

Central Bank Independence and Inflation: An Empirical Approach

by Mohammad Muzahidul Anam Khan

ID: 8922008

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Supervisor: Professor Lilia Karnizova

ECO6999

Ottawa, Ontario

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Abstract:

Central bank independence is defined as the autonomy of central banks from politically controlled and motivated branches of the government and the ability to set independently the goals of monetary policy. This paper investigates a relationship between legal independence of central banks and inflation for one hundred and seventeen countries in a period from 1970 to 2010 using a two-way fixed effect model. The paper finds a negative relationship between these two variables, after controlling for several other macroeconomic and policy indicators. A comprehensive investigation further reveals that the relation between central bank independence and inflation varies with the income level of the country. This paper concludes that neither too rich nor too poor countries can benefit from a legal reform of a central bank. The study also identifies that central bank autonomy matters more after 1990, compared to the previous twenty years. Broad money growth and financial openness of a country are found to be more robust determinants of inflation, as compared to the legal independence of the central bank.

Key Words: *Central Bank Independence, Inflation, Two-Way Fixed Effect, Financial Openness.*

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Section 1: Introduction

Since the mid-1990s, a significant decrease in the annual inflation rate has been observed among the nations around the world. Hyperinflationary events have become rare for both advanced economies, and, with minor exceptions, emerging economies. While 56 countries experienced double-digit inflation in the year 1975, the number of such countries declined to 12 by the end of the year 2012.¹ Some academics and financial press have credited the autonomy of central banks for this success. However, contending views are also not uncommon (Hayo et al. 2002, Campillo et al. 1997).

Earlier economic studies on the importance of central bank autonomy have constituted a detailed groundwork and developed several arguments regarding the mechanisms and economic rationality for central bank independence. These works have led economists and financial practitioners to believe that central bank independence is one of the key elements for a successful inflation control. Kydland and Prescott (1977) conveyed their argument on the preference of rule-based policymaking over discretionary policymaking and eventually concluded that the discretionary policymaking by the policymakers will not typically result in a maximization of the social objective function. Barro and Gordon (1983) addressed the issue of dynamic inconsistency and showed why a greater independence of the central bank is required to formulate a credible, consistent and efficient monetary policy. Rogoff (1985) put forward the idea of a “conservative and independent central banker” and showed how this central banker’s policy results in a low and stable inflation compared to a less “conservative and independent central banker”. Following these theoretical propositions, Banaian et al. (1983) and Cukierman et al. (1993) provided some empirical evidence affirming the presence of a negative relationship between inflation and central bank independence. Alesina and Summers (1993) further showed that this negative relationship

¹ World Development Indicator, 2017, World Bank Publication.

did not come at a cost of lower real economic activity. An increasing concern regarding central bank independence (CBI) led to structural and governance-related reforms in developed countries. For developing and emerging countries, the change came after the “Washington Consensus” (Williamson 1990) and the subsequent effort exerted by the supra-national organizations (World Bank, International Monetary Fund etc.). These efforts were targeted for an economy-wide reform that included financial and trade liberalization, judicial changes, privatization, etc. The CBI was only a part of the policy prescription(s).

However, some recent studies have found evidence that challenges the association between the CBI and inflation. The arguments of these studies focused on the construction of the CBI index, causality (Hayo et al. 2002), and the fact that including high inflation countries might have driven the negative relationship in the first place. Fuhrer (1997) presented some evidence regarding the inconsistency of the relationship when more independent variables are included in the model. In addition, some studies concluded that the relationship is positive (Campillo et al. 1997). Posso and Tawadros (2013) provide a brief survey of the earlier studies investigating the link between the CBI and inflation.

Faced with these two opposite but plausible types of evidence, this paper tries to answer the following research questions: “Do differences in the level of central bank independence explain the differences in inflation experiences across countries and over time? Do developed and emerging nations benefit from the CBI in the same way when trying to achieve low and stable inflation rate?”

This paper defines the CBI as a degree of autonomy enjoyed by a central bank from the legislative and executive branches (politically controlled) of the government (Dolmas et al. 2000). Central banks are one of the core institutions that can affect the whole economy through various monetary channels. The most common policy goal of any central bank is to maintain a low and stable

inflation rate in the economy.² This paper assumes that central banks base their policymaking and communication on some sort of a nominal anchor. The anchor may involve targeting monetary aggregates or inflation rate, explicitly or implicitly. To achieve their targets, central banks use various kinds of conventional or unconventional policy instruments. Therefore, to formulate and implement monetary policy, an independent central bank should have the ability to set goals for the monetary policy (goal independence) and have the ability to set policy instruments to implement the monetary policy (policy independence).

Garriga (2016) proposed a legal independence measure for the central banks. She created a CBI index that follows the direction and attributes of the Cukierman et al. (1992) index. Garriga incorporated important attributes like personnel independence (governing council tenure and individuals free from political pressure) and financial independence (central banks must have sufficient financial resources to fulfill their mandates and have the ability to avoid monetary subordination to fiscal policy) along with policy independence to create the index. She integrated these measures into a single numeric value, which has been identified as the CBI index throughout this paper.³

One of the research questions that the current paper tries to answer is whether a relationship exists between the CBI and inflation. This paper finds a conditional negative correlation between these two variables (see Section 4). However, it is unable to conclude that the relationship is causal. This issue can be clarified with the help of an example.

Suppose for a given country, the pre-reform monetary policy is accommodative to fiscal policy and the inflation is higher. The amendment of the central bank law grants the central bank more independence and the post-reform inflation is found to be lower. It cannot be concluded that the

² The words “most common” are used because of the diverse objectives of the central banks that have been observed around the world. Business cycle conditions of the economy is another important variable that all the central banks consider. However, in the emerging economies, central banks are also found to be responsible for credit control, exchange rate interventions and bank regulations. These objectives do not complement each other all the time.

³ This paper uses the weighted CBI index proposed by Garriga (2016).

central bank reform has caused the inflation to decrease (controlling for other exogenous factors) because the reform itself is the result of higher inflation (endogeneity problem).

Sometimes the causality cannot be established due to statistical limitation(s). If the pre and post-reform inflation outcome is indistinguishable, then the effect of the reform cannot be ascertained. Persistence of the pre-reform level of inflation following a positive central bank reform can result from two different scenarios. First, if the political and institutional systems in the country are not actively engaged in designing and implementing a reform by themselves, then the effectiveness of the reform may be subsided. Such outcomes observed mainly in countries with lower per capita income, where reforms are usually prescribed by donor agencies, but the ability and/or the willingness of the recipient country to implement the reform is absent. Acemoglu (2006) suggests this mainly happens when the politically powerful communities have preferences that are alienated from the general public interests. Instances of such policy reform failures can be observed in sub-Saharan African nations (Van de Walle 2001), in South American nations (Velasco 2005) and, in the recent past, in Zimbabwe. Second, if the pre-reform period has a low and stable inflation rate, then the effectiveness of central bank reform is difficult to quantify from the inflation outcome alone. The Bank of England can be a good example of this kind of scenario.⁴ To summarize, it is highly plausible that the CBI effects on the inflation performance will be unsubstantiated by both the ill-functioning and less accountable political and institutional systems as well as by the already well-functioning systems.

It is now evident why it is difficult to establish a causal relationship between the CBI and inflation from a single CBI index measure. Some adjustments at the econometric model are made to mitigate the limitations stated above and to reveal the true nature of the relationship between inflation and the CBI. These adjustments are based on the assumptions that countries do not introduce a central

⁴ A detailed case study regarding this issue is provided in the Section 2 of this paper.

bank reform on a stand-alone basis. Rather, they introduce a series of reforms that are necessary for the well functioning, inflation targeting system (Acemoglu et al. 2008). These reforms should work together as an anti-inflation vaccine. Therefore, to better understand the relationship between inflation and the CBI, other policy measures must be introduced as control variables.

Major policies that may affect inflation outcomes are the central government's fiscal policy, trade policy, and financial liberalization policy. Fiscal expenditures are one of the most important policy measures other than the monetary policy that can affect the inflation outcome. If the government spending is higher than the socially optimal level, it may affect price stability. An accommodative central bank (lower CBI) will try to finance the deficit of the fiscal authorities. A more independent central bank will be less willing to monetize the deficit, which will likely lead to lower inflation (Martin 2015). Trade policy is represented by the trade openness and included in the analysis following Bogoev et al. (2012) and Romer (1993). Countries that are more open to trade, are expected to be less exploited by local monopolies and price distortions. Trading of goods and services will help the price levels to converge to the international level more quickly, compared to a relatively closed economy. Finally, financial liberalization will ensure the currency value of the country is kept at the level that is expected by the market participants. Less restrictions on the capital account will constrict the scope of the central bank's intention to formulate and implement accommodative monetary policy. Monetary policy will be closely monitored by the private sector and any signal of weak monetary policy will be penalized with capital flight (Gupta 2008).

Other than these policy controls, two macroeconomic variables are also introduced as control variables to the model. They are growth in the general economic activity (real GDP growth) and broad money growth. Broad money growth is an important control measure, as it is considered one of the important variables that closely affect inflation over the long run (Benati 2009, Giannone et al. 2008).

This paper contributes to the field of central bank independence literature in several ways. Firstly, the paper uses data from one hundred and seventeen countries over the period spanning from 1970 to 2010. Most of the previous literature worked only with the OECD or developed countries or with a smaller sample set. This larger sample set can provide a detailed insight into the dynamics of the CBI-inflation relation by incorporating the emerging nations as well as the nations that experience persistent low per capita income. Secondly, due to the advantage of the larger sample, this study can extend the analysis to understand which countries most benefit from a central bank reform. Thirdly, the financial openness of a country plays an important part in the determination of price stability, yet reforms in the area of financial liberalization have been ignored in previous studies on CBI-inflation dynamics. Reforms in the financial openness and trade openness are considered as important controls in this analysis along with the fiscal policy. Fourthly, most of the previous models ignored the time fixed effects. This paper incorporates them to control for the variables that are not captured by the country-level variables or time invariant un-observables. The results in Section 4 show that these time effects are jointly statistically significant. Therefore, using a one-way fixed effect model may suffer from an omitted variable bias. Finally, several alternative panel model specifications have been considered for this analysis. Despite the variations in their assumptions and calculation processes, the relationship between the CBI and inflation has been found to be stable (almost of a similar magnitude) and consistent (negative sign of the coefficient) for the whole sample.

The rest of the paper is organized as follows. The next Section discusses the reduced form relationship observed between the CBI and inflation and further investigates this relationship using some country-specific case studies. Section 3 discusses the choice of the variables, their transformations and sources and the empirical model pursued by the study. Section 4 discusses the results and its implications. The concluding section summarizes the paper's view of the research questions, as well as briefly discusses the strength and limitations of the analysis.

Section 2: Reduced Form Analysis and Case Studies

The world inflation rate, on average, has shown some dramatic variations over the past years.

Figure 1 shows 2010 US\$ GDP weighted inflation rate for the sample countries from 1970 to 2012. The shaded area under the graph shows, on average, high inflationary periods experienced by these countries. Inflation peaked in the year 1990 at 133.0%, while the average inflation rate stood at 36.2% from 1973 to 1995.

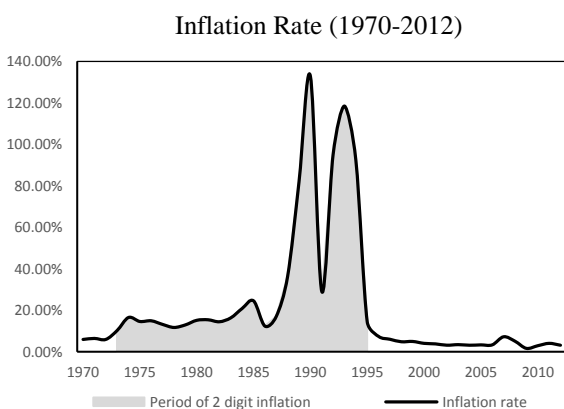


Figure 1: Cross-country average inflation rate (2010 US\$ GDP weighted)⁵. Data Source: World Development Indicators, 2017, World Bank. Calculation: Author. The y-axis represents the 2010 US\$ GDP weighted annual inflation rate and the x-axis represents the year.

This high level of average inflation, spanning from 1988 to 1994 has been influenced by the higher inflation experienced in Latin and Central American countries in the late 1980s and, additionally, by eastern European countries in the early 1990s.

A rapid change in the geopolitical structure around the world, the war in Iraq, failed reforms in Latin countries and a transitional shock experienced in Europe were the major drivers of this extraordinary level of price hike in those countries. Even if this transitory period (1988-1994) is ignored, the world inflation level, on average, was 15.4% during 1973-1987. On the other hand, as **Figure 1** also shows, the average inflation experienced during 1996-2012 was down to 4.3%, with the lowest level experienced in 2009 at 1.7%.

A more comprehensive observation reveals that, although the average world inflation has experienced a moderation in the late part of the 1990s, industrialized nations started to experience

⁵ A detailed discussion of the data used in this paper is left to the data and methodology section.

the same phenomena since the late 1980s. Three alternative explanations have been coined by economists to justify this development: ‘Good Policy’, ‘Good Luck’ and structural shifts (e.g., less dependence on oil). It has been argued that the inflation moderation is due to good monetary policy and GDP growth moderation is mainly due to a structural shift and good luck (Pescatori 2008). In his lecture at the meeting of the Eastern Economic Association in 2004, the Governor of the Federal Reserve, Ben Bernanke, argued that monetary policy might have reduced the variability of output as well. Though the ‘Good Luck’ hypothesis is still out there, the majority of the economic literature supports the notion that the alleviation of inflation volatility can be attributed to good monetary policy, at least for the OECD countries. The focus of this paper is not to take a stance on the “Good Luck” vs. “Good Policy” debate, but to ascertain the arguments put forward by economists. That is the moderation in inflation experienced around the world after 1990 can be attributed to the better monetary policy formulation and execution by the central banks of the respective countries. However, how much of the formulation and execution of good monetary policy can be attributed to the legal independence of the central bank is the matter of the investigation of this paper.

As discussed in the introductory section, a central bank’s ability to successfully achieve its policy goals lie with its ability to independently conduct and implement monetary policy by having a greater control over its instrument(s). This independence is compromised when the government of the country imposes restrictions that may handicap the central bank to conduct its business (Dolmas et al 2000). Given this argument, it can be assumed that an independent central bank will formulate and implement the monetary policy to achieve its goal to curb inflation and reduce its volatility in an unbiased manner (minimize the loss function). In other words, it can be inferred

that a more independent central bank will be able to focus its activities and resources in such a manner that will ensure its firmer grip on the price level of the economy.

This kind of inferences are strong and require some preliminary analysis that supports the conjecture. Some stylized facts are pursued in *Figure 2*. First, an index of central bank independence (CBI), prepared by Garriga (2016), is used for the study that includes the period from 1970 to 2012.⁶ This is an ascending index, meaning higher value of the index can be interpreted as the greater independence of central bank (or less government control over central bank). A cross-sectional average of the CBI is calculated for each year. Second, the inflation data for each country is transformed in the following manner:

$$Inflation(Adjusted)_{i,t} = \frac{Inflation_{i,t}}{1 + Inflation_{i,t}} \quad (1)$$

This adjustment is made to reduce the impact of the hyperinflationary periods (outliers) as well as to reduce the heteroskedasticity, which might dominate the result of this analysis (Acemoglu et al. 2008). Petrevski et al. (2012) defined this term as the real depreciation of money, and Cukierman et al. (1992) used this approach as an alternative measure of inflation. This paper also considered the logarithmic transformation of inflation but discontinued the effort due to the presence of zero or near zero inflation rate experienced by some countries. The cross-sectional unweighted average of adjusted inflation is taken for each year.

Figure 2(b) shows a strong negative contemporaneous correlation between inflation and the CBI. Both the slope coefficient and the intercept are significant at all levels. *Figure 2(a)* also supports the idea that increasing CBI decreases inflation. However, it also shows that, before 1994, the CBI-inflation correlation was negligible.

⁶ Some features of the index have already been discussed in the introductory section. Some other features of the CBI will be discussed in the next section.

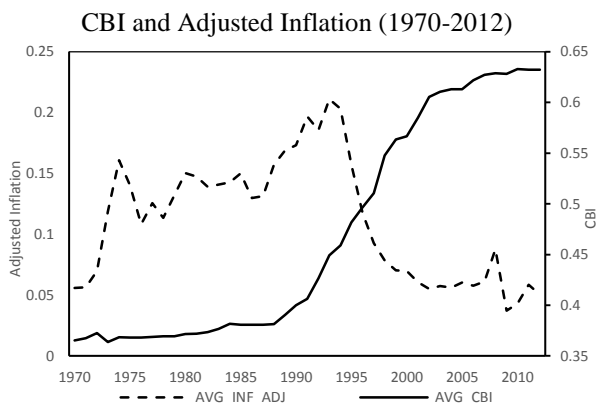


Figure 2(a): Cross country average of the CBI and adjusted inflation rate over time. Left axis uses the world average of the adjusted (unweighted) inflation and the right axis represents the world average of the CBI index for each year. The horizontal axis represents time in the year.

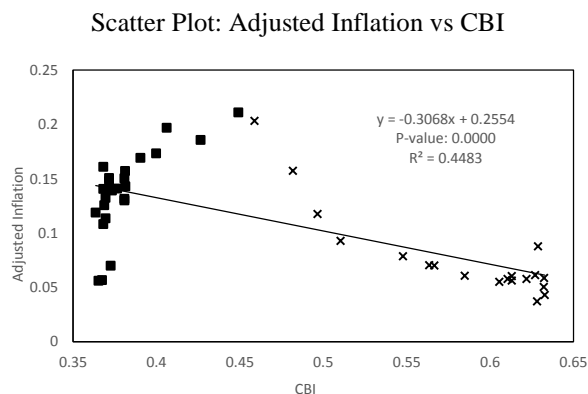


Figure 2(b): Each square marker shows a contemporaneous correlation between the average CBI and average adjusted inflation before 1994, and the crossed markers represent observations during and after 1994. The solid line represents the best fitted linear relation between inflation-CBI over the whole period. Upper right-hand corner presents the regression statistics (y is adjusted inflation and x is CBI).

The CBI index (average) kinked upward after 1988, while inflation started to fall since 1994. A summary of the findings is as followed:

- The CBI had a strong contemporaneous negative correlation with inflation. Moreover, the current level of the CBI might affect the future inflation rate as well;
- The CBI- inflation co-movement was found to be positive before 1994. Observations reveal that, from 1970 to 1994, the average CBI index increased by 25.6%, while the average inflation rate over the period remained around 16.3%. After 1994, the CBI-inflation had a strong negative correlation. From 1994 to 2012, the CBI index increased by 37.8%, while the average inflation rate almost halved, and dropped to 7.6%.

On average, when considering the evidence from the whole sample, **Figure 2(b)** seems to support the conjecture previously made in this section- a more independent central bank will result in a low inflation. **Figure 2(a)** also suggests that there might be a delayed response of inflation, along with the contemporaneous response, to the change in the level of the CBI.

So far, any influence of other macroeconomic and country-specific variable on inflation has been absent from the discussion. Although some preliminary evidence has been produced, it is hard to bank on the relationship produced by this reduced form of empirical analysis. The reform of the central bank is a crucial factor in controlling inflation, but it alone cannot ensure the stability of the variable. A further investigation into the residuals produced by the reduced form analysis presented in *Figure 2(b)* reveals that the residuals might be suffering from non-spherical disturbances. The residual plot resulting from *Figure 2(b)* is reported in *Figure 3*. A closer investigation reveals that the residuals are autocorrelated and heteroskedastic.

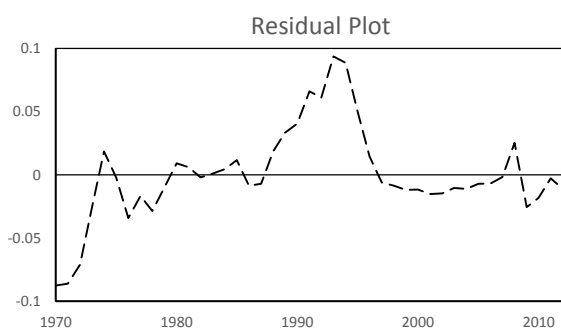


Figure 3: The residual plot from the inflation-CBI regression presented in Figure 2(b). The left-hand axis reports the residual from the regression. The horizontal axis presents the time in years (1970- 2012)

But this plot also gives the insight that the residuals are high and consistently positive between the year of 1988 to 1996. It suggests that some year specific factors might be acting as important determinants of the inflation over the sample period considered.

A more rigorous and cautious approach is warranted for further analysis. Before introducing a more profound empirical analysis, some country-level analysis is deemed necessary to understand the underlying conditions that are needed to be fulfilled for a reform to become successful. This paper will now carefully dissuade its focus from a general cross-country analysis towards a country-specific analysis. A set of country-specific case studies have been developed to understand the dynamics between the CBI and inflation.⁷

⁷ For all cases, inflation is represented by the adjusted inflation as described in equation (1).

#1 A case for failed reforms: Zimbabwe and Venezuela

Zimbabwe's Inflation (1970-2007)

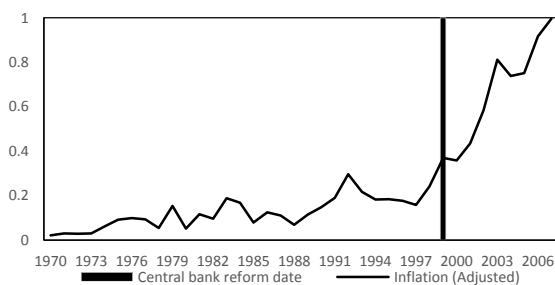


Figure 4(a): The vertical axis represents adjusted inflation and the horizontal axis represents time in the year. The vertical solid line represents the year of central bank reform. The figure reveals the hyperinflationary episode experienced in the post-reform Zimbabwe

Venezuela's Inflation and Broad Money Growth Rate (1970-2013)

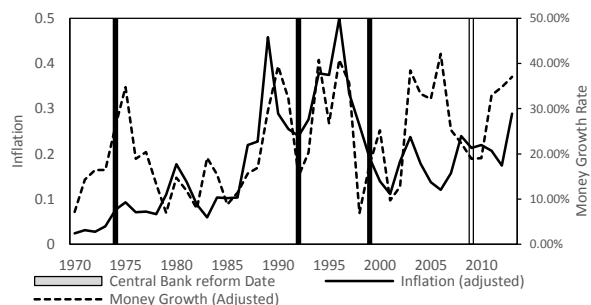


Figure 4(b): The left vertical axis represents adjusted inflation, the right axis shows the broad money growth rate, and the horizontal axis represents time in the year. The vertical solid line represents the year of central bank reform. The transparent vertical line represents a legal change that reduced the autonomy of the central bank. Venezuelan economy experienced a consistently high inflation rate over the years, though several reform attempts were made to make the central bank independent.

The Reserve Bank of Zimbabwe was legally provided with full autonomy in 1995 through the change in their Bank Act. Inflation control was also made the sole objective of the reserve bank (Acemoglu et al. 2008). However, increasing the independence of the central bank and subsequently allowing it to operate under full autonomy did not work for Zimbabwe. The inflation situation deteriorated after the central bank reform, and it led to one of the most devastating currency crises of the twenty-first century. On the other hand, Venezuela is an example of multiple policy reform failure. After the first reform in 1974, inflation rate soared, and worse, became more volatile. Two subsequent reforms also did not help. Finally, in 2009, the government of Venezuela reduced the autonomy of Banco Central de Venezuela (central bank of Venezuela)⁸ and as expected, no improvement in the inflation environment was observed for the remaining period.

Why did these reforms fail? The Zimbabwe government was printing money to finance the second Congo war as well as providing higher salaries to army and government officials.⁹ On the other

⁸ The white column in the right side of Figure 4(b) shows the date when the autonomy of the central bank was reduced.

⁹ "Economics of violence", Economist (Issue: April 2011) and Acemoglu et al. (2008).

hand, central bank reform was mainly a result of outside pressure created by the International Monetary Fund's technical assistance team (Dornbusch 2001). As this reform was not shaped by the internal dynamics, it failed to provide the desired result for Zimbabwe (Acemoglu et al. 2008). On the other hand, the Venezuelan economy was in a state of stagflation in the early 1970s (World Bank Country Report, May 2017). Low or negative output growth coupled with higher inflation took the economy almost to the brink of collapse. In the late 1980s and 1990s, the high inflation was a result of the "Inflation Correction", result of structural reforms that corrected most of the past distortionary pricing mechanism (Haggerty et al. 1993). In the following years, Venezuela encountered a series of international sanctions and simultaneously instigated some internal politically motivated policy decisions that led to higher and more volatile inflation.

2 A case for successful reforms: China and Colombia

China's Inflation and Broad Money Growth Rate (1984-2014)

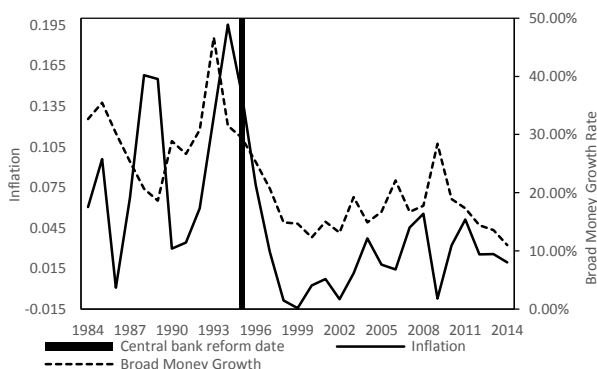


Figure 5(a): The left vertical axis represents adjusted inflation (solid line), the right axis shows the broad money growth rate, in percent (dotted line) and the horizontal axis represents time in the year. The vertical solid line represents the year of central bank reform. Low and stable inflation was experienced in the post-reform China.

Colombia's Inflation and Broad Money Growth Rate (1972-2014)

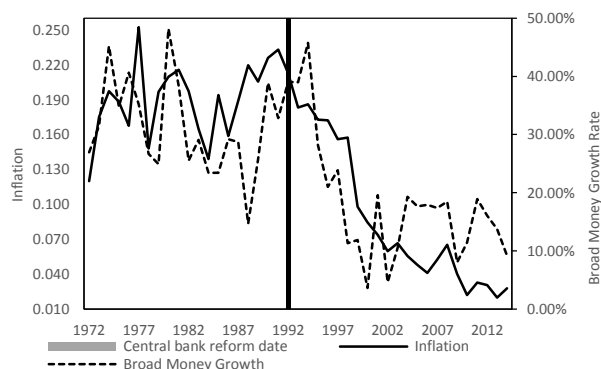


Figure 5(b): The left vertical axis represents adjusted inflation (solid line), the right axis shows the broad money growth rate, in percent (dotted line) and the horizontal axis represents time in the year. The vertical solid line represents the year of central bank reform. The figure depicts a triumph over inflation in the post-reform Colombia.

Both China and Colombia have achieved remarkable success in controlling inflation in their post-reform years. For both countries, inflation was at its peak in the prior year(s) of the reform. After central bank reform, average inflation rate was 3.0% and 10.3% for China and Colombia,

respectively.¹⁰ Compared to the pre-reform period, the post reform inflation rates almost halved for both countries. From **Figure 5**, it can be observed that the inflation rate declined in tandem with the broad money growth rate. There is one achievement of the reform that is not so apparent from the figure above. The contemporaneous correlation between broad money growth rate and inflation rate in the pre-reform era was -0.08 and 0.25 for China and Colombia, respectively. This correlation was 0.55 and 0.73 in the post-reform period. Therefore, monetary policy authority not only improved the inflation environment through a better monetary aggregate management but also managed to peg inflation rate more closely to the variation of monetary aggregates.

3 Hidden success of reform: A curious case of South Korea and the United Kingdom

Korea’s Inflation, Broad Money Growth Rate and Debt to GDP Ratio (1971-2014)

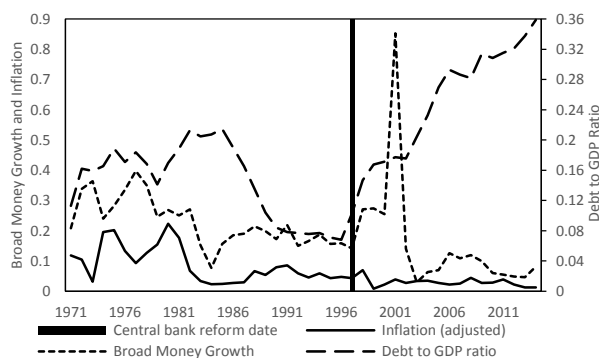


Figure 6(a): The left vertical axis represents adjusted inflation (solid line) and broad money growth rate (dotted line), the right axis shows the debt to GDP ratio (broken line) and the horizontal axis represents time in the year. The vertical solid line represents the year of central bank reform. Inflation was stable and low in South Korea before and after the reform, however, debt- to GDP ratio skyrocketed in the post-reform period.

UK’s Inflation, Broad Money Growth Rate and Debt to GDP Ratio (1970-2014)

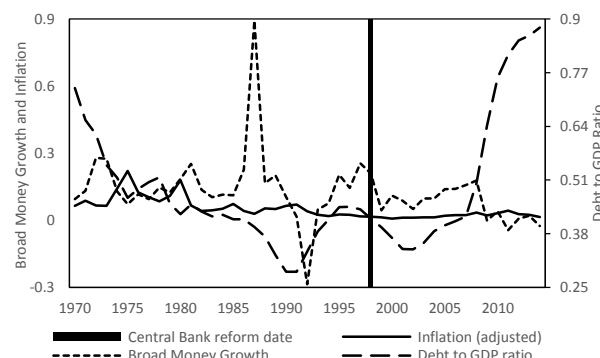


Figure 6(b): The left vertical axis represents adjusted inflation (solid line) and broad money growth rate (dotted line), the right axis shows the debt to GDP ratio (broken line) and the horizontal axis represents time in the year. The vertical solid line represents the year of central bank reform. A similar pattern is found in the UK as it is found in the South Korean case.

The Bank of Korea and the Bank of England became inflation-targeting central banks almost at the same time (1997-98). However, when the reform took place, both countries were already in the state of low inflation. This is an interesting case because pre-existing low inflationary

¹⁰ After 2000, Colombia’s inflation rate averaged 4.8%.

environment makes it hard to identify the impact of the central bank reform in the post-reform periods. Money growth declined significantly for both countries in the post-reform periods compared to the pre-reform periods. For Korea, the volatility of money growth increased after the reform but seemed to have no effect on the inflation rate. For the UK, on the other hand, money growth volatility declined. As a result, both inflation and money growth rate failed to provide concrete evidence that can be interpreted as a success of the reform. However, the real effect of the reform can only be understood when debt-to-GDP ratio is included in the figure. For both countries, debt-to-GDP ratio increased significantly in the post-reform era. Increasing debt-to-GDP ratio indicates the government's fiscal policy goal was to increase the deficit.¹¹ Martin (2015) argued the larger financial burden through accumulated debt will cause the inflation to rise as long as the central bank's monetary policy is accommodative. However, in this case, the independent central banks of these two countries were strictly inflation targeting and hence, less accommodative. The expected impact of rising deficit on the price level was not realized due to the inflation targeting nature of these central banks. Here, the hidden success of the central bank reform was to keep the inflation at the pre-existing low level even in the face of larger financial burden experienced by these economies over time. This mitigating effect of central bank monetary policy cannot be observed graphically or measured with simple statistical techniques presented in this section.

After carefully assessing the above three cases, it can be concluded that the affect of central bank independence on inflation is not straightforward. The reform may or may not work (Cases 1 and 2) and even if the reform has worked, it may be difficult to measure the true impact of the CBI on

¹¹ Higher debt-to-GDP ratio is assumed to be caused by the larger fiscal deficit, either through lower taxation or larger government expenditure relative to GDP.

the inflation (Case 3). The impact of the CBI on inflation rate may vary from country to country depending on the economic and political structure of these countries. Therefore, country-specific factors may play a key role while conducting an empirical analysis to identify the relationship between inflation and the CBI.

In summary, a panel model is needed to be specified that controls for both country-specific and time-specific un-observables. The next section will focus on these characteristics of the analysis to formulate the empirical methods to further conduct the research.

Section 3: Methodology and Data

This paper employs a panel data model consisting of one hundred and seventeen countries from around the world. Sample countries are chosen from different regions, political settings and different economic conditions. Nonetheless, the selection is constrained by the availability of the central bank independence (CBI) index, and also on the availability of the macroeconomic data from the reliable source(s). Data is collected on an annual basis, and the sample covers the period from 1970 to 2010. The paper works with an unbalanced panel dataset. Some of the observations are unavailable due to the changes in the political structure in Europe that has instigated the emergence of several new countries. The lack of historical surveys carried out in the developing nations has also contributed to the factor. In some cases, data is simply absent from the dataset used in this paper.

3 (a) Model: A simple two-way fixed effect model is employed to conduct the empirical study. The case studies and the residual plot analysis from the previous section suggest that control for both country-specific and time-specific un-observables are important to understand the CBI-inflation dynamics. From this point of view, a two-way within estimation method can be described in the following manner:

$$y_{it} - \bar{y}_i - \bar{y}_t + \bar{y} = (CBI_{it} - \overline{CBI}_i - \overline{CBI}_t + \overline{CBI}_{..})\beta + (X'_{it} - \overline{X}'_i - \overline{X}'_t + \overline{X}'_{..})\delta + \epsilon_{it} - \bar{\epsilon}_i - \bar{\epsilon}_t + \bar{\epsilon}_{..} \quad (2)$$

Here y_{it} is the adjusted inflation in country i and year t , CIB_{it} is the central bank independence index in country i and year t . The coefficient of interest is β ; X'_{it} represents the vector of control variable. It includes the financial openness index, trade policy, fiscal discipline, real GDP and broad money growth. A detailed description of these variables is provided in the data part of this section. \bar{y}_i is the average of the dependent variable of each country i , \bar{y}_t is the average of the dependent variable for each time t , and \bar{y} is the average of the dependent variable for the whole sample. Other variables of equation (2) can be described in a similar manner. Equation (2) can be re-written as followed:

$$y_{it} - \bar{y}_i + \bar{y} = \theta + \gamma_t + (CBI_{it} - \overline{CBI}_i + \overline{CBI}_{..})\beta + (X'_{it} - \overline{X}'_i + \overline{X}'_{..})\delta + \epsilon_{it} - \bar{\epsilon}_i + \bar{\epsilon}_{..} \quad (3)$$

Equation (3) represents a within estimation model where it only uses the deviation from the country level averages and uses time dummies (λ_t) to control for the time effects. It also includes a constant term θ . For both balanced and unbalanced panel, equations (2) and (3) can be used interchangeably. For the rest of the paper, equation (3) is used as the baseline model because it provides some additional information regarding the coefficients of the time dummies in the regression output.

Clustering is an important aspect of the two-way model. Standard errors can be simultaneously clustered at both country-level and yearly, assuming error terms are correlated both at the within-country level and within-time periods. However, two-way clustering cannot be carried out given the unbalanced nature of the panel setting of this paper. The problem is acute when analyzing the non-OECD, low-income and middle-income sub-sample classes separately. This is due to the insufficient number of observations encountered for these sub-sample classes. For these sub-sample classes, variance-covariance matrix is found to be non-positive semi-definite. Although this problem can be mitigated by the adjustment suggested by Cameron et al. (2008), the

modification still fails to identify the overall significance of the regression. Nonetheless, for the full sample and for the OECD sub-sample, two-way clustering is attainable. As a result of this limitation, the robust standard errors are clustered at the country level only. The estimated results incorporating two-way clustering for the full sample and other sub-samples are provided in Table C.1 of Appendix C.

A two-way (within) fixed effect model assumes the same slope and constant variance for all the countries. This assumption will be relaxed in the robustness analysis section where the paper will assume both intercept and slopes are different for different countries.

The objective of the study is to assess the relationship between the CBI and inflation controlling for other policy and macroeconomic variables. One major concern about the policy variables is that they tend to affect the dependent variable contemporaneously and over time. That is, some of the policy changes will affect the inflation outcome over the years. Rather than using distributed lagged values, which require subjective judgments, the model assumes that the policy variables will affect the average inflation experience over the years to come for a given country. Therefore, rather using the continuous series from 1970-2010, the model made observation 5 years apart that starts from 1970 and the last observation is made in 2010. For each observation point, the CBI and the financial openness index is taken as it is for a given year. Inflation data is geometrically averaged using the current year and the next four years.¹² Also, the real GDP growth and broad money growth data are averaged using the same manner. However, the other two policy variables, trade and fiscal policy indicators, are arithmetically averaged using the current year and the next

¹² For example, the 1970 observation for each country is constructed as followed: CBI and financial openness observation are made in 1970, corresponding inflation value is the geometric average of inflation over 1970-1974. This average inflation is regarded as the 1970 observation and so on. Last CBI and financial openness observation are made in 2010, therefore the corresponding inflation data for each country is the geometric average of inflation of that country over the years 2010- 2014.

four years.¹³ These two policy variables, unlike the CBI and the financial openness index, are more prone to yearly changes and on average, expected to affect the inflation rate on a yearly basis. Because of this kind of construction, rather having forty-one observations, the paper has limited itself to nine observations per country.

3 (b) Data: The CBI is the main variable of interest. As described earlier, the dataset is used from Garriga's (2016) published dataset. The dataset follows the attributes of the index proposed by Cukierman et al (1992) but extends it for large numbers of developing countries. Therefore, this dataset enables this paper to use a more diversified sample set. This paper uses the weighted CBI index for the analytical purpose. The weighting scheme is provided in Garriga (2016).

The dependent variable is the annual inflation rate; annual data is geometrically averaged over five years for each country to create one observation. The average inflation data is then transformed in the manner described in equation (1). The data on inflation is drawn from World Development Indicator (2017) dataset published by the World Bank.¹⁴

For the financial openness index, this paper uses the Chinn- Ito index (KAOPEN) that measures a country's degree of capital account openness. The dataset covers the period from 1970-2015 for one hundred and eighty- two countries. Chinn et al. (2006) provide a detailed description of the data series. For the trade policy indicator (TROPEN), the paper uses the trade openness series published by World Bank. Trade openness is measured as the sum of export and import of goods and services measured as a share of GDP of the country. Fiscal discipline indicator is represented

¹³ Trade policy indicator is chosen as the trade openness to GDP ratio and fiscal policy indicator is chosen as government debt-to-GDP ratio

¹⁴ Some country-level data are also collected from International Financial Statistics (IMF), respective central banks and Garriga (2016).

by the government debt-to-GDP ratio (DGR).¹⁵ The data of debt-to-GDP ratio is drawn from World Development Indicator (2017) dataset published by the World Bank. Both the trade openness and debt-to-GDP ratio variables are checked and extended with the help of the International Financial Statistics (IFS) dataset published by the International Monetary Fund.

Finally, the real GDP growth rate (GDP_GR) and the broad money growth rate (BM_GR) data are collected from the World Development Indicator (2017) dataset published by the World Bank. However, for broad money dataset, some country-level data are also collected from the IFS dataset and respective central banks.

For the member countries of the European monetary union, individual country level broad money data for the whole sample period is unavailable in most of the reliable data series publications.¹⁶ For these countries, country-specific liquid liabilities are considered to be a proxy to the broad money. This dataset is available in Global Financial Development (data code: GFDD.OI.07) dataset. This data is used as a proxy for broad money by World Bank to calculate the financial development index. This dataset is available only in 2000 US\$ and converted using the following formula: $Broad\ Money_{it} = Liquid\ Liability_{it}^{US\$(2000)} \times \frac{CPI_{US,t}}{CPI_{US,2000}} \times FX_t$; where CPI_t is the price level of the US goods and services, and FX_t is the currency exchange rate per US\$.

Financial openness dataset is available in logarithmic format; hence to make the coefficients comparable, other variables like the CBI, trade openness and debt to GDP ratio are also transformed logarithmically. This step is not mandatory but taken anyway to have some comparability among the coefficients of the regression analysis.

¹⁵ Debt is the entire stock of direct government fixed-term contractual obligations to others outstanding on a particular date. It is the gross amount of government liabilities reduced by the amount of equity and financial derivatives held by the government (WDI definition). Fiscal policy indicator is best represented by the central government's budget deficit as a share of total GDP of the country. However, this variable is unavailable for all the countries in the renown datasets. Due to lack of compatibility, this particular data sourced at individual country level is not considered.

¹⁶ Such datasets are World Development Indicator of World Bank, IFS of IMF, OECD data and Europa.

Panel level summary statistics is as followed:

Table 1: Panel Data- Summary Statistics

Variable		Mean	Std. Dev.	Min	Max	Observations
Inflation	Overall	0.2483	0.9775	-0.0304	15.6193	N = 953
	Between		0.4464	0.0256	2.2972	n = 117
	Within		0.8811	-1.9823	13.5704	T-bar = 8.1453
CBI Index	Overall	0.4810	0.2144	0.0167	0.9040	N = 918
	Between		0.1601	0.1619	0.8597	n = 117
	Within		0.1480	0.0752	0.9325	T-bar = 7.8462
Financial Openness Index	Overall	0.0533	1.5157	-1.9036	2.3744	N = 923
	Between		1.1433	-1.4477	2.3744	n = 117
	Within		1.0046	-3.3062	3.2377	T-bar = 7.8889
Trade Openness	Overall	0.7126	0.4635	0.0679	4.1086	N = 924
	Between		0.4215	0.2011	3.4324	n = 117
	Within		0.1689	-0.0798	1.9095	T-bar = 7.8974
Debt to GDP Ratio	Overall	0.5844	0.5864	0.0097	7.5353	N = 917
	Between		0.4208	0.0633	3.0441	n = 116
	Within		0.4142	-1.8569	5.9821	T-bar = 7.9052
Real GDP Growth	Overall	0.0334	0.0347	-0.3152	0.1866	N = 937
	Between		0.0177	-0.0127	0.1038	n = 117
	Within		0.0304	-0.2880	0.1915	T-bar = 8.0086
Money Growth	Overall	0.2907	0.8556	-0.5516	11.7358	N = 938
	Between		0.4413	0.0093	2.3686	n = 117
	Within		0.7546	-1.9379	9.6579	T-bar = 8.0171
Adjusted Inflation	Overall	0.1152	0.1524	-0.0313	0.9899	N = 953
	Between		0.0883	0.0245	0.4247	n = 117
	Within		0.1272	-0.2495	0.8243	T-bar = 8.1453

Note: Panel level summary statistics includes the dependent variable (inflation) and independent variables considered for the baseline model. Time Frame: 1970-2010; each observation is made with a 5 years gap. Std. Dev means standard deviation, Min means minimum value of the observations and Max means maximum value. N represents the total number of observations and n represents the number of countries included. T-bar represents average number of observations per country. Financial openness index is in logarithmic form. All other variables statistics are presented in fraction.

Inflation data shows a mean value of 24.8% with overall standard deviation of 97.8%. This mean is on the higher side and influenced mainly by the hyperinflationary periods. As mentioned earlier, this outlier driven dataset can cause some serious problems in the regression analysis. Table 1 also reports the statistics for the adjusted inflation, measured from using equation (1). The overall and within variation of this variable is much refined, and it is able to reduce the weight of the outliers.

One main concern with CBI index and financial openness index is that whether they possess enough within variation to be considered as a time variant regressors. Table 1 shows, both variables have within variation, and their overall variation is almost equally driven from within and between variations. Among other variables, money growth seemed to have a high mean (29.1% average annual growth) and variation. The between variation of money growth and inflation is found to be similar for the sample countries.

The name of the countries used as the sample in this paper, along with their income level (high, low and medium) as well as the geographic region they belong to, is reported in the Table A of Appendix A.

Section 4: Results

This study focuses on the conditional correlation between the CBI and inflation that has been experienced across countries and over time. A two-way fixed effect model represented by equation (3) is chosen for the study. To identify whether or not country specific heterogeneity is correlated with the regressors, a Hausman test has been performed. The test result suggests that the fixed effect estimators are consistent and efficient. The Breusch–Pagan LM test suggests that the pooled regression model is not appropriate for this analysis. However, the robustness analysis part of this section will compare the results from the random effect model and the pooled regression model with the baseline two-way fixed effect model.

After selecting the model, a further analysis is conducted to identify the presence of the group-wise heteroskedasticity and autocorrelation in the panel data. A modified Wald test is performed to identify the presence of group-wise heteroskedasticity and a LM test proposed by Wooldridge (2002) is conducted to identify the presence of autocorrelation in the panel data. The tests conclude that there are group-wise heteroskedasticity and autocorrelation present in the data. Taking these

features under consideration, robust standard errors are used in the two-way fixed effect model. The standard errors are clustered at the individual (country) level. These test results are presented in Appendix B.¹⁷

Table 2 presents the estimates of the fixed effect model using equation (3). The first column is a single variable regression, where the adjusted inflation is regressed against the weighted CBI index. The parameter estimate shows the negative sign, as expected, and it is significant at the 10% level. The second column shows the estimates of the baseline model; however, no time fixed effects are considered under this scenario ($\lambda_t = 0$). The CBI coefficient has the desired negative sign and significant at the 1% level. The result also shows that lesser control over the cross-border capital movement has a negative effect on the inflation (at 1% significance level), all else equal. The result supports the findings from previous studies (Gruben et al. 2002, Gupta 2008). This is an important finding of this paper because it shows the importance of capital account openness in curbing inflation. Gupta (2008) argued that capital account liberalization mitigates the policymaker's incentive generate inflationary shock. Central bank's monetary policy will be closely monitored by the private sector and any signal of weak monetary policy will be penalized with capital flight. That is, the interest rate elasticity of money demand will be higher for the countries with more capital account openness (Gruben et al. 2002). Trade openness also shows the desired negative sign, but the parameter estimate is not significant at any level. Government debt-to-GDP ratio has the positive sign as expected and marginally significant at the 10% level. Both the macroeconomic variables show the desired effect on inflation.

¹⁷ Hausman test, Breusch – Pagan LM test and Wald tests are discussed in detail in Baltagi (2008).

Table 2: Two-Way Fixed Effect Model

Variable	Dependent Variable: Adjusted Inflation					
	(1) (Full Sample)	(2) (Full Sample)	(3) (Full Sample)	(4) (OECD)	(5) (Non- OECD)	(6) Difference (4)-(5)
CBI	-0.0356* [0.0202]	-0.0450*** [0.0136]	-0.0261** [0.0131]	0.0001 [0.0078]	-0.0395* [0.0209]	0.0396* [0.0223]
Financial Openness		-0.0240*** [0.0033]	-0.0209*** [0.0035]	-0.0119*** [0.0028]	-0.0235*** [0.0047]	0.0116** [0.0055]
Trade Openness		-0.0297 [0.0185]	-0.0072 [0.0224]	0.0149 [0.0342]	-0.0140 [0.0273]	0.0289 [0.0433]
Fiscal Discipline		0.0117* [0.0068]	0.0153* [0.0080]	0.0057 [0.0075]	0.0123* [0.0096]	-0.0066 [0.0121]
GDP Growth		-1.0758*** [0.2756]	-1.0148*** [0.3064]	-0.9744*** [0.2459]	-1.0480*** [0.3753]	0.0736 [0.4469]
Money Growth		0.0997*** [0.0189]	0.1000*** [0.0189]	0.2168*** [0.0448]	0.0930*** [0.0164]	0.1238** [0.0470]
Constant	0.0715*** [0.0222]	0.0776*** [0.0180]	0.1136*** [0.0317]	0.1141*** [0.0352]	0.0844* [0.0469]	0.0945*** [0.0333]
No of countries	117	116	116	35	81	116
Observations	915	818	818	277	541	818
F-stat	14.67	31.16	21.78	66.68	16.56	42.85
R ²	0.13	0.56	0.58	0.75	0.56	0.59
ρ	0.3764	0.4351	0.4449	0.3954	0.4477	0.4591
Time Dummies	Yes	No	Yes	Yes	Yes	Yes

Note: *, ** and *** means 10%, 5% and 1% level of significance, respectively. 1st column shows the regression between the CBI and inflation only. 2nd column show the baseline regression without the time fixed effect. 3rd column is the main model of the paper. 4th and 5th column show the result for the OECD and non-OECD country level regression, respectively. Last column shows the differences between the estimates of OECD and non-OECD countries. Columns (3)-(5) uses equation (3) presented in the previous section. Time frame considered for all regression are 1970- 2010. Regression results from columns (2)-(6) show the number of countries are 116 because government debt to GDP ratio data for Niger is unavailable. ρ represents the fraction of variation due to α_i . Robust standard errors is used in all cases, they are clustered at the country level (figure in parentheses).

Column (3) of Table 2 is the focal point of this paper. It includes the time fixed effects. The statistical rationale to include the time fixed effect is justified by a combined F-test.¹⁸

This paper has used an adjusted measure of inflation, as shown in equation (1), as the dependent variable for all the regressions. The coefficients depict the relation between the regressors and adjusted inflation, all else equal. Before any further analysis can be pursued, the following

¹⁸ F-Stat is $F(8, 115) = 12.34$ and the null hypothesis that all the time dummies are statistically insignificant is rejected at all significance levels. The joint test confirms the rationality of including time fixed effect. Ignoring the time effect may introduce omission bias in the model.

transformation of the coefficients is deemed necessary to understand the relation between inflation and the regressors:

$$\text{Approximate } \Delta \text{Inflation} = \frac{\beta}{1-\beta} \text{ for CBI and } \frac{\delta}{1-\delta} \text{ for all } X \quad (4)$$

Column (3) shows that the negative effect of the CBI and capital account openness are still significant (at 5% and 1% level, respectively) and the positive effect of fiscal discipline prevails at the 10% level of significance. The coefficient of the trade openness variable is still insignificant, and the magnitude is close to zero. The reason for this insignificance can be described as the small open economies' inability to exert influence on the terms of trade (Bogoev et al. 2012). The magnitudes of all the coefficients are found to be higher compared to the Column (2) estimates, representing the importance of using time fixed effects.

A percentage change in the CBI index is expected to reduce inflation by 2.5%, all else equal. The sign and magnitude are comparable to the findings of Cukierman et al. (1992), albeit their relation was not found to be significant for the full sample. This may be caused from a smaller sample size used by Cukierman et al. (1992). The magnitude of the impact is reasonable and shows that the legal reforms, on average, has a substantial impact on inflation.

An increase in the financial openness index decrease the inflation by 2.1%, all else equal. This result is compatible with the findings of Gruben et al. (2002), but the magnitude is on the lower side of the range estimated by Gruben et al. (2002). The result provides an important evidence, that countries with less capital control is expected to experience lower inflation rates, all else equal.

A percentage increase in the debt-to-GDP ratio increases the inflation by 1.6% on average. The sign and the magnitude of the estimate is believable but economically inconclusive. This is because the government debt does not increase the inflation itself, unless it is monetized. Therefore, to understand the role of government debt on inflation, a deeper analysis is required.

The government debt and its monetization issue can be better understood if the combined effect of the CBI and debt-to-GDP ratio on inflation is comprehended. The estimated parameters of these variables have opposite signs with different magnitudes, and both are significant at least at 10% level. Martin (2015) argued that the benefits from increasing the CBI in reducing inflation will be eroded by the actions of the fiscal authorities, as they will be induced to increase the deficit (thus increasing debt-to-GDP ratio) to reduce intertemporal distortion. In section 2 of this paper, such incident has been observed in case study # 3. To analyze Martin's hypothesis, a test has been developed to identify the affect of the linear combination of these two estimated coefficients on inflation. The null hypothesis of the test is as follows:

$$H_0: \beta + \delta_{LN_DGR} = 0 \quad (4)$$

That is the beneficiary effect of the CBI (β) is expected to be abated by the decisions of the fiscal authorities (δ_{LN_DGR}) in such a manner that their combined long-term effect on inflation will not be significantly different from 0. The magnitude of the combined coefficient has been found to be -0.0109 with a standard error of 0.0131, a both way t-test shows that the coefficient is insignificant at all levels. The result confirms Martin's hypothesis and concludes that benefit from the increasing the CBI is alleviated through the actions of the fiscal authorities over the long-term.

Column (3) answers the first research question- CBI has a conditional negative correlation with the inflation. This finding is confirmed by some previous studies (Garriga 2016, Grilli et al. 1991, Acemoglu et al. 2008). Although combined result finds a reliable answer to the first research question of the paper, it sheds little light on the second question of this paper. As argued in section 2, the impact of changing the CBI is expected to be different for different countries. Columns (4) and (5) of Table 2 investigates this issue for two set of sub-samples: Column (4) includes only the OECD countries and Column (5) presents the result for the non-OECD countries. For the OECD

countries, the CBI coefficient is found to be near zero and insignificant, whereas, for the non-OECD countries, the coefficient is found to be negative and significant at 10% level. Thus, central bank reform has a heterogeneous effect on OECD and non-OECD countries. Column (6) shows that the difference between the CBI estimates are significant at 10% level. This finding provides a preliminary evidence in favour of heterogeneity, nonetheless, administers only a partial answer to the second research question.

Acemoglu et al. (2008) argued that countries with strongest institutions and weakest institutions are expected to be less affected by the central bank reform, only the countries with intermediary constraints on institutions will be affected significantly. To find a clearer answer to the second research question, a thorough analysis of the aforementioned hypothesis is required.

Clearly, the current differentiation between OECD and non-OECD countries are insufficient to analyze the stated hypothesis. Thus, the paper divides the sample countries into three groups, based on their 2016 per capita income. These groups are named as the low-income group (DEV-1), middle-income group (DEV-2), and high-income group (DEV-3). These groups are formed based on the World Bank definition¹⁹ but instead of using four groups as proposed by the institution, the paper is settled with only three groups, mainly due to lack of observations. Countries with per capita income lower than US\$3,000 are included in the low-income group, while countries with per capita income greater than US\$12,000 are included in the high-income group. Rest of the countries are placed in the middle-income group. Here an implicit assumption is made that the countries with lower income will have weaker institutions and countries with higher income will have the strongest institutions.

¹⁹ <https://datahelpdesk.worldbank.org/knowledgebase/articles/906519-world-bank-country-and-lending-groups>.

The anticipated result of the analysis is that the CBI coefficient will be insignificant for the DEV-1 and DEV-3 group, while negative and significant for the DEV-2 group. That is, the analysis will focus on the assumption made by the Acemoglu et al. (2008)- the countries with intermediary institutional constraints is expected to benefit most from the central bank reform.

Table 3: Two-Way Fixed Effect Model- Heterogeneity of the CBI-Inflation Relation Based on Differential Per Capita Income of the Country.

Variable	Dependent Variable: Adjusted Inflation			
	(1) (Full Sample)	(2) (DEV-1)	(3) (DEV-2)	(4) (DEV-3)
CBI	-0.0261** [0.0131]	0.0090 [0.0631]	-0.0489** [0.0223]	-0.0026 [0.0107]
Financial Openness	-0.0209*** [0.0035]	-0.0177** [0.0070]	-0.0268*** [0.0063]	-0.0149*** [0.0043]
Trade Openness	-0.0072 [0.0224]	0.0118 [0.0374]	-0.0711* [0.0351]	-0.0072 [0.0288]
Fiscal Discipline	0.0153* [0.0080]	0.0320* [0.0167]	0.0098 [0.0175]	0.0090 [0.0073]
GDP Growth	-1.0148*** [0.3064]	-1.3723* [0.7381]	-1.0449*** [0.2202]	-0.5377*** [0.1850]
Money Growth	0.1000*** [0.0189]	0.0912*** [0.0209]	0.0888*** [0.0209]	0.2266*** [0.0450]
Constant	0.1136*** [0.0317]	0.1950* [0.1071]	0.0325 [0.0545]	0.0862*** [0.0298]
No of countries	116	34	40	42
Observations	818	236	262	320
F-stat	21.78	20.20	11.93	39.84
R ²	0.58	0.47	0.62	0.75

Note: *, ** and *** means 10%, 5% and 1% level of significance respectively. 1st column is the baseline model presented in the Column (3) of Table 2. 2nd, 3rd and 4th columns show the regression results for the low-income, middle-income and high-income countries, respectively. Columns (1)-(4) uses equation 3 presented in the previous section. All regressions consider both individual effect and time fixed effect. Time frame considered for all regression are 1970- 2010. Robust standard errors are used, they are clustered at the country level (figure in parentheses).

Table 3 shows the result of the analysis. For instant comparison, Column (3) of Table 2 is reproduced here as the first column. Table 3 results confirm that the middle-income countries benefit most from the central bank reform. For these countries, the sign of the CBI coefficient is negative, and the magnitude is higher than that of the full sample analysis. Low-income countries have a low and insignificant coefficient and the sign is opposite to the desired outcome; high-

income countries have the negative but insignificant coefficient. However, to confirm the Acemoglu et al's (2008) proposition, Table 3 needs some expansion by adding interaction terms to the regression model and increase the understanding by examining the slope differences among these countries. Table C.2 of appendix C presents the result of the differenced regression.

The differenced regression shows that inflation in the middle-income countries decline by 4.4% more when compared to the high-income countries for a percentage change in the CBI index. The result is significant at 10% level. This difference shows that the legal reform matters for these countries as there are scope to improve the inflation outcome by improving the central bank's governance and operating structure. When compared to the low-income countries, the middle-income countries' inflation declines by 5.5% more for a percentage increase in the CBI index. However, the difference is not significant at any level.

It can be concluded from the evidence provided in Tables 3 and C.2, that the central bank reform will only work when the economic context is right. High-income countries that already enjoy strong institutions and a culture of pristine accountability will benefit less from any further reform because there will be less room for further improvement. Also, weaker economies, lacking the ability and willingness to form stronger institutions, will also benefit less from the reform, because the other branches of the system will be less efficient, and the relevance of the reform will not be properly understood by the authorities. For countries with a medium income level, the central bank reform works better. Though these countries also have weaker institutions to start with, the implementation of the central bank reform is much more effective and well understood compared to that of the low-income countries. For these countries, the central bank reform comes with a broader package (e.g., Argentina) and necessary steps are taken to make the reform successful (Acemoglu et al. 2008).

Table C.2 further shows that the financial openness has no differential effect on the inflation outcome. On the other hand, Table 3 shows that financial openness is significant for all the income groups at least at 5% level and the magnitude of the estimates lie between 1.5%-2.6%. Combining the evidence found in Tables 3 and C.2, this paper concludes that the countries enjoying lesser restriction on international capital movement are more successful to curb inflation compared to the more restrictive countries, all else equal. This finding is consistent with the findings of Gruben et al. (2002) and the result does not depend on the country's level of per capita income. Trade openness also helps the middle-income countries to curb inflation. Romer (1993) argued that the openness mitigates the output-inflation trade-off.

Finally, Table 3 provides evidence that monetary aggregate growth has a positive relationship with inflation, and this relationship is significant at all levels and for all income groups. For the high-income nations, the magnitude of the money growth coefficient is quite large, a percentage increase in the money growth leads to 29.3% increase in inflation. Table C.2 shows this sensitivity is higher than that of the middle-income and low-income groups, by 16.0% and 15.6%, respectively. All else equal, on average, money growth has a fiercer effect on the inflation of high-income countries compared to the other income groups. The results from Tables 2 and 3 confirm the importance of the quantity theory of money and its inextinguishable relevance in the determination of the inflation over the last four decades.

The baseline model (equation 3) used in this paper can be extended in several directions by including some more variables that are used in the previous studies. Dolmas et al. (2000) argued that wider income inequality will cause higher inflation for a given level of the CBI. However, the channel used in this case is the welfare spending of the government, which might be correlated with the debt to GDP ratio of the country. This paper has developed two extended models, one that

includes income inequality as a variable but excludes the debt-to-GDP ratio, and the other that includes both variables. Both models show that income inequality has no significant effect on inflation, thus fail to support the findings of Dolmas et al. (2000).

Human capital plays a major role in the formation and functioning of an economy. Higher human capital is desired for higher growth, all else equal. There is a significant difference in human capital between the high-income and low or middle-income countries. Another possible extension of the model will be to include the human capital factor into the baseline model. Assuming the nature of the human capital will be different for different countries, the paper has divided the countries into OECD and non-OECD sub-samples for the experiment. The inclusion of human capital index (HCI) in the baseline model shows that human capital has a positive correlation with inflation for the non-OECD countries (10% level of significance) and negative correlation for the OECD countries (1% level of significance), all else equal. Finally, as proposed by Acemoglu et al. (2008), political rights and civil rights of the residents of a country plays a crucial part in the success of the policy reform. An extension of the baseline model includes a variable that represents the political and civil rights enjoyed by the people in a particular country but found no evidence to confirm the proposition of the Acemoglu et al. (2008). The regression results of the extended models are produced in Table C.3 of Appendix C. Notes of Table C.3 includes some descriptions regarding the income inequality, human capital and political right variables.

4 (a) Robustness Analysis:

Table 4 investigates the robustness of the observation made in *Figure 2(a)* of section 2, that suggests the negative relation between the CBI and inflation has become more evident after 1990. Considering the reforms and liberalization efforts has proliferated in the late 1980s and early

1990s, the paper assumes that the relation between the inflation and independent variables should differ significantly before and after 1990, and thus deserves a separate and reflective examination.

Table 5 focuses on the effect of different assumption(s) regarding the regression intercept and slope characteristics and impact of these assumptions on the regressor coefficients and their inferences. This table will particularly work with random effect and mixed-effect models.

Finally, this sub-section will investigate the CBI-inflation relation by adopting a different measure of monetary aggregate and identify whether the relationship is statistically and economically meaningful or not.

i) The CBI-inflation relation before and after 1990: Table 4 is constructed using the similar structure of Table 3, however, divides the sample into two periods: pre and post-1990. Column (1) of Table 4 provides a full sample analysis for the aforementioned periods, separately. The CBI coefficient is insignificant in the pre-1990 years; however, it is negative and marginally significant (at 10% level) after 1990. This is expected, as the concept of the CBI has only been popularized since the late 1980s. Countries around the world have made a conscious effort to concede central banks more independence only after a noticeable contribution and argumentation conveyed by the renown economists and economic institutions in favour of the independence. Money growth effect is almost similar in both periods, suggesting the relationship between monetary aggregate and price level holds for the entire sample periods for all the sample countries.

Low-income economies in Column (2) show a negative and significant correlation between inflation and the CBI before 1990. Despite the significance of the relation, the magnitude of the coefficient exerts some doubt about this relationship observed in Column (2).

Table 4: Two-Way Fixed Effect Model- The CBI-Inflation Relation in Pre and Post 1990

Variable	Dependent Variable: Adjusted Inflation							
	(1) (Full Sample)		(2) (DEV-1)		(3) (DEV-2)		(4) (DEV-3)	
	Before 1990	After 1990	Before 1990	After 1990	Before 1990	After 1990	Before 1990	After 1990
CBI	-0.0075 [0.0123]	-0.0278* [0.0164]	-1.1498** [0.5296]	0.0428 [0.0374]	-0.0092 [0.0215]	-0.0540* [0.0304]	-0.0137 [0.0239]	0.0009 [0.0102]
Financial Openness	-0.0236*** [0.0055]	-0.0208*** [0.0049]	-0.0180 [0.0130]	-0.0085 [0.0065]	-0.0284*** [0.0069]	-0.0288*** [0.0077]	-0.0207*** [0.0070]	-0.0065*** [0.0023]
Trade Openness	-0.0076 [0.0385]	-0.0119 [0.0265]	-0.0682* [0.0383]	0.0178 [0.0375]	-0.0757 [0.0544]	-0.0792* [0.0432]	0.0171 [0.0593]	0.0023 [0.0335]
Fiscal Discipline	-0.0046 [0.0118]	0.0144 [0.0110]	-0.0274 [0.0248]	0.0291** [0.0125]	0.0104 [0.0197]	0.0204 [0.0243]	0.0084 [0.0139]	0.0055 [0.0098]
GDP Growth	-0.6798*** [0.2086]	-1.2338*** [0.3874]	-0.3819 [0.2701]	-1.8688** [0.8905]	-1.1801** [0.4885]	-1.0948*** [0.3364]	-0.8120** [0.3327]	-0.7464*** [0.1959]
Money Growth	0.0933*** [0.0158]	0.0964*** [0.0255]	0.0840*** [0.0132]	0.1860*** [0.0271]	0.1012*** [0.0221]	0.0773*** [0.0137]	0.1572*** [0.0341]	0.4085*** [0.0579]
Constant	0.0804* [0.0429]	0.1213*** [0.0224]	-1.0560** [0.4907]	0.1805*** [0.0499]	0.1877** [0.0725]	0.1142*** [0.0418]	0.1118** [0.0456]	0.0588*** [0.0171]
No of countries	77	116	23	34	23	40	31	42
Observations	276	542	77	159	78	184	121	199
F-stat	8.96	17.26	10.27	13.58	76.29	11.58	8.57	11.36
R ²	0.67	0.48	0.10	0.40	0.52	0.52	0.74	0.81

Note: *, ** and *** means 10%, 5% and 1% level of significance, respectively. 1st column presents the full sample analysis of the baseline model, however divides the sample into two periods: first one starting from 1970 and ends before 1990, while the second sample starts from 1990 and ends in 2010. 2nd, 3rd and 4th column does the same, but for the sub-sample divided into DEV-1 (low-income economies), DEV-2 (middle-income economies) and DEV-3 high-income economies. Column 1-4 uses equation 3 presented in the previous Section. Regressions include both individual effect and time fixed effect. Robust standard errors are used, they are clustered at the country level (figure in parentheses)

There lies no feasible economic or political explanation for this relationship. These economies, however, have benefited from the trade openness in the earlier times, but the benefits are faded away in the later years. Fiscal policy plays an important (5% level of significance) role in the determination of inflation outcome in the later years. As most of these economies are relatively closed in terms of capital account convertibility, the coefficient for the financial openness is found to be insignificant for both the periods. This is in contrast with the findings of the Column (2) of Table 3, where the financial openness showed a significant negative relationship with inflation. Therefore, the evidence from the low-income economies seem to be contradictory and cannot be considered as robust.

Middle-income economies in Column (3) show that the CBI-inflation relation improved after 1990 and provide evidence that these are the countries that benefit most from the central bank reform. They also exhibit a stable and significant relationship between international finance flow and inflation. Trade has become more important in controlling the price level after 1990. Monetary aggregate growth and inflation relation seem to be stable over the entire period.

Developed economies in Column (4) show no significant relationship between inflation and the CBI in any of the sub-periods. Effect of the reform cannot be interpreted accordingly for these economies, at least from this setup. As argued earlier, these economies have already placed a robust and accountable system earlier, hence, incremental benefits from the reform might be too small to be identified through a statistical analysis. The financial openness coefficient is significant (1% level) for both periods, however, the magnitude of the coefficient experienced a decline after 1990. This is because these economies have been open for a long time, and any further benefits from capital mobility are expected to be diminishing. The relationship between the monetary aggregate and the inflation seemed to be volatile in these economies compared to the emerging economies. Inflation has become more sensitive to monetary growth after 1990.

ii) Alternative approaches for panel data modelling: Table 5 investigates the CBI-inflation relationship using several other alternative panel models with different assumptions about the intercept term and regression slopes. For instant comparison, Column (3) of Table 2 is reproduced here as the first column of Table 5. Column (2) presents the results of the pooled regression. This variation of the pooled regression assumes country-specific effect $\alpha_i = 0$ but $\lambda_i \neq 0$. The magnitude of the coefficients of the CBI and financial openness are higher compared to other models. Also, the sign of the fiscal policy coefficient is found to be opposite to the desired outcome. None of the policy variables are found to be significant, except for the financial openness coefficient estimate.

Table 5: The CBI-Inflation Relation- Different Estimation Techniques.

Variable	Dependent Variable: Adjusted Inflation					
	1 (Two-way Fixed)	2 (Pooled)	3 (One-way Random)	4 (Two-way Random)	5 (Mixed- intercept)	6 (Mixed- Region Dummy)
CBI	-0.0261** [0.0131]	-0.0058 [0.0104]	-0.0209** [0.0096]	-0.0228*** [0.0076]	-0.0186* [0.0097]	-0.0113* [0.0107]
Financial Openness	-0.0209*** [0.0035]	-0.0194*** [0.0036]	-0.0211*** [0.0030]	-0.0216*** [0.0023]	-0.0210*** [0.0031]	-0.0103*** [0.0022]
Trade Openness	-0.0072 [0.0224]	-0.0142 [0.0103]	-0.0091 [0.0121]	-0.0135 [0.0084]	-0.0108 [0.0126]	-0.0007 [0.0080]
Fiscal Discipline	0.0153* [0.0080]	-0.0003 [0.0069]	0.0087 [0.0062]	0.0072 [0.0048]	0.0080 [0.0071]	0.0100** [0.0046]
GDP Growth	-1.0148*** [0.3064]	-0.7886*** [0.2732]	-1.0069*** [0.2543]	-0.9588*** [0.1053]	-0.9413*** [0.2798]	-0.7092*** [0.1780]
Money Growth	0.1000*** [0.0189]	0.1179*** [0.0257]	0.1052*** [0.0211]	0.1047*** [0.0041]	0.1046*** [0.0207]	0.2891*** [0.0332]
Constant	0.1136*** [0.0317]	0.0860*** [0.0213]	2.3905*** [0.5446]	0.0993*** [0.0115]	0.1047*** [0.0236]	0.0741*** [0.0218]
No of individual effects	116	-	116	1	116	116
Observations	818	818	818	818	818	818
F-stat	21.78	22.95	-	-	-	-
Wald test	-	-	244.76	1046.72	-	-
R ²	0.58	0.60	0.58	-	-	-
Region	-	-	-	-	-	13

Note: *, ** and *** means 10%, 5% and 1% level of significance, respectively. 1st, 2nd and 3rd column uses the two way fixed effect model, pooled regression model and one way random effect model, respectively. 4th column represents the two-way random effect model. 5th and 6th columns produce the results from mixed effect models that uses maximum likelihood estimators. Model in column 4 assumes only that the constant terms will vary from country to country, but the slope of the regressors will be fixed. 5th column, on the other hand also produces the result of mixed effect model but this time the model assumes that the intercepts will differ only from one region to another and the slope of the regressors will also vary from country to country. Unlike other models that uses robust standard errors clustered at the country level (figures in parentheses), column 6 uses robust standard errors clustered at the regional level. Column 4 uses regular standard errors. Time frame considered for all regression are 1970- 2010.

In Column (3), random effect model with small sample Swamy-Arora estimators with country-level variance component is used (Swamy et al. 1972). Also, instead of year dummies, a continuous time trend is used. The standard errors are robust and clustered at the country level. The results from Column (1) (two-way fixed effect) and Column (3) (random effect with Swamy-Arora estimator) provide similar results. The magnitude of the regressor estimates, their signs and significance are comparable. However, the debt-to-GDP ratio is insignificant in the random effect regression. The problem with the Column (3) specification is that it is a one-way error component

model. That is α_i is a country-specific random heterogeneity and included in the regression as an error component ($\alpha_i + \epsilon_{it}$). Time-specific random heterogeneity has been ignored here. Column (4) represents the two-way random effect model, where both time-specific and country-specific random heterogeneity is included as the error components ($\alpha_i + \lambda_t + \epsilon_{it}$). No time trend has been used for this specification.

The coefficient estimates of Column (4) are similar to those found in Column (1) and (3). The CBI-inflation relation is now significant at the 1% level, along with financial openness, GDP growth and money growth. The signs of the coefficients are as desired. However, standard errors are neither robust nor clustered, which may cause the standard errors to be deflated, thus resulting in a higher significance level for the regressor estimates.

The last two columns employ the mixed-effect regression model. The mixed model considerations are made by assuming that there are some elements of both fixed and random effect present in the data generation process. For Column (5), each country is assumed to have their own intercept that is randomly deviating from the mean intercept of the sample. It also assumes the slope of the regression is fixed, therefore, the result will be a group of parallel lines each representing a country. Also, the errors around each regression line are assumed to be uncorrelated.

Column (6) of Table 5 introduces more complexity in the analysis. First, the assumption that the slopes of the regression are fixed is relaxed here assuming different slopes for different countries. The study also extends its analysis by introducing a regional dummy variable into the system.

The rationale for introducing a regional dummy arises from the consideration that the countries are more affected by their regional economic activities than the world economy as a whole. Also, regional geography plays a crucial role in determining a country's nature of economic activity. For example, war has crippled the economic prosperity in some Middle Eastern and North African

countries. Some countries are affected in these regions by war, although they are not directly participating in any kind of war. Some other examples are as follows: a) the states within the European Union enjoys free trade with each other that is inaccessible to other countries; b) NAFTA revision is expected to affect the North American countries more compared to other countries; c) Economic activities of the Pacific countries are frequently interrupted by the natural calamities compared to the other parts of the world. In a nutshell, it is highly unlikely that two distinctive regions will be affected by the same incident in a similar manner over a long period of time. This paper assumes that the regional setting of a country will only affect the intercept of the regression and a country, classified under a particular region, will have different slope and intercept. Time dummies are assumed to only have fixed effect and no random effect.

Columns (5) and (6) of Table 5 show the fixed effect results of the mixed effect model. The random effect results are presented in the Table C.4 of Appendix C. Column (5) of Table 5 reports the fixed effect estimates of the random slope assumption; and the results estimated are found to be similar to the baseline fixed effect model. Column (6) of Table 4 shows the fixed effect result of the mixed-effect model that includes the regionally induced variation in the intercept and also allows for the variation in both intercept and the slope at the country level. The random effect results in the Table C.4(b) of appendix C shows none of the standard deviations of the slope or intercept produce a conclusive evidence that the regional effect is significant or the variation of the slope at the country level is a good statistical choice.

After considering all the possible model specification and their results, this study can conclude that the result presented in Column (1) (baseline fixed effect model) is a reasonable choice and can be approached confidently in the multi-country setting. The conditional correlation between the CBI and inflation is found to be significant at least at 10% level in all the models, except the pooled regression analysis. The coefficient estimates range from -0.0261 to -0.0113 (except pooled OLS), suggesting that a percentage increase in the CBI index (more independence) will be associated

with 1.0%-2.5% fall in inflation, on average. The conditional correlation between the financial openness index and inflation is found to be significant at 1% level for all the models. The coefficient estimates range from -0.0216 to -0.0103 for all models, suggesting that a percentage increase in the financial openness index will be associated with 1.0%-2.0% fall in average inflation. The relation between fiscal policy and inflation is not significant in all the models; however, a percentage increase in the government debt-to-GDP ratio may increase the average inflation by 0.7%-1.6%.

iii) Alternative variables: Although this paper uses the CBI index as a measure of legal independence of the central bank and assumed it has a low correlation with the broad money growth rate, there is a possibility that the broad money growth is affected by the CBI index itself.²⁰ For this, to remove the central bank's influence from the broad money growth rate, this paper changed the monetary aggregate variable and used money velocity as an alternative measure of the monetary aggregate. The money velocity is defined as followed:

$$\text{Money Velocity} = \frac{\text{Real GDP growth rate} \times \text{Inflation rate}}{\text{Broad money growth rate}} \quad (5)$$

Due to the volatile nature of inflation, the money velocity is further modified as followed:

$$\text{Adjusted Money Velocity} = \frac{\text{Money Velocity}}{1 + \text{Money Velocity}} \quad (6)$$

Other variables and the structure of the model is kept same. The coefficient of the money velocity is found to be insignificant. However, no significant change in the CBI coefficient has been observed. The paper concludes that the money velocity is not the best possible choice as a measure of monetary aggregate for this analysis.

²⁰ Although the variance inflation factor and pairwise correlation suggest there is low correlation between these two variables.

Section 5: Conclusion

This paper investigates the relationship between the central bank independence and inflation in a panel data setting that involves one hundred and seventeen countries. The observations are made on an annual basis from 1970 to 2010. A two-way fixed effect approach has been chosen as the baseline empirical model that considers both the time and country-specific heterogeneity.

Since the late 1980s, central bank autonomy has been proposed as a possible remedy for inflation control, and governments around the world have granted central banks more autonomy in conducting monetary policy. This study has found that, on average, the central bank independence and inflation have a negative correlation, after controlling for other policy and macroeconomic variables. However, the CBI-inflation relationship is found to be neither statistically nor economically significant for the high and low income countries. Only the middle-income economies show a statistically and economically meaningful relationship between these two variables. As argued earlier, these economies are actively trying to develop their institutional standards and wilfully opting for a greater central bank autonomy under a broader policy package targeted to curb inflation. The setting works for these countries because the previous policy settings seemed to be accommodative to fiscal policy or suboptimal due to other political reasons.

On the other hand, the high-income economies benefit less from the increasing autonomy of the central bank. This fact may be attributed to two reasons. First, the pre-reform inflation level is found to be low for these countries and incremental autonomy provided to the central banks failed to add much value to the process of reducing inflation. Second, the pre-reform broad policy setting was not accommodative to fiscal policy. Rather the institutions of these countries are found to be working more efficiently compared to the other countries in the world.

For the low-income economies, the institutional reforms failed because in most cases, they resulted from the policy prescriptions offered by the international organizations. These reforms largely contradicted with the existing institutional settings and the policymakers' interest. They therefore lacked the spontaneity and the urgency from the country's perspective that was required for the success of the reform. A further analysis reveals that the CBI is more effective after 1990 compared to the pre-1990 period.

Financial openness plays an important part in controlling inflation. Countries that are more financially open to the world experience lower inflation compared to the less financially open economies. This paper also concludes that monetary aggregate growth is the most consistent determinant of inflation over the long-term, as proposed by the quantity theory of money.

The central bank independence index used in this paper is based on the legal (de jure) independence of the central bank and proposed by Garriga (2016). This measure may be inadequate, as it does not incorporate any measurement that represents the de facto or the true independence of the central bank, which may be a more practical choice for the CBI. Any difference between de jure index proposed by Garriga (2016) and a de facto index may be considered as a measurement error (Brumm 2002). This error is expected to be higher for the low-income countries, where the existence of the law and implementation of the law are two separate things. For future studies, a measure for central bank's de facto or true independence may be developed to understand a more detailed dynamics between the CBI and inflation.

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Appendix A

Table A: Country Names and its Features

Country Name	Income Level	Region
Canada	High Income	North America
Mexico	Middle Income	North America
United States of America	High Income	North America
Barbados	High Income	Caribbean Islands
Belize	Middle Income	Caribbean Islands
Dominican Republic	Middle Income	Caribbean Islands
Jamaica	Middle Income	Caribbean Islands
Saint Lucia	Middle Income	Caribbean Islands
Trinidad and Tobago	High Income	Caribbean Islands
Costa Rica	Middle Income	Central America
El Salvador	Middle Income	Central America
Guatemala	Middle Income	Central America
Honduras	Low Income	Central America
Nicaragua	Low Income	Central America
Panama	Middle Income	Central America
Argentina	Middle Income	South America
Bolivia	Low Income	South America
Brazil	Middle Income	South America
Chile	High Income	South America
Colombia	Middle Income	South America
Ecuador	Middle Income	South America
Guyana	Middle Income	South America
Paraguay	Middle Income	South America
Peru	Middle Income	South America
Uruguay	High Income	South America
Venezuela	Middle Income	South America
Australia	High Income	Pacific
Fiji	Middle Income	Pacific
New Zealand	High Income	Pacific
Tonga	Middle Income	Pacific
Egypt	Low Income	North Africa & Middle East
Iran	Middle Income	North Africa & Middle East
Israel	High Income	North Africa & Middle East
Jordan	Middle Income	North Africa & Middle East
Morocco	Middle Income	North Africa & Middle East
Qatar	High Income	North Africa & Middle East
Sudan	Low Income	North Africa & Middle East
Tunisia	Middle Income	North Africa & Middle East
Turkey	High Income	North Africa & Middle East
Burkina Faso	Low Income	Sub-Saharan Africa
Burundi	Low Income	Sub-Saharan Africa
Cameroon	Low Income	Sub-Saharan Africa
Central African Republic	Low Income	Sub-Saharan Africa
Ethiopia	Low Income	Sub-Saharan Africa
Ghana	Low Income	Sub-Saharan Africa
Guinea-Bissau	Low Income	Sub-Saharan Africa
Ivory Coast	Low Income	Sub-Saharan Africa
Kenya	Low Income	Sub-Saharan Africa
Mali	Low Income	Sub-Saharan Africa

Country Name	Income Level	Region
Mauritania	Low Income	Sub- Saharan Africa
Niger	Low Income	Sub- Saharan Africa
Nigeria	Low Income	Sub- Saharan Africa
Senegal	Low Income	Sub- Saharan Africa
Uganda	Low Income	Sub- Saharan Africa
Botswana	Middle Income	Southern Africa
Madagascar	Low Income	Southern Africa
Malawi	Low Income	Southern Africa
Mozambique	Low Income	Southern Africa
South Africa	Middle Income	Southern Africa
Tanzania	Low Income	Southern Africa
Zambia	Low Income	Southern Africa
Zimbabwe	Low Income	Southern Africa
Bangladesh	Low Income	South East Asia
India	Low Income	South East Asia
Nepal	Low Income	South East Asia
Pakistan	Low Income	South East Asia
Sri Lanka	Middle Income	South East Asia
Cambodia	Low Income	South Asia
Indonesia	Middle Income	South Asia
Laos	Low Income	South Asia
Malaysia	Middle Income	South Asia
Philippines	Low Income	South Asia
Singapore	High Income	South Asia
Thailand	Middle Income	South Asia
Austria	High Income	EU
Belgium	High Income	EU
Bulgaria	Middle Income	EU
Croatia	High Income	EU
Czech Republic	High Income	EU
Denmark	High Income	EU
Estonia	High Income	EU
Finland	High Income	EU
France	High Income	EU
Germany	High Income	EU
Greece	High Income	EU
Hungary	High Income	EU
Ireland	High Income	EU
Italy	High Income	EU
Latvia	High Income	EU
Lithuania	High Income	EU
Luxembourg	High Income	EU
Netherlands	High Income	EU
Norway	High Income	EU
Poland	High Income	EU
Portugal	High Income	EU
Romania	Middle Income	EU
Slovakia	High Income	EU
Slovenia	High Income	EU
Spain	High Income	EU
Sweden	High Income	EU
Switzerland	High Income	EU

Country Name	Income Level	Region
United Kingdom	High Income	EU
Albania	Middle Income	East Europe and Central Asia
Armenia	Middle Income	East Europe and Central Asia
Azerbaijan	Middle Income	East Europe and Central Asia
Belarus	Middle Income	East Europe and Central Asia
Georgia	Middle Income	East Europe and Central Asia
Iceland	High Income	East Europe and Central Asia
Kazakhstan	Middle Income	East Europe and Central Asia
Macedonia	Middle Income	East Europe and Central Asia
Moldova	Low Income	East Europe and Central Asia
Russian Federation	Middle Income	East Europe and Central Asia
Ukraine	Middle Income	East Europe and Central Asia
China	Middle Income	East Asia
Japan	High Income	East Asia
Korea, Republic of	High Income	East Asia
Mongolia	Middle Income	East Asia

Appendix B: Selecting Fixed effect model

a) *Hausman Test*: This test compares the fixed effect and random effect estimators. The null hypothesis of the test is that the constant term is uncorrelated with the explanatory variables while the alternative hypothesis is that there is some correlation between them. Rejecting the null hypothesis entails that the fixed effect estimators are consistent and efficient.

Table B.1: Hausman Test Statistics

Variable	Dependent Variable: Adjusted Inflation			
	Fixed effect estimates (b)	Random effect estimates (B)	Difference (b-B)	Standard Errors
CBI	-0.0450	-0.0343	-0.0107	[0.0047]
Financial Openness	-0.0240	-0.0231	-0.0001	[0.0013]
Trade Openness	-0.0297	-0.0198	-0.0099	[0.0094]
Fiscal Discipline	0.0117	0.0048	0.0069	[0.0026]
GDP Growth	-1.0758	-1.0198	-0.0559	[0.0392]
Money Growth	0.0997	0.1057	-0.0060	[0.0009]

H_0 = Difference in coefficients are not systematic. $\chi^2 (6) = 55.25$ (Probability $> \chi^2 = 0.0000$).

Difference between the variance of b and variance of B is positive definite. The result of this test suggests that fixed effect estimators are both efficient and consistent.

b) *Breusch – Pagan LM Test*: This test compares the random effect and pooled regression estimators. The null hypothesis of the test contemplates the variance of the individual effects are zero. Alternative hypothesis suggests that the random effect is more appropriate for the model. The test result finds the value of the $\overline{\chi^2}(1) = 254.14$, eventually suggesting that the null hypothesis is rejected at all levels. Thus, concluding that the pooled OLS model is not appropriate in this setting.

Combining the two tests, it can be concluded that, although random effect model can be preferred over pooled regression, however, fixed effect model estimators are more consistent and efficient than the random effect estimators.

c) *Wald Test for group-wise heteroskedasticity*: The null hypothesis of the test is as follows:

$$H_0: \sigma_i^2 = \sigma^2 \text{ for all } i.$$

That is the variance at the group level (σ_i) will be equal to the overall variance (σ). The test result finds the value of the $\chi^2(116) = 4.2 \times 10^{32}$, eventually suggesting that the null hypothesis is rejected at all levels, concluding the presence of group-wise heteroskedasticity in the panel data.

d) *Wooldridge Test for autocorrelation*: Null hypothesis of this test suggests that no first order autocorrelation is present in the panel data. A F-test is conducted, and the test statistic is found to be $F(1,112) = 21.018$, thus rejecting the null hypothesis at all levels, concluding the presence of first order autocorrelation in the panel data.

Appendix C

Table C.1: Two-Way Fixed Effect Model with Robust Standard Errors Clustered at Both Country Level and Yearly.

Dependent Variable: Adjusted Inflation

Variable	1 (Full Sample)	2 (OECD)	3 (Non-OECD)	4 (DEV-1)	5 (DEV-2)	6 (DEV-3)
CBI	-0.0261* [0.0134]	0.0001 [0.0097]	-0.0395 [0.0237]	0.0090 [0.0583]	-0.0489* [0.0230]	-0.0026 [0.0093]
Financial Openness	-0.0209*** [0.0030]	-0.0119*** [0.0029]	-0.0235*** [0.0047]	-0.0177 [0.0099]	-0.0268*** [0.0055]	-0.0149** [0.0046]
Trade Openness	-0.0072 [0.0221]	0.0149 [0.0377]	-0.0140 [0.0248]	0.0118 [0.0318]	-0.0711* [0.0359]	-0.0072 [0.0269]
Fiscal Discipline	0.0153* [0.0074]	0.0057 [0.0072]	0.0123 [0.0097]	0.0320* [0.0216]	0.0098 [0.0171]	0.0090 [0.0073]
GDP Growth	-1.0148*** [0.2890]	-0.9744*** [0.2411]	-1.0480** [0.3602]	-1.3723 [0.7470]	-1.0449*** [0.1802]	-0.5377*** [0.1477]
Money Growth	0.1000*** [0.0142]	0.2168*** [0.0472]	0.0930*** [0.0112]	0.0912*** [0.0180]	0.0888*** [0.0206]	0.2266*** [0.0518]
No of countries	114	35	79	33	39	42
Observations	816	277	539	235	261	320
F-stat	918.48	187.08	-	-	-	43.45
Adjusted R ²	0.74	0.83	0.72	0.65	0.79	0.82

Note: *, ** and *** means 10%, 5% and 1% level of significance respectively. 1st column shows the full sample regression. 2nd and 3rd columns show the regression for OECD and non-OECD countries. Column 4, 5 and 6 show the regression results for low-income, middle-income and high-income countries, respectively. Column 1-6 uses equation 2 presented in Section 2. Time frame considered for all regression are 1970- 2010. For all cases, robust standard errors are used, they are clustered at the country level and yearly (figure in parentheses). Table C.1 can be compared with Table 1 (Column 1-3) and Table 2 (Column 4-6). Obviously the regressor coefficients are same but the standard errors are slightly different. For the CBI coefficient, significance level declined in for the regression conducted in column 1, 3 and 5, however the coefficient remains significant at the 10% level for column 1 and 5. F-stat is unavailable for the regression in column 3-5.

Table C.2: Heterogeneity of the CBI-Inflation Relation Based on Differential Per Capita Income of the Country (Differences in Slope).

Variable	Dependent Variable: Adjusted Inflation		
	(1) (DEV-3) – (DEV-2)	(1) (DEV-1) – (DEV-2)	(1) (DEV-3) – (DEV-1)
CBI	0.0463* [0.0245]	0.0579 [0.0663]	-0.0116 [0.0632]
Financial Openness	0.0119 [0.0076]	0.0091 [0.0094]	0.0028 [0.0082]
Trade Openness	0.0783* [0.0451]	0.0830 [0.0509]	-0.0047 [0.0467]
Fiscal Discipline	-0.0009 [0.0188]	0.0222 [0.0240]	-0.0231 [0.0180]
GDP Growth	0.5072* [0.2855]	-0.3274 [0.7630]	0.8346 [0.7515]
Money Growth	0.1378*** [0.0494]	0.0025 [0.0293]	0.1353*** [0.0494]
Constant	0.0620** [0.0293]	0.1095* [0.0578]	0.1324*** [0.0480]
No of countries	82	74	76
Observations	582	498	556
F-stat	26.15	16.32	30.37
R ²	0.64	0.39	0.41

Note: *, ** and *** means 10%, 5% and 1% level of significance respectively. 1st column shows the differences in slope coefficients for the high-income and middle-income countries. 2nd and 3rd columns show the same for the low-income vs. middle-income and high-income vs. low income countries, respectively. All regressions consider both individual effect and time fixed effect. Time frame considered for all regression are 1970- 2010. Robust standard errors are used, they are clustered at the country level (figure in parentheses). In all cases, differences in time dummy estimates are found to be jointly insignificant at all levels.

Table C.3: Two-Way Fixed Effect Model- Extended Model with Income Inequality, Human Capital Index and Political Rights

Variable	Dependent Variable: Adjusted Inflation				
	1 (Full Sample)	2 (Full Sample)	3 (OECD)	4 (Non-OECD)	5 (Full Sample)
CBI	-0.0224* [0.0122]	-0.0261** [0.0127]	0.0055 [0.0080]	-0.0485** [0.0213]	-0.0259** [0.0130]
Financial Openness	-0.0222*** [0.0038]	-0.0214*** [0.0038]	-0.0108*** [0.0026]	-0.0242*** [0.0047]	-0.0209*** [0.0034]
Trade Openness	-0.0238 [0.0243]	-0.0247 [0.0224]	0.0407 [0.0366]	-0.0194 [0.0291]	-0.0078 [0.0220]
Fiscal Discipline		0.0197** [0.0084]	0.0044 [0.0069]	0.0194** [0.0094]	0.0152* [0.0079]
GDP Growth	-1.1556*** [0.2625]	-1.1515*** [0.2849]	-1.1825*** [0.2372]	-0.9957** [0.4262]	-1.0002*** [0.2966]
Money Growth	0.1087*** [0.0302]	0.1086*** [0.0295]	0.2122*** [0.0436]	0.0917*** [0.0154]	0.1000*** [0.0189]
Income Inequality	-0.0514 [0.0565]	-0.0661 [0.0594]			
Human Capital Index			-0.2555*** [0.0839]	0.1402* [0.0833]	
Political Rights					0.0029 [0.0035]
Constant	0.0371 [0.0364]	0.0476 [0.0659]	0.3705*** [0.0975]	0.0286 [0.0721]	0.1013*** [0.0296]
No of countries	117	116	35	74	116
Observations	744	728	277	513	818
F-stat	20.72	20.54	97.41	20.88	21.40
R ²	0.55	0.54	0.70	0.60	0.58
ρ	0.5158	0.5447	0.5196	0.4159	0.4377
Time Dummies	Yes	Yes	Yes	Yes	Yes

Notes: *, ** and *** means 10%, 5% and 1% level of significance respectively. 1st column shows the full sample baseline regression but replaced Debt to GDP ratio with income inequality. Column 2 includes both debt to GDP ratio and income inequality. Column 3 and 4 extends the baseline model for OECD and non-OECD countries, respectively, by including Human capital index as a variable. Column 5 extends the baseline model by including political right index as a variable. Time frame considered for all regression are 1970- 2010. ρ represents the fraction of variation due to α_i . Robust standard errors is used, they are clustered at the country level (figure in parentheses).

The income inequality data is collected from the SWIID 6.1 dataset. The Gini coefficients reported in the dataset are modeled. It has a large coverage across countries and over time (Solt 2016). Human capital index (HCI) dataset is collected from the Penn World Table (v9.0). It is constructed based on years of schooling and returns on education. Political rights (PR) data is collected from the Freedom House country and territory and statutes dataset (1972-2016).

Table C.4: Mixed Effect Models- Random Variations

a) Mixed effect model: Extension of Column (5) of the Table 5 (Section 4)- assumes random effect will only shift the regression line but no effect on the slope.

Random Effect Parameter	Estimate	Robust standard errors	95% confidence interval	
Country: Identity				
Standard deviation of constants	0.0507	[0.0040]	0.0434	0.0591
Standard deviation of residuals	0.0669	[0.0070]	0.0546	0.0821

b) Mixed effect model: Extension of Column (6) of the Table 5 (Section 4)- assumes random effect will change the slope. Regional effects are also considered as the 2nd level effect.

Random Effect Parameter	Estimate	Robust standard errors	95% confidence interval	
Region: Identity				
Standard deviation of constants	0.0222	[0.0189]	0.0042	0.1178
Country: Independent				
Standard deviation of slope-central bank independence	0.0315	[0.1220]	0.0000	62.3883
Standard deviation of slope-financial openness	2.81×10^{-9}	[-]	-	-
Standard deviation of slope-trade openness	1.53×10^{-9}	$[2.38 \times 10^{-7}]$	1.0×10^{-141}	2.2×10^{123}
Standard deviation of slope-fiscal discipline	0.0055	[0.1790]	1.15×10^{-30}	2.64×10^{25}
Standard deviation of slope-GDP growth	0.6654	[0.6014]	0.1132	3.9119
Standard deviation of slope-money growth	0.1432	[0.0734]	0.0527	0.3910
Standard deviation of constants	0.0113	[0.4229]	1.71×10^{-34}	7.47×10^{29}
Standard deviation of residuals	0.0404	[0.0823]	0.0007	2.1864

c) Random portion of the two-Way random effect model: Column (4) of Table 5 (Section 4)

Random Effect Parameter	Estimate	Robust standard errors	95% confidence interval	
Country: Identity				
Variance of constants- country	0.0026	[0.0004]	0.0018	0.0036
Year: Identity				
Variance of constants- year	0.0003	[0.0002]	0.0001	0.0009
Variance of residuals	0.0045	[0.0002]	0.0041	0.0050