potential *de facto* fiscal support (Debt / Revenue)	
	SGMM (1-1)	SGMM (2-2)	SGMM (1-2)	SGMM (2-2)	SGMM (1-1)	SGMM (2-2)
	(1)	(2)	(3)	(4)	(5)	(6)
INF_{t-1}	0.5624***	0.5346***	0.5030***	0.4729***	0.5308***	0.4893***
	(0.1131)	(0.1080)	(0.1184)	(0.0986)	(0.1086)	(0.0962)
I_i^N*CBFS1 $_{t-1}$	**-0.2990****	**-0.2826*****	**-0.3214*****	**-0.2945*****	**-0.2725***	**-0.2463****
	(0.1233)	**(0.0617)**	**(0.1200)**	**(0.1080)**	**(0.1370)**	**(0.1076)**
GDP_PC_{t-1}	-0.0008**	-0.0008**	-0.0006**	-0.0006*	-0.0007**	-0.0007**
	(0.0003)	(0.0003)	(0.0003)	(0.0003)	(0.0003)	(0.0003)
GAP_{t-1}	0.1165*	0.1297**	0.1091**	0.1369**	0.1056*	0.1321**
	(0.0598)	(0.0617)	(0.0535)	(0.0657)	(0.0546)	(0.0640)
$CRIS_t$	0.0975***	0.0932***	0.0924***	0.0874***	0.0943***	0.0920***
	(0.0206)	(0.0118)	(0.0159)	(0.0103)	(0.0218)	(0.0100)
OIL_g_t	0.0008***	0.0007***	0.0009***	0.0008***	0.0009***	0.0008***
	(0.0002)	(0.0002)	(0.0002)	(0.0002)	(0.0002)	(0.0002)
$TREND_t$	0.0023***	0.0020**	0.0015*	0.0016*	0.0019**	0.0018*
	(0.0006)	(0.0008)	(0.0008)	(0.0009)	(0.0007)	(0.0009)
BM_ta_{I-1}	-0.0007	_	-0.0004	_	-0.0005	_
	(0.0005)		(0.0005)		(0.0005)	
BM_g_{I-1}	_	-0.0031		-0.0018	_	-0.0025
		(0.0050)		(0.0048)		(0.0049)
Constant	0.0179**	0.0227***	0.0203**	0.0216***	0.0193**	0.0224***
	(0.0075)	(0.0073)	(0.0078)	(0.0076)	(0.0075)	(0.0077)
Number of observations	576	506	576	506	576	506
Hansen test (pvalue)	0.315	0.795	0.542	0.896	0.483	0.822
AR(2) test (pvalue)	0.976	0.842	0.888	0.835	0.797	0.947

Notes: see Table 1. BM_g is base money growth, BM_ta is base money scaled by the total asset of the central bank. In (x-y), x now corresponds to the number of lags instrumenting both INF_{t-1} and BM_g_{I-1}. (or BM_ta_{I-1}).

Table A9: Central Bank Financial Strength and inflation: no *de facto* fiscal support and high central bank independence cases, robustness checks estimates with time dummies

	N = no potential *de facto* fiscal support (Sovereign Rating)		N = no potential *de facto* fiscal support (Debt / GDP)		N = no potential *de facto* fiscal support (Debt / Revenue)		N = High central bank independence (Turnover index)
	SGMM (1-1)	SGMM (1-1)	SGMM (1-1)	SGMM (1-1)	SGMM (1-2)	SGMM (1-2)	SGMM (1-2)
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
INF_{t-1}	0.5522***	0.5143***	0.5377***	0.5143***	0.5546***	0.5376***	0.5449***
	(0.0665)	(0.0701)	(0.0686)	(0.0701)	(0.0627)	(0.0650)	(0.0692)
$\mathbf{I_i^N}$***CBFS1** $_{t-1}$	**-0.2369*** **	**-0.2966*** **	**-0.2608*** **	**-0.2966*** **	**-0.2535*** **	**-0.2543*** **	**-0.0758**
	(0.0634)	**(0.0851)**	**(0.0884)**	**(0.0851)**	**(0.0713)**	**(0.0756)**	**(0.0488)**
GDP_PC_{t-1}	-0.0007***	-0.0006***	-0.0006***	-0.0006***	-0.0007***	-0.0006***	-0.0005*
	(0.0002)	(0.0002)	(0.0002)	(0.0002)	(0.0002)	(0.0002)	(0.0003)
GAP_{t-1}	0.1226**	0.1078*	0.1205**	0.1078*	0.1189**	0.1087*	0.1106*
	(0.0584)	(0.0631)	(0.0587)	(0.0631)	(0.0566)	(0.0626)	(0.0618)
$CRIS_t$	0.0980***	0.0792***	0.0916***	0.0792***	0.0982***	0.0875***	0.0877***
	(0.0183)	(0.0153)	(0.0177)	(0.0153)	(0.0169)	(0.0162)	(0.0190)
CBI_I	-	0.0635*	-	0.0635*	-	0.0692**	-
		(0.0352)		(0.0352)		(0.0301)	
Constant	0.0671***	0.0072	0.0656***	0.0072	0.0665***	0.0058	0.0143*
	(0.0076)	(0.0097)	(0.0072)	(0.0097)	(0.0073)	(0.0087)	(0.0077)
Time dummies	YES	YES	YES	YES	YES	YES	YES
Number of observations	789	751	789	751	789	751	751
Hansen test (pvalue)	0.477	0.318	0.542	0.484	0.721	0.590	0.718
AR(2) test (pvalue)	0.892	0.932	0.846	0.978	0.943	0.854	0.806

Notes: see Table A7. Time dummies are dummy variables each taking the value of 1 for the corresponding year, 0 otherwise.

Appendix 3: Generating data for missing sovereign debt rating

I select the explanatory variables following the literature (see Afonso *et al.* (2011) or Cantor *et al.* (1996)[38]) and use a similar regression approach to Afonso *et al.* (2011) to predict ratings. That is, to capture the fixed effects potentially correlated with the explanatory variables (that we can't predict), I include in the regression a country-level average of the initial explanatory variables over the time period. This is equivalent to the often called Mundlak-specification (Mundlak, 1978)[39]. These average variables can be seen as the long-run determinants of ratings, while the initial variables can be seen as the short-term determinants. The model estimated is therefore the following:

$$R_{i,t} = \alpha + \beta\, K_{i,t} + \gamma\, Z_i + \delta\, \overline{K}_i + \varepsilon_i + \mu_{i,t}$$

With $R_{i,t}$ the average rating, $K_{i,t}$ the vector capturing the short term determinants of rating (initially I use: GDP per capita, real GDP growth, government debt, government deficit, government effectiveness, foreign reserves and gold over exports, policy instability), Z_i relevant country-specific dummies for the rating (dummy equal to 1 if the country experienced a sovereign crisis and a dummy capturing the country's economic developing stage according to the IMF specification previously mentioned), $\overline{K}_i$ the vector capturing the country-mean of the variables in $K_{i,t}$ (long term determinants of rating), ε_i the fixed effects and $\mu_{i,t}$ the error term.

The implicit assumption I make with this specification is that the expected value of a country's fixed effect is a linear combination of the country-level mean of the initial variables. That is:

$$E\left(\varepsilon_i \;/\; K_{i,t}, Z_i\right) = \delta\, \overline{K}_i$$

So that the potential correlation between the initial variables and the fixed effects errors becomes non-problematic for the identification of the coefficients with the inclusion of the long term averages of the initial variables (Mundlak, 1978).

As the variable $R_{i,t}$ is an average of the ratings, I have many different values. I therefore use a simple linear model in the analysis. I chose a random effect specification to deal with potential variance heterogeneity induced by the fixed effect, with a cluster-robust variance/covariance matrix for the standard errors in order to take into account both serial

[38] Cantor, R., Packer, F., 1996. Determinants and impact of sovereign credit ratings. The Journal of Fixed Income 6, 76-91.
[39] Mundlak, Y., 1978. On the pooling of time series and cross section data. Econometrica, 46, 69-85.

correlation and heteroscedasticity. To build the predictions, variables appearing as non-significant at the 10% threshold are removed one by one from the regression (starting from the less significant). Results of the estimates are displayed in Table A10.

As compared with the results of Afonso *et al.* (2011) with the same specification, my model gives quite good forecasts: 48% of the predictions predict the average rating with an error of inferior to 1 (given that the rating goes from 1 to 17), 80% with an error inferior to 2. If we round the value of the ratings to the closest integer (for the predicted value as well as for the average rating), 26% of our predictions are exact, 66% lie within one notch and 90% within two notches. Removing the non-significant variables improves the fit (the R-square reaches 0.9), and the fact the non-significant country-mean variables are removed doesn't significantly alter the quality of the estimates as compared with a fixed effect specification (column 3), what makes it arguable that keeping only the significant variable is justified both by common sense and by the fact it doesn't prevent the identification of the coefficients.

Table A10: Sovereign Debt ratings determinants

	All variables, re (1)	Only significant variables, re (2)	Only significant variables, fe (3)
GDP_PC $_t$	-0.0947***	-0.1000***	-0.1039***
	(0.0297)	(0.0204)	(0.0281)
GDP_G $_t$	-0.0131	-	-
	(0.0177)		
DEBT $_t$	0.0171**	0.0194***	0.0192**
	(0.0072)	(0.0060)	(0.0074)
DEF $_t$	-0.0088	-	-
	(0.0243)		
GOVEFF $_t$	-1.6436***	-1.9294***	-1.6919***
	(0.5582)	(0.3638)	(0.5553)
POLINST $_t$	-0.5886***	-0.5120***	-0.5971***
	(0.2195)	(0.1707)	(0.2098)
SCRIS $_t$	0.5664	0.6173*	0.5708
	(0.4226)	(0.3439)	(0.3574)
RES $_t$	-7.59e-08	-6.46e-08	-7.26e-08
	(5.39e-08)	(4.00e-08)	(5.21e-08)
INF$_t$	5.0232**	4.7129**	4.3563**
	(2.2626)	(2.1290)	(2.1684)
GDP_PC_mean $_i$	0.0155	-	-
	(0.0416)		
GDP_G_mean $_i$	-0.0097	-	-
	(0.0886)		
DEBT_mean $_i$	0.0044	-	-
	(0.0124)		
DEF_mean $_i$	-0.1056**	-0.1075***	-
	(0.0480)	(0.0405)	
GOVEFF_mean $_i$	-0.7950	-	-
	(0.7408)		
POLINST_mean $_i$	0.2813	-	-
	(0.3732)		
RES_mean $_i$	0.0000	-	-
	(0.0000)		
INF_mean $_i$	0.0297	-	-
	(0.0288)		
SCRIS_dum $_i$	1.4892**	1.6960***	-
	(0.6510)	(0.6309)	
Country_classif $_i$	1.3949***	1.6084***	-
	(0.3922)	(0.3568)	
Constant	7.1051***	7.0785***	10.9311***
	(1.0669)	(1.0269)	(0.7394)
Observations	546	555	555

Notes : the dependent variable is the average of the debt rating provided by the three main rating agencies (Standard and Poors, Moody's and Fitch). GDP_PC $_t$ is the GDP per Capita at Purchasing Power Parity ; GDP_G $_t$ is the growth of real GDP ; DEBT $_t$ is the ratio of government gross debt to GDP ; DEF $_t$ is the ratio of government deficit to GDP ; GOVEFF $_t$ is the government effectiveness index of the World Bank ; POLINST $_t$ is the policy instability index of the World Bank ; SCRIS $_t$ is a dummy variable taking the value of 1 when a sovereign currency crisis occurs ; RES $_t$ is the ratio of foreign reserves and gold to exports ; INF$_t$ is a rescaled measure of the inflation rate $d = \pi / (1 + \pi)$, where π is the rate of change of CPI ; X_mean $_i$ refers to the country-level average of the variable X ; SCRIS_dum $_i$ is a dummy variable taking the value of 1 if the country experienced a sovereign crisis during the sample period ; Country_classif $_i$ is a variable taking the value of 1 for advanced countries, 2 for emerging countries and 3 for developing countries (with the same classification as previously used). Statistical significance levels are based upon t-stats. * Statistical significance at 10% level ** Statistical significance at 5% level *** Statistical significance at 1% level

Appendix 4: The System GMM method

Let us write the simple dynamic model we want to estimate as follows:

$$\mathrm{y_{it}} = \alpha \mathrm{y_{it-1}} + \beta X_{\mathrm{it}} + \mathrm{v_i} + \mathrm{u_{it}} \quad (1)$$

where y is the dependent variable (inflation), X represents the set of explanatory variables, other than lagged inflation and including our indicator of CBFS, v is an unobserved country-specific effect, u is the error term. $i = 1, \dots, \mathrm{N}$ are the cross section units and $\mathrm{t} = 1, \dots, \mathrm{T}$ the time periods. When the time period is small, the above model suffers from the Nickel bias (Nickell, 1981). The "Difference GMM" approach developed -among others- by Arellano and Bond (1991) copes in particular with this issue. Arellano and Bond (1991) propose to difference the above equation:

$$\mathrm{y_{it}} - \mathrm{y_{it-1}} = \alpha(\mathrm{y_{it-1}} - \mathrm{y_{it-2}}) + \beta(X_{it} - X_{it-1}) + (\mathrm{u_{it}} - \mathrm{u_{it-1}}) \quad (2)$$

and use the generalized method of moments popularized by Hansen (1982). Differencing eliminates the fixed effects but also introduces a new bias: the lagged dependent variable $(\boldsymbol{y_{it-1}} - y_{it-2})$ is now by construction correlated with the error term $(\mathrm{u_{it}} - \mathbf{u_{it-1}})$. To deal with this issue, Arellano and Bond (1991) use the lag levels of the explanatory variables to instrument the differences. Those are valid instruments as long as the error term u is not serially correlated and the explanatory variables weakly exogenous. Arellano and Bond (1991) accordingly propose the following moment conditions:

$$E[y_{it-k}(u_{it} - u_{it-1})] = 0 \text{ for } k \geq 2; t = 3, \dots, T$$

$$E[X_{it-k}(u_{it} - u_{it-1})] = 0 \text{ for } k \geq 2; t = 3, \dots, T$$

Based on these moment conditions they propose a two-step GMM estimator. In the first step the error terms are assumed to be independent, homoscedastic across countries and over time. In the second step, the residuals obtained in the first step are used to construct a consistent estimate of the variance-covariance matrix. Thus the estimator obtained is shown to be efficient and robust to different patterns of heteroscedasticity and cross-correlation.

Nevertheless, several econometric shortcomings have been later observed with the first-differenced GMM estimator. Blundell and Bond (1998) show in particular that this estimator behaves very poorly in cases where the dependent variable shows significant persistency. As an illustration, in the extreme case where the dependent variable's behavior is close to a random walk, past levels of the seemingly random-walk dependent variable convey little information about its future changes and therefore untransformed lags are weak instruments for transformed variables. Also, the estimator has been shown to have large finite sample bias and poor precision in simulation studies in such cases (Alonso-Borrego and Arellano, 1996; Blundell and Bond, 1998[40]).

The estimator later proposed by Blundell and Bond (1998) copes with these weaknesses. Blundell and Bond (1998) make use of additional moment conditions and propose an estimator that can dramatically improve the performance of the above first-differenced estimator. Their estimator combines in a system the regression in difference of the usual "Difference GMM" approach (the "difference part") with a new regression in levels (the "level part"), the two equations being distinctly instrumented. In the regression in levels, the levels of the variables are instrumented with their lagged first-difference, while in the regression in difference the difference of the variables remain instrumented by the lagged levels. Thus, the additional moment conditions exploited are the following[41]:

$$E[(y_{it-k} - y_{it-k-1})\ (\mathrm{v_i} + u_{it})] = 0 \text{ for } k = 1$$

$$E[X_{it-k} - X_{it-k-1})\ (\mathrm{v_i} + u_{it})] = 0 \text{ for } k = 1$$

Under the validity of the extra assumption that the new instruments (the lagged first-difference) are not correlated with the individual fixed effects, this estimator is shown to outperform the "Difference-GMM" estimator in terms of precision and to have good finite sample properties in contrast with the latter[42].

[40] Blundell and Bond (1998) find a downward bias in their Monte-Carlo experiments.

[41] Using all the available first-difference lags would make some moment conditions redundant in the system as most of these moment conditions are mathematically equivalent to the one used in the "difference part". Consequently, only the most recent difference is used as an instrument in the "level part".

[42] More precisely, the gain in precision is shown to increase with the value of the autoregressive parameter for the dependent variable (Blundell and Bond (1998) only take the lag dependent variable as an explanatory variable in their Monte Carlo analysis) and as the number of time series observations gets smaller.