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Doctoral Thesis

Essays in Macroeconomics

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Declaration of Authorship

I, Angelos Athanasopoulos, declare that this thesis, titled "Essays in Macroeconomics", and submitted to Trinity College Dublin for the degree of Doctor in Philosophy (Ph.D.), has not been submitted as an exercise for a degree at this or any other university. I confirm that I was the lead author for each of the co-authored chapters in the thesis. All research contained herein is entirely my and my co-authors' work.

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Summary

This dissertation is a collection of three essays in empirical macroeconomics.

Chapter 1 examines the long-run effects of central bank independence on inflation. Applying a dynamic panel strategy to account for the persistence of inflation the chapter shows that improvements in central bank independence have a larger effect on inflation in the long-term, as compared to the short-term. The analysis shows that these effects are more significant in developing countries. The chapter also provides causal evidence of the effects of central bank reform by applying a doubly robust propensity score weighted estimation as well as an instrumental variables approach. The conclusions of the first chapter is that central bank independence plays an important role in lowering inflation in the long-term, particularly in developing countries.

Chapter 2 provides novel evidence of the medium-term relationship between central bank independence and government debt. The analysis shows that central bank independence and reform are associated with an increase of government debt and a fall of the interest rate on the debt. These effects are pronounced for developing countries. The chapter interprets the evidence as suggesting that central bank independence increases fiscal space. The chapter also provides evidence that increased central bank independence lowers the pro-cyclicality of fiscal policy for developing economies, thus allowing countries to "graduate" from emerging economy status to a developed economy one.

Chapter 3 is interested in the causes and consequences of zombie firms. The chapter provides evidence of a collateral channel for the misallocation of credit. These findings are then related to the zombie congestion spill-over effects literature and it is argued that the negative spill-over effects of zombies in the literature are, at least partially, related to the role of collateral in lending. The claim in this chapter is that zombie lending is due to a commitment problem for lenders who cannot credibly commit ex ante not to refinance ex post in the presence of sunk costs. Evidence provided in the chapter shows that the stronger the effective creditor rights protection

is in a country the higher the available leverage that firms can obtain, and the more serious the adverse selection ex ante is. Therefore the zombie firms problem can be traced back to an excessive build-up of leverage facilitated by a bank-based system excessively reliant on collateralisation.

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For Elaine and Calliope

Introduction

This collection of essays is interested in two important current economic policy issues. The first two chapters examine the effects of central bank independence on inflation and on public debt. The third chapter is interested in the causes and consequences of zombie firms.

Central Bank Independence

Central bank independence has recently re-emerged as a major political economy issue. Starting in the wake of the great inflation of the 1970s with the theoretical contributions of Kydland and Prescott (1977) and Rogoff (1985), central bank independence (CBI) gradually came to be accepted as the established and possibly optimal institutional design for monetary policy. Throughout the period from the mid-1980s to the eve of the Global Financial Crisis central bank legislation was amended in countries around the globe and central bank independence enhanced, a process we briefly review in Chapter 1. The rise of the credibility of central banks during the long period of the Great Moderation meant that monetary policy was "the only game in town" in the decade following the 2008-2010 crisis. Yet the unexpected rise of inflation since the COVID-19 pandemic has re-ignited the debate about the significance of central bank independence. Politicians and commentators have increasingly argued in the recent period for a closer coordination between the central bank and the government, some openly questioning the legitimacy of central bank independence. The two first chapters in this collection of essays are motivated by such arguments about the appropriate role of central banks in macroeconomic policymaking. These chapters examine the effects of central bank independence on inflation and on public debt and try to bring new policy-relevant evidence to the debate.

Chapter 1, co-authored with Donato Masciandaro and Davide Romelli, revisits the central bank independence-inflation nexus from the perspective of the long-term effects of CBI. The chapter contributes to the literature in several ways. First, we are interested in the long-term effects of CBI on inflation rather than the short-term effects usually studied in the literature. We provide novel evidence that the effects of central bank independence accrue over time as the long-term (15 years or more) effects are larger than the short-term effects. Second, the analysis is based on a large sample of 154 advanced economies and developing countries using a new index of central bank independence recently introduced by Romelli (2022). This *de jure* index extends the classical CBI indices originally introduced in the 1990s and includes comprehensive information on many aspects of the relationship between the central bank and the government. Thirdly, we apply several empirical strategies to provide causal evidence of the effects of CBI on inflation. To estimate the long-term effects of CBI in our baseline approach we estimate a dynamic panel model accounting for inflation dynamics and trace the impulse response function of inflation to changes of the CBI index. In our second approach, we apply the Jorda (2005) local projection method and directly estimate the effects of increased CBI on inflation for horizons up to fifteen years. Our local projections estimates confirm the results from our dynamic panel model and show that the long-term effects of CBI are considerably larger than the immediate short-term effects. To provide causal evidence of these effects we adopt a treatment effects framework and estimate a doubly robust propensity score weighted model of the effects of central bank reform confirming our baseline results. Finally, we also provide instrumental variables evidence using the regional peer pressure instrument approach recently applied by Acemoglu et al. (2019). The findings of Chapter 1 highlight the role of central bank independence. The significance of the long-term effects of credible monetary policy caution against calls for temporary deviation from optimal policies.

Chapter 2, co-authored with Nicolò Fraccaroli and Davide Romelli, turns its attention to the effects of CBI on public debt. This is a much less studied area and the chapter provides novel evidence that CBI allows a country to carry a larger public debt without the need for a higher interest rate. The chapter is motivated by the scale of expansionary policies adopted by many countries during the COVID-19 pandemic.

The remarkably fast recovery of the world economy from the COVID-19 shock has strengthened the belief that direct quantitative approaches to macroeconomic stabilisation can be powerful and effective. Prominent economists and politicians have called for increased coordination between the monetary authority and the treasury in order to facilitate the growth and development policies of the government.

The chapter contributes to the debate by examining the effects that limitations on central bank lending to the government have on public debt and government interest rates. More independent central banks restrict the amount and tighten the conditions of central bank financing to the government. Exploiting information from the Romelli (2022) index of CBI the analysis shows that tighter lending conditions by more independent central banks are associated with an increase of government debt and a fall of the interest rate on the debt. These effects are pronounced for developing countries. Contrary to claims that *direct* support by the central bank facilitates government policies we show that central banks can increase the fiscal space of the government by credibly pledging *not* to lend excessively to the government. If monetary financing and quantitative interventions by the central bank to assist the government are deemed to be inconsistent with monetary stability then investors would not want to hold government debt as its value will be eroded by future inflation. In that respect central bank independence and monetary policy credibility are "fiscal assets" in the terms of Willems and Zettelmeyer (2022), expanding government's fiscal space. The findings in the chapter highlight the importance of adherence to clearly specified rules. As Reis (2022) argues governments can avoid painful austerity in recessions by adopting polices that enhance and preserve rather than undermine the independence of the central bank.

Zombie firms

Chapter 3 is examining another important policy issue, the causes and consequences of zombie firms. Zombies are generally defined as low productivity poorly performing and possibly insolvent firms that however remain in operation due to forbearance from their banks. The increasing prevalence of zombies in recent years has led to concerns

about the spill-over effects of zombies on non-zombie firms. A growing literature, reviewed in the chapter, generally finds important negative spill-over effects. Zombies "congest" input and output markets, keeping labour costs high and depriving healthy firms of credit, while keeping output prices low and depressing sector profitability. A prominent theory of zombie firms links them to zombie lending (Hoshi, 2006; Peek and Rosengren, 2005; Caballero et al., 2008). Under-capitalised banks at risk of a forced recapitalisation face perverse incentives and delay crystallisation of losses on non-performing loans by providing additional credit to firms that would have normally been foreclosed. The standard policy implication of the zombie firms/zombie lending nexus is that a swift and adequate recapitalisation of banks, coupled with structural reforms of insolvency regimes, would allow an economy to deal with the zombie "infestation" problem, facilitating the exit of low productivity firms and re-invigorating business dynamics and firm turnover (Andrews et al., 2017; Adalet McGowan et al., 2018; Andrews and Petroulakis, 2019; Acharya et al., 2019).

Chapter 3, largely completed before the recent important increase in the number of zombie firms in the aftermath of the COVID-19 pandemic government intervention programs, provides evidence of a complementary collateral channel for the misallocation of credit to zombie firms. Analysing data for 14 European economies and 54 2-digit sectors for the period 2003-2015 the chapter shows that tangible collateral availability predicts zombie status at the firm level and zombie "infestation" at the sector level. These findings are then related to the zombie congestion spill-over effects literature, and it is argued that negative spill-over effects of zombies on non-zombies in the literature can, at least partially, be explained by to the role of collateral. The claim in the chapter is that zombie lending is akin to the "soft budget constraints" problem of Kornai (1986) and Dewatripont and Maskin (1995): banks, unable to make credible commitments, cannot stop refinancing unprofitable projects in the presence of sunk costs. When collateralisation facilitates lending, evidence provided in the chapter shows that the higher the effective creditor rights protection in a country, the higher the available leverage that firms can obtain, and the more serious the ex ante adverse selection problem is. Therefore, similar to the argument of Gopinath et al. (2017), the zombie firms problem can be traced back to an excessive build-up of leverage facilitated by a bank-based system excessively reliant on collateralisation.

The policy implications of the argument in the chapter focus on the structure of finance, i.e. debt vs. equity funding, rather than the current cyclical health of a banking sector that the perverse incentives zombie lending approach that Acharya et al. (2019) or the OECD researchers cited earlier would favour.

Overall, the three chapters of this collection are interested in current and important macro economic policy issues: the structure of finance and business dynamics, the role of central bank independence and the control of inflation, and government debt and the coordination between the central bank and the treasury. This collection of essays tries to provide policy relevant evidence on these issues.

Chapter 1

Inflation: persistence and central bank independence

1.1 Introduction

Central bank independence has recently re-emerged as a major political economy issue. After the Great Moderation period, that the former governor of the Bank of England, Mervyn King (2003), dubbed as the NICE (non-inflationary consistent expansion) years, many economies are experiencing high levels of inflation (Schnabel, 2022). In an environment of heightened inflation uncertainty conducting monetary policy effectively has become even more urgent.

There is a broad consensus that effective monetary policies have been at least a contributing factor to the Great Moderation. Yet, doubts about the importance of independent monetary policy institutions have recently been expressed. Prominent politicians have voiced concerns about the role of independent central banks, and proposed reviewing or even curtailing their independence (CNBC, 2022). For example, former US President Donald Trump, openly criticized the Federal Reserve for the four interest rate hikes in 2018 (Binder, 2021). More recently, European leaders expressed concerns over the speed at which the European Central Bank has been raising the interest rates in 2022 and worry about the implications this may have on growth (Politico, 2022).[1] On the other hand, academics and central bankers alike continue to

[1] Sanna Marin, Finland's prime minister, has been among the first European leaders to re-open the debate on the issue. In early October 2022, various newspapers reported the news about her retweet of an article, followed by the quote: "There is something seriously wrong with the prevailing ideas of monetary policy when central banks protect their credibility by driving economies into recession" Financial Times (2022).

defend central bank independence as a cornerstone of good economic policy making (Rajan, 2016; Rogoff, 2021; Haldane, 2020; Jordan, 2022; Plosser, 2022).

There are sound theoretical reasons to believe that an independent central bank can achieve superior outcomes than a monetary authority under the complete control of the government (see Barro and Gordon, 1983a, among many others). However, the empirical literature on the effects of central bank independence on inflation provides conflicting evidence. Reviewing this literature, Masciandaro et al. (2020) highlight the diversity of empirical approaches applied and come to the conclusion that there is no consensus on the effect of central bank independence on many macroeconomic variables, including inflation.

While the literature on the effects of central bank independence on inflation is vast, there is a surprisingly little interest in the long-run effects of central bank reform on inflation. Most studies either completely ignore inflation dynamics in the specifications examined, or, when lagged values of inflation are included in the models, the interest is mainly to improve the model fit rather than to analyse the dynamic effects of central bank independence on inflation. In this paper we fill this gap in the literature.

Our focus on dynamics is motivated by the persistent nature of the inflationary process and by the role that beliefs and expectations play in monetary policy. From an economic perspective, the effects of a successful structural reform can be expected to be long-lasting. A *de jure* commitment of a government not to interfere in the making of monetary policy will only gain credibility over time and through experience. Indeed as we show in our analysis, countries that are perceived to be less developed seem to gain more from such commitments over the long-run.

From a statistical point of view, the long-run effect of a shock to a persistent process is expected to be higher the more persistent the process is. In simple auto-regressive models of inflation the persistence of inflation is sufficiently high to justify our focus in the long-run effects rather than the short-run effects which have generally been the interest in the literature.

There are both theoretical and econometric reasons to believe that a reform in central bank design has long-run effects on inflation that are substantially higher than the immediate short-run effects. However, these long-run effects have been less

analysed in the literature so far, which has focused more on the contemporaneous effects. Structural reforms generally can have large immediate effects of course, but most of the modern theories on inflation stress the importance of expectations. A new commitment by the government not to influence the anti-inflationary policies of the central bank would only be incorporated in expectations slowly, as agents take time to assess the credibility of the reform.[2] From an econometric perspective, there is a consensus that inflation is generally a persistent, though stationary, process.[3] For any persistent series the long-run effects of a shock, like reforms in central bank design, can be considerably larger than the effect upon impact.

Our empirical strategy estimates the long-run effects of changes in central bank independence on inflation by employing both dynamic panel estimators and local projections. Compared to static analyses that are still prevalent in the literature, our dynamic panel modelling approach not only accounts for the persistence of inflation but also explicitly uses it in the estimation of the long-run effects of central bank independence on inflation.

Our study uses the central bank independence index introduced in Romelli (2022), a *de jure* index of central bank independence based on the codification of the central bank legislation of 154 countries over the period of 1972-2017. Using this index, we are able to study the dynamic effects of central bank independence on inflation for a large set of countries. In our baseline specification, we use a conventional dynamic panel model able to account for the dynamics of inflation. Such model has been used extensively in the literature on structural changes (see Acemoglu et al., 2019, on the effects of democratizations on GDP per capita). Using the Jorda (2005) local projection approach, we also employ a direct estimation method to quantify the long-run effects of central bank independence on inflation. Finally, to deal with the potential endogeneity of structural reforms, we employ both a doubly robust local projection estimation as proposed by Jordà and Taylor (2016) and an instrumental

[2] Cukierman and Meltzer (1986) define credibility in terms of the speed with which the public recognizes changes in the objectives of the policymaker, though in their setting the policy maker reveals his preferences through monetary policy control rather than by declaring a new policy framework. In the case of *de jure* independence there is uncertainty about the significance of the declaration, so the slower dynamics of partial gains in credibility would lead to a long-run effect that is higher than the short-run impact.

[3] See (Fuhrer, 2010) for a comprehensive review of the concept of inflation persistence in macroeconomic theory and empirics.

variable local projections analysis.

To preview our results, we find that a country moving from the first to the fourth quartile of the distribution of central bank independence would experience a long-run reduction of annual inflation of approximately 1.5 percentage points. However, for developing countries, the effect is considerably larger, with an average decrease in annual inflation of around 7.25 percentage points. Drawing on the impulse response functions of inflation to changes in central bank independence, we show that the effects of central bank reforms take time to materialize. Overall, our results indicate that it is developing economies that primarily benefit from improvements in central bank independence.

Our study contributes to two strands of the literature: the one on institutional reforms and the one on the link between central bank independence and inflation. As noted by Acemoglu et al. (2008), central bank independence is a narrow reform, with a clearly delineated target, i.e. inflation. Our focus on the long-run effects of central bank reforms on inflation highlights the dynamic effects of institutional changes, which can be driven by a multitude of political and economic factors (Masciandaro and Romelli, 2015; Romelli, 2022).

We also contribute to the literature on central bank independence in several ways. First, we quantify the long-run effect of central bank reforms on inflation. Indeed, given the persistent nature of inflation (Fuhrer, 2010), one could expect that the effects of a reform in central bank independence would not be short-lived. On the contrary, the positive effects of a reform might materialize after a certain number of years, especially in countries in which the central bank initially lacks credibility. Second, we apply a doubly robust estimation to account for the endogeneity of central bank reform. Finally, we also provide suggestive evidence that central bank independence lowers inflation persistence.

The rest of the paper is organized as follows. The section 1.2 briefly reviews the literature. In section 1.3 we describe our data, while section 1.4 presents the empirical strategies employed in the paper. Section 1.5 presents the results and section 1.6 concludes.

1.2 Literature review

As the literature on the effects of Central bank independence (CBI, henceforth) on inflation is extensive and no review can possibly do it justice, this section provides a brief overview of the methodological evolution of this literature, and its impact on policy.[4]

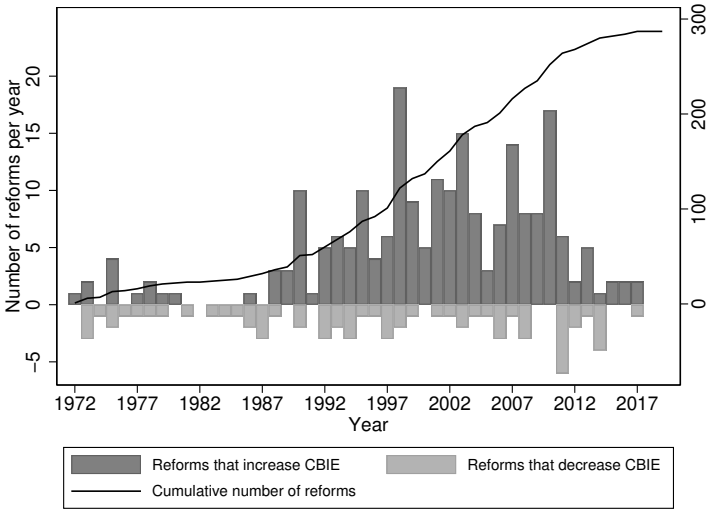
The modern empirical literature on CBI starts in the early 1990s when the first indices of *de jure* CBI were proposed by Grilli et al. (1991) and Cukierman (1992). These indices were obtained by codifying central bank legislations at distant points in time. The lack of temporal variability had the inevitable consequence that early empirical work on the effects of CBI on inflation or other macroeconomic variables was based on cross-sectional analyses. While the results were generally in favour of the adoption of central bank reforms aimed at increasing central bank independence (Alesina and Summers, 1993), concerns about the well-known limitations of cross-country regressions remained unanswered.

Regardless of the strength of the empirical evidence at the time, central bank independence proved a very attractive policy solution to some of the macro-economic policy making challenges identified by the rational expectations revolution in the 1970s. Central bank independence, combined with the "more conservative that the median voter" central banker of Rogoff (1985), offered a natural answer to the time inconsistency problem identified by Kydland and Prescott (1977) and Barro and Gordon (1983a). In the game of chicken of Sargent and Wallace (1981), delegating monetary policy to an independent central bank provides for a possible resolution of the conflict.

As Figure 1.1 illustrates, a shift in economic policy making towards more independent central banks started in the late 1980s. This development in central bank institutional design had the fortuitous result that it was now possible to implement panel data methods when analysing the relationship between central bank independence and macroeconomic variables. Over the last two decades, a second generation of scholars started to compute dynamic indices of CBI and considerably expanded

[4]See Klomp and De Haan (2010) for a meta-regression analysis of the studies examining the relationship between inflation and central bank independence and Masciandaro et al. (2020) for an overview of the empirical studies focusing on the link between central bank independence, inflation, and other macroeconomic variables.

FIGURE 1.1: Central Bank legislative reforms (1972-2017)



Notes: The figure shows the frequency of reforms that increased/decreased the CBIE index, together with the cumulative number of reforms in central bank independence between 1972 and 2017.
Source: Romelli (2022).

the number of countries covered. These studies have mainly confirmed the negative *short-run* relationship between central bank independence and inflation (see Polillo and Guillén, 2005; Crowe and Meade, 2008; Jacome and Vazquez, 2008; Arnone and Romelli, 2013; Bodea and Hicks, 2015b; Garriga and Rodriguez, 2020; Jacome and Pienknagura, 2022a). Our paper complements this still growing literature by providing evidence of the *long-run* effects of central bank independence on inflation.

Central bank independence as a monetary policy regime shift is also associated with the large literature on the credibility of a disinflation process. The literature on partially credible disinflation goes back to at least Cukierman and Meltzer (1986) where credibility is defined as the "speed with which the public recognises changes in the objective function of the policymaker". More recently, researches have analysed the relationship between central bank credibility and its persistent effects on inflation (see Erceg and Levin, 2003; Rudd and Whelan, 2003; Bordo and Siklos, 2015, among others). These studies link the monetary policy regime of a country with its disinflation process. Our paper also contributes to this strand of literature.

Our paper is also related to the large and still inconclusive literature on the effects of monetary policy regimes on the persistence of inflation. By the early 2000s, as the dis-inflationary process was increasingly evident, the "good luck vs. good policy"

debate on the origins of the Great Moderation also involved the question of inflation persistence. Major contributions in this literature like Benati (2008), Benati and Surico (2008), or O'Reilly and Whelan (2005) did not reach a consensus on the effects of monetary policy on the persistence of inflation. By the end of the 2010s, as the Phillips curve was flattening and inflation was also becoming increasingly insensitive to its own lags, researchers concluded that inflation was purely forward looking and well anchored (see for example Blanchard, 2018).[5] The recent resurgence of inflation gives a new urgency in understanding the determinants of inflation persistence. Our paper provides some evidence that central bank independence can also lower inflation persistence.

1.3 Data and descriptive statistics

This section describes the data used in the analysis. The index of central bank independence used in the paper is presented in Section 1.3.1. Section 1.3.2 discusses our dependent variable, i.e. inflation, while Section 2.2.3 describes the additional control variables used in the analysis.

1.3.1 Index of central bank independence

As discussed in Arnone and Romelli (2013), legal indices of CBI can be considered appropriate measures for the analysis of the relationship between CBI and inflation for three main reasons. First, because the mere adoption of a legal statute aiming at guaranteeing central bank independence might dampen inflationary expectations in the economy (Polillo and Guillén, 2005). Second, because they focus on specific claims contained in central bank legislations and are less biased by the presence of possible subjective judgments. Finally, because the *de facto* indices of CBI characterize the independence of a central bank on the turnover rate of its central bank governor, disregarding the institutional characteristics of a country's monetary policy authority.

[5] The policy conclusion of Blanchard (2018) that "given the evidence [..] on stickiness of inflation expectations [..] there is a strong case, although not an overwhelming case, to allow US output to exceed potential for some time, so as to reintegrate some of the workers who left the labor force during the last ten years" echos the concerns of Pivetta and Reis (2007) that "detecting whether persistence has recently fallen is key in assessing the likelihood of recidivism by the central bank".

In this paper we use the Central Bank Independence - Extended (CBIE) index introduced in Romelli (2022) for a sample of 154 countries, over the period 1972 to 2017.[6] This index uses the classical indices of CBI, i.e. the Grilli et al. (1991, GMT, hereafter) and Cukierman et al. (1992, CWN, hereafter) indices, to develop a new and comprehensive index of central bank independence that covers a wider range of central bank characteristics. In its most disaggregated format, this new index provides information on 42 criteria of central bank institutional design. By incorporating the characteristics of *both* the GMT and CWN indices, this index aims at overcoming the main criticism of these classical measures of CBI, i.e. the fact that only nine characteristics are common to both indices, out of a respective total of 15 in GMT and 16 in CWN (see Mangano, 1998). Apart from integrating these two well-know indices, the CBIE index also includes new criteria able to capture good practices in central bank financial independence and accountability. The information collected is used to build a new index of central bank independence which ranges from 0 (no independence) to 1 (full independence).

Employing this dynamic index, we are able to implement the most extensive analysis on the long-run effects of central bank independence on inflation. By analysing the period 1972-2017, we are able to capture all the reforms adopted by central banks after the collapse of the Bretton Woods system, the full set of reforms implemented by European countries before and after the creation of the euro, as well as the reforms adopted after the 2008-09 Global Financial Crisis.

Table 1.1 provides an overview of the evolution of the CBIE index across decades. It shows a clear increase in the average level of CBI, which increased by more that 50 percent between the 1970s and nowadays. Looking at the full set of changes in central bank design implemented between 1972 and 2017, we identify 220 reforms which increased the degree of CBI and 65 reversals. Focusing on the sub-sample of advanced economies and developing countries, it is possible to notice how 55% of the changes had been implemented before the 2000s among the first group of countries, while 55% of institutional changes took place in the last 20 years among developing countries.

[6] See Appendix Table 1.A for the full set of countries and information on data availability.

TABLE 1.1: Summary statistics on the evolution of the CBIE index

Period	Countries	# of Obs	# of Reforms	# of Reversals	Mean	Min	Max
Full sample							
1972-1979	93	719	11	10	0.457	0.122	0.691
1980-1989	110	1034	8	10	0.459	0.099	0.73
1990-1999	148	1363	75	18	0.506	0.142	0.929
2000-2009	154	1529	89	13	0.605	0.142	0.929
2010-2017	154	1232	37	14	0.653	0.209	0.929
Advanced economies							
1972-1979	25	193	4	3	0.435	0.18	0.691
1980-1989	26	257	3	3	0.44	0.147	0.691
1990-1999	34	322	33	2	0.535	0.147	0.929
2000-2009	34	340	23	3	0.724	0.325	0.929
2010-2017	34	272	4	8	0.75	0.325	0.929
Developing countries							
1972-1979	68	526	7	7	0.465	0.122	0.681
1980-1989	84	777	5	7	0.466	0.099	0.73
1990-1999	114	1041	42	16	0.497	0.142	0.899
2000-2009	120	1189	66	10	0.571	0.142	0.899
2010-2017	120	960	33	6	0.626	0.209	0.899

Notes: Table provides summary statistics for the CBIE index of central bank independence. The sample of Advanced economies includes all OECD member countries in 2020. The sample of Developing countries include all non-OECD member countries in 2020.

1.3.2 Inflation

Our dependent variable is inflation, computed as the annual percentage change in the consumer price index, obtained from the World Bank (series FP.CPI.TOTL.ZG). Following Cukierman (1992), and many others in the literature on the CBI-inflation nexus, we re-scale inflation using the formula:

$$\pi_{c,t} = \frac{inflation_{c,t}}{1 + inflation_{c,t}},$$

where $inflation_{c,t}$ is the annual percentage change in the consumer price index in country c in year t. This transformation alleviates the problem of very high inflation rates having disproportionate effects our analysis.

Table 1.2 presents descriptive statistics for inflation for the full sample of countries, as well as for the sub-samples of advanced economies and developing countries. This table, also reports the descriptive statistics for inflation obtained by splitting the sample between pre and post-reform periods. The t-statistic of a t-test on the equality of means between pre and post-reform periods for inflation is t = 13.10, p-value<0.001, indicating that the post-reform sample is characterized by a lower inflation level.

TABLE 1.2: Inflation summary statistics

Variable	Obs	Mean	Std. Dev.	Min	Max
All countries	5091	8.39	12.176	-21.419	99.581
Advanced economies	1339	4.902	6.304	-4.688	90.492
Developing countries	3752	9.635	13.457	-21.419	99.581
Pre-reform	3100	10.152	13.795	-21.419	99.581
Post-reform	1991	5.647	8.394	-11.194	96.719

Notes: Table provides summary statistics for inflation. The pre-reform group includes all years before the adoption of the largest reforms in CBI. The post-reform sample refers to all the years following the reform that brought the highest change in a country's degree of CBI. Countries who never reformed their central bank legislation are included in the pre-reform sample.

1.3.3 Additional control variables

The set of additional control variables included in our analysis aim at capturing possible confounding effects. We broadly cluster these controls in three groups: business cycle, economic openness, and developmental level.[7]

In all our estimations, we control for the business cycle by including a measure of the output gap, which we proxy with deviations of real GDP from a Hodrick-Prescott trend. We also include the ratio of public debt to GDP, as an indicator of the fiscal stance of the government and the corresponding inflation risks.

The exposure of an economy to external competition and international price developments is equally an important determinant of inflation (Romer, 1993). As standard in the literature, we control for the degree of openness to trade of a country, calculated as the sum of imports and exports divided by GDP. We also include the Chinn and Ito (2008) index of capital account openness to control for other policy choices that might impact the ability of the central bank to manage inflation. Finally, we add an exchange rate regime dummy that takes the value of 1 for the years in which a currency peg is in place in a country.

The level of development of an economy and the type of institutions in place are also important determinants of the inflationary environment of a country. Acemoglu et al. (2008) analyses the relationship between political institutions and central bank independence (see also Bodea and Hicks, 2015a). We control for these effects by

[7]The definitions and data sources for all the variables used in the paper are provided in Appendix 1.B, while Appendix Table 1.B.2 provides some summary statistics.

including the Polity index, as well as the level of GDP per capita of a country as a broader index of development.

1.4 Empirical strategy

In this section we provide details of the empirical strategies we apply. The dynamic panel models discussed in Section 1.4.1 allow for the estimation of the long-run effects of CBI on inflation using an inflation dynamics modelling approach. Our second strategy in section 1.4.2 applies the Jorda (2005) local projection method. In section 1.4.3 we introduce our third empirical strategy, a doubly robust estimation method that models the selection into central bank reform as a first stage in the estimation process, while in section 1.4.4 we discuss the instrumental variable local projections approach used.

1.4.1 Dynamic panel models

The first model we use to estimate the effects of CBI on inflation is a dynamic (linear) panel model for inflation with country and time-fixed effects and an auto-regressive process for the inflation dynamics.[8]

Specifically, we estimate the following dynamic panel model:

$$\pi_{c,t} = \beta_1 CBI_{c,t-1} + \sum_{i=1}^{p} \gamma_i \pi_{c,t-i} + \Theta' X_{c,t} + \alpha_c + \delta_t + \varepsilon_t \tag{1.1}$$

where $\pi_{c,t}$ is the level of inflation in country c at time t, CBI is the index of central bank independence in country c at time *t-1*. $X_{c,t}$ is a vector of control variables.[9] Country-specific intercepts, α_c, absorb the impact of any time-invariant country characteristics.[10] The full set of time fixed effects is captured by δ_t. Our specification also includes p lags of inflation to control for its dynamics, while error term ε_t captures

[8] A fixed effects/within estimator is appropriate in this case given that the within-country standard deviation of inflation is twice as large as the between countries one, i.e. 24.8% versus 12.6%. Appendix 1.C provides a detailed description of the specification search for the dynamic panel models we used.

[9] These control variables are grouped in three categories: business cycle (output gap and debt to GDP), economic openness (openness to trade, Chinn-Ito index, and exchange rate regime) and development level variables (Log of GDP per capita and Polity index).

[10] A large political economy literature has tried to explain how the political characteristics of different societies lead to different institutional arrangements. However, for the purpose of our analysis, the country-specific intercepts best summarize the idea in Eijffinger and de Haan (1996), i.e. that "every society gets the central bank it deserves".

all other time-varying unobservable shocks to the inflation process.[11] To account for cross sectional dependence we estimate Driscoll and Kraay (1998) errors.

Economically, the identifying assumption implies that conditional on the lags of inflation, the country fixed effects, and the other controls, countries that reformed their central bank design were not in a different trend with respect to countries that did not reform.

For our model we therefore assume that countries that reform their central bank did not have a different inflation experience in the run up to the reform (controlled for by the lags of inflation included in the specification), given other long-run characteristics captured by the country fixed effects (and other controls as the case might be).

Formally, the identifying assumption of sequential exogeneity implies that the level of CBI and past inflation are orthogonal to contemporaneous and future shocks to inflation and that inflation shocks themselves are serially uncorrelated:

$$E[\varepsilon_{c,t} \mid \pi_c^{1:(t-1)}, CBI_c^{1:T}, \alpha_c, \delta_t] = 0, \ \forall c, t > t_0.$$

The inclusion of a sufficient number of lags of inflation is required to eliminate the serial correlation of the residuals and to assure the stationarity of the inflation process.

Under these assumptions, the modeling of inflation dynamics helps us to estimate not only the short-run, or "on impact", effect of a reform in central bank design, but also its long-run effects.[12] A dynamic panel model with auto-regressive inflation dynamics such as ours fully characterises the time trajectory of the effects of CBI on inflation. In other words, under the assumption that the model is correctly specified, i.e. that its lag structure adequately captures the dynamics of inflation, and that all relevant confounding factors are accounted for, the time pattern of the effects

[11] The inclusion of lags of the dependent variable in a model with fixed effects mechanically introduces correlation between the demeaned regressor and the demeaned error term which leads to Nickell's 1981 bias. Therefore the results of our dynamic panel model with fixed effects have an asymptotic bias of order 1/T. In our data the average country is observed for 32 years, so the resulting bias is trivially small, see Judson and Owen (1999) and Beck and Katz (2011).

[12] It is well known that adding lags of inflation greatly improves the accuracy of the estimates of inflation models, see for example Fuhrer (2010).

of central bank reform on inflation is derived by extrapolating the linear inflation process into the future. [13]

For a dynamic model with an estimated persistence of the inflation process equal to $\omega = \sum_{c=1}^{p} \gamma_c$, a shock to CBI has a short-run effect on inflation equal to β_1 at time t. But the effect of the change in CBI continues to influence inflation through the lags of inflation in subsequent periods, i.e. $\beta_1\alpha$ in $t+1$, $\beta_1\alpha^2$ in $t+2$, and so on. The cumulative long-run effect is therefore the sum of these effects, i.e. a geometric series $\beta_1 \sum_{c=1}^{\infty} \gamma_c$ that converges to the standard formula:

$$\frac{\widehat{\beta}_1}{1 - \sum_{c=1}^{p} \hat{\gamma}_c}, \tag{1.2}$$

as long as $|\sum_{i=1}^{p} \gamma_c| < 1$.

As a consequence, the persistence of inflation determines the difference between the short-run and the long-run effects of CBI on inflation, with this gap increasing with the persistence of the series. For a highly persistent series such as inflation, the long-run effect can be considerably larger that the short-run effect. As inflation persistence varies with the credibility and transparency of monetary policy regimes (Erceg and Levin, 2003; Rudd and Whelan, 2003), countries characterised by a lower credibility of their central bank might experience a larger reduction in their inflation persistence following a reform in central bank design, maximizing therefore the benefits of a reform. The relationship between the dynamic behaviour of inflation and the effects of central bank reforms is the core insight of our dynamic panel approach.

1.4.2 Local projections

Our second strategy to estimate the long-run effects of CBI is through a direct estimation approach using Jorda's 2005 local projections. This method directly estimates the effect of central bank reforms on inflation at multiple horizon dates separately: horizon $t+h$ outcomes are projected on $t=0$ values.[14] In our application we specifically estimate the following set of equations:

[13] While a dynamic panel approach is fairly standard in the literature of reforms, to the best of our knowledge this is the first study that utilises the model-implied inflation persistence to estimate the long-run effects of CBI reforms.

[14] As shown in Montiel Olea and Plagborg-Møller (2021), the local projections method estimates the same object as the traditional (vector) auto-regression approach.

$$\pi_{c,t+h} = \alpha_c^h + \Lambda^h CBI_{c,t} + \beta_{1h} \sum_{l=1}^{l=4} \pi_{c,t-l} + \beta'_{2h} X_{c,t} + u_{c,t+h} \tag{1.3}$$

where $h = 1, .., 15$ is the forecast horizon and $\pi_{c,t+h}$ denotes the level of inflation in country c in year $t+h$.[15] The maintained identifying assumption is of sequential exogeneity, as in the dynamic panel models. As before, *CBI* is the index of central bank independence in country c at time t. We include four lags of the dependent variable and a vector $X_{c,t}$ of controls similar to the dynamic panel specifications, while error term ε_t captures all other time-varying unobservable shocks to the inflation process. As in the dynamic panel models, we account for cross sectional dependence be estimating Driscoll and Kraay (1998) errors. The set of $h=15$ coefficients Λ^h traces the effects of central bank independence on inflation over the forecasting horizon.

1.4.3 Doubly robust local projections

In this section we present our third empirical strategy that addresses the potential endogeneity of central bank reforms. In economic terms the endogeneity of central bank reforms means that countries that undertake a reform expected higher benefits from that reform than countries that do not. In econometric terms endogeneity of treatment implies that the treatment status of a country is correlated with the potential outcomes of the treatment. To address this challenge to inference, we follow the method recently used in Jordà and Taylor (2016) and de Haan and Wiese (2022), i.e. an augmented inverse probability weighting method (see Imbens, 2004, among others). The augmented inverse probability weighting method we apply here uses a *weighted* regression adjustment approach to estimate counterfactual outcomes for treated and untreated units, conditional on covariates as the case might be. The method specifies a model for selection into treatment and uses the estimated probability scores as the weights in the counterfactual estimation. The difference in the average estimated outcomes for treated and untreated units is the average treatment

[15] Note that our dependent variable is the *one-year* inflation at some forward horizon h. Other studies have used the cumulative change of the price index between time t and horizon time $t+h$ as the dependent variable. This choice of variable transformation implies that agents care primarily about past inflation. Although it is theoretically possible that past inflation is the main driver of agents' behaviour, we opted to use the one-year inflation rate, as it is consistent with the idea that agents are forward-looking. In Appendix section 1.F we show that our results are qualitatively unchanged when we use the cumulative change of the price index as the dependent variable for our analysis.

effect of our intervention, i.e. a central bank reform. This method is doubly robust in the sense of Robins et al. (1994) as we only need one of the treatment selection model or the outcome model not to be miss-specified for the method to produce consistent estimates.

The first step of this approach is the estimation of the probability of reform. We, therefore, transform the continuous index of CBI into a dichotomous index of central bank reform, that takes the value of one in the year in which the largest reform in central bank design is implemented.[16] In order to account only for sizeable changes in the CBI index, we run the analysis by focusing on countries that have implemented reforms that are larger than the median reform in CBI. This yields 93 events of central bank reform in our sample.

In estimating the probit model of the probability of reform we follow the suggestion of Jordà and Taylor (2016) and estimate a saturated model. This means that in the model we include not only the control variables that are in our baseline outcome model but also any variables that are unbalanced between the treatment and control groups and that can plausibly affect the probability of reform.

Specifically we estimate the following model:

$$Prob(Reform_{c,t} = 1) = F\Big(\beta_1' \, CBI_{c,t-1} + \beta_2' \, \pi_{c,t-1} + \beta_3' \, X_{c,t}^{Cycle} + \beta_4' \, X_{c,t}^{OpenEcon} + \beta_5' \, X_{c,t}^{Crises} + u_{c,t}\Big) \tag{1.4}$$

where $Reform_{c,t}$ is a dummy variable that takes the value of one if a reform takes place in country c at time t and F is the cumulative normal distribution. We first include the lagged value the CBI index in a country in order to capture the idea in Romelli (2022) that central bank reforms show a certain degree of inertia. Vectors $X_{c,t}$ include different sets of controls. We include lags of inflation, of GDP growth, of debt to GDP, and of the level of per capita GDP in a first set of business cycle controls. Dummies for the existence of a foreign exchange peg, or membership in a currency union are included in the group marked *OpenEcon*. To capture the idea that

[16] In our sample most countries reform their central bank once, but we also identify a limited number of reversals of reforms, i.e. cases in which the degree of central bank independence decreases following a reform. For the purpose of this exercise, we only consider the reform that brought the largest change in the degree of central bank independence. As the only country which implemented meaningful reversals is Argentina (in 2003 and 2012), we run robustness tests excluding this country and find that the results are essentially unchanged.

external pressure from peers can be a determinant of reform we include the lag of the average level of the CBI index in countries in the same geographical region of country c. Finally, following Romelli (2022) we also include crisis indicators. Specifically, we add dummies for an inflation crisis with over 20% inflation in the last two years, as well as an indicator that the country was part of an IMF program in the previous two years.

Next, we estimate average treatment effects by applying the Oaxaca-Blinder regression adjustment method for the estimation of counterfactuals within a local projections framework.[17]

The objective of the probit model in the first stage is to produce predicted probabilities of reform, commonly called propensity scores (p-scores, hereafter). These p-scores are then used to re-weight the main outcome model in the regression adjustment in order to approach the experimental design benchmark of random assignment. In this re-weighting, observations that were treated, i.e. when a reform took place, are weighted by the inverse of their propensity score, and observations that were not treated are weighted by the inverse of one minus their propensity score. In this way observations with high probability of being treated are under-weighted and observations with low probability are over-weighted, in a sense balancing the sample.[18]

1.4.4 Instrumental variables local projections

In this section we present an instrumental variables estimator to address the potential endogeneity of central bank reforms. Romelli (2022) shows that one of the main determinants of central bank reform is peer pressure, as countries that are further away from their regional peers are more likely to adopt reforms that increase their level of independence.[19] We define our instrument of peer pressure as the 75th percentile of the distribution of the CBI index in a region in a given year, excluding the own-country observation. Regional peer countries are identified using the classification

[17] See Kline (2011) for details of the doubly robust properties of the estimator. Similar to our dynamic panel method, the identifying assumption in the treatment effects framework is that there is sequential ignorability.

[18] The method accounts for the fact that the probability scores are themselves estimates by applying an adjustment factor. For details see Jordà and Taylor (2016).

[19] A similar notion has been used by Acemoglu et al. (2019), who exploit waves of democratisation in the construction of their instruments.

in Acemoglu et al. (2019).[20] The assumption for our choice of instrument is that the level of central bank independence of regional leaders does not have an effect on the inflation of neighbours. On the other hand, regional neighbours with more independent central banks might incite a country to reform its own central bank. In the estimates of the first stage regressions reported in Appendix 1.G we show that our instrument is indeed highly correlated with the level of CBI.[21] In our specifications we include the same set of time varying controls that we use in both the dynamic panel and in the local projections estimates.

1.5 Results

This section presents the results of our analysis on the relationship between inflation and central bank independence. In section 1.5.1 we present the estimates of the dynamic panel models and draw the dynamic panel impulse response functions (DP-IRFs) for inflation. We then present the results using local projection methods, i.e. the linear, the doubly robust and the instrumental variable ones, in section 1.5.2. Finally, in section 1.5.3 we provide suggestive evidence on the effects of central bank independence on the persistence of inflation.

1.5.1 Dynamic panel models

This section presents the analysis using the dynamic panel framework. In columns (1) and (2) of Table 1.3, we present the results run on the full sample of countries, while the estimations run on the sub-samples of advanced and developing countries are presented in columns (3)-(4) and (5)-(6), respectively.[22]

Columns (1), (3), and (5) present the estimates of the effect of CBI on inflation taking into account the inflation dynamics only. The preferred specification that we use to capture the dynamic process of inflation includes four lags of inflation.[23]

[20] Recent studies that have used similar instruments are Bodea and Hicks (2015b) and Garriga and Rodriguez (2020)

[21] Garriga and Rodriguez (2020) finds similar level of first stage correlation between a similarly constructed instrument and a CBI index

[22] Countries are classified as advanced or developing following the OECD classification. Appendix table 2.A.1 presents the countries in our sample.

[23] In Appendix 1.D, we discuss the selection of the lag length used to identify the preferred specification.

TABLE 1.3: Dynamic effects of CBI, baseline results

	All countries		Advanced economies		Developing countries	
	(1)	(2)	(3)	(4)	(5)	(6)
CBI_{t-1}	-2.218*	-2.426**	-1.149**	-1.166**	-5.033**	-5.612**
	(1.105)	(1.085)	(0.491)	(0.398)	(2.141)	(1.987)
$Inflation_{t-1}$	0.705**	0.731**	0.763**	0.738**	0.699**	0.722**
	(0.046)	(0.050)	(0.086)	(0.049)	(0.048)	(0.051)
$Inflation_{t-2}$	-0.092**	-0.142**	-0.031	-0.133**	-0.095**	-0.146**
	(0.039)	(0.046)	(0.073)	(0.056)	(0.040)	(0.048)
$Inflation_{t-3}$	0.060	0.087**	0.034	0.043	0.059	0.086**
	(0.036)	(0.038)	(0.042)	(0.057)	(0.038)	(0.038)
$Inflation_{t-4}$	0.045	0.026	-0.022	0.005	0.048	0.029
	(0.028)	(0.031)	(0.022)	(0.022)	(0.030)	(0.033)
Output gap		-4.140		14.380**		-5.901
		(3.730)		(2.811)		(3.998)
Debt to GDP		2.306**		-0.152		2.756**
		(0.710)		(0.217)		(0.883)
Exchange rate regime		-1.144**		-0.207		-1.368**
		(0.288)		(0.136)		(0.476)
Openness to trade		0.012*		0.002		0.014
		(0.006)		(0.004)		(0.008)
Chinn-Ito index		-0.633**		-0.375**		-0.780**
		(0.157)		(0.094)		(0.231)
Log of GDP per capita		0.007		0.009		0.003
		(0.007)		(0.006)		(0.008)
Polity		0.032		-0.101		0.065
		(0.043)		(0.089)		(0.045)
Effect of CB reform after 10 years	-7.278**	-7.689**	-4.291**	-3.314**	-16.187**	-17.304**
	(3.430)	(3.202)	(1.921)	(1.101)	(6.496)	(5.897)
Long-run effect of CB reform	-7.850**	-8.112**	-4.491**	-3.358**	-17.396**	-18.191**
	(3.677)	(3.329)	(2.040)	(1.114)	(6.954)	(6.159)
Persistence of Inflation process	0.717**	0.701**	0.744**	0.653**	0.711**	0.692**
	(0.046)	(0.042)	(0.042)	(0.032)	(0.049)	(0.044)
Unit root test	-15.361	-10.469	-6.733	-4.026	-10.992	-8.867
p value (reject unit root)	0.000	0.000	0.000	0.000	0.000	0.000
Sample inflation mean	17.534	19.752	4.437	4.250	22.347	26.092
Observations	4491	3683	1207	1069	3284	2614
Countries in sample	147	126	33	30	114	96

Notes: The dependent variable is the normalised level of inflation. CBI is the Central Bank Independence - Extended index introduced in Romelli (2022). *Output gap* is the deviation of real GDP from the Hodrick-Prescott filter. *Debt to GDP* is the Debt to GPD ratio of a country. *Exchange rate regime* is a dummy equal to one for countries adopting a fixed exchange rate regime. *Openness to trade* is the degree of trade openness of a country measured as the ratio of imports plus exports over GDP. *Chinn-Ito index* is the Chinn and Ito (2008) index of financial openness. *Log of GDP per capita* is the logarithm of the level of GDP per capita of a country. *Polity* is the Polity index of democracy. All models include country and year fixed effect. Levin et al. (2002) unit root test. Driscoll and Kraay (1998) standard errors in parentheses. ***/**/* denote significance at 1, 5 and 10 percent levels, respectively.

The estimates of the short-run effects of the lag of the CBI index on inflation in columns (1), (3), and (5) show that higher central bank independence has a statistically significant negative effect on inflation in the full sample of countries (column 1) and in the sub-sample of developing countries (column 5).

The magnitude of the coefficients indicates that the negative effects of CBI on inflation is primarily driven by developing countries. This suggest that developing countries are those who benefit the most from reforms in central bank design. Earlier studies on the CBI-inflation nexus found that *de jure* measures of CBI were negatively associated with inflation among advanced economies, but this was not the case for

developing countries. At the same time, the studies focusing on *de facto* measures of CBI, i.e. the turnover rate of central bank governors, suggested a negative relation between CBI and inflation for all countries, irrespective of their level of development (see Klomp and De Haan, 2010, for a meta-regression analysis on this earlier literature). However, more recent papers have shown that CBI is negatively associated with inflation also among developing countries (Dincer and Eichengreen, 2014; Garriga and Rodriguez, 2020) and less so among advanced economies when we focus on the post 2000 period (Balls et al., 2018; Haldane, 2020; Ioannidou et al., 2023). One of the possible explanations for the difference in the results between earlier and more recent literature relates to the timing of reforms across countries. Indeed, as shown in Table 1.1 the majority of the reforms in CBI took place prior to the 2000s among advanced economies and after it for developing countries. In addition, the possible beneficial effects of reforms might materialize immediately after a reform in some countries, while in other countries, such as those characterized by a lower degree of central bank independence and credibility, it might take more time to build trust and influence firms and consumer expectations. This motivates our decision to not only focus on the short-run, but also on the long-run effects of central bank reforms on inflation.

Looking at the estimates of persistence specifically, in each column we present the estimates of the auto-regressive coefficients of inflation up to four lags, as well as the sum of these coefficients (marked as *Persistence of Inflation process*). Across all estimations, we find that inflation is a persistent but stationary process as the sum of all the lagged coefficients is generally in the 0.65-0.75 range, and always significantly different (smaller) that one, i.e. the required condition for the convergence of an infinite series of effects.[24]

Given the dynamic structure of our model, we can calculate the long-run effects of CBI on inflation, which we report for each one of the specifications in the table. In each column we report two long-run effects: i) the cumulative effects of a reform on inflation after 10 years (*Effect of CB reform after 10 years*) and ii) the cumulative long-run effect (*Long-run effect of CB reform*), computed following equation (1.2).

[24]The inclusion of lagged values of inflation also helps address the "reversion to the mean" problem in the identification of the treatment effects of changes in the monetary policy framework most prominently remarked by Ball and Sheridan (2004) in the case of inflation targeting.

As expected in the case of a rather persistent process like inflation, the reported long-run effects are substantially larger than the short-run ones.

In columns (2), (4), and (6) of Table 1.3, our estimates also included a set of control variables normally used in the literature (see Arnone and Romelli, 2013, among others). To capture short-run business cycle effects we first include a measure of the output gap as in a standard Phillips curve representation as well as a measure of debt to GDP. Next, we include structural features of the economy like the degree of openness to trade measured as the share of imports plus exports over GDP, an indicator of the degree of financial account openness of a country, i.e. the Chinn and Ito (2008) index, and a dummy that captures the presence of a fixed exchange regime. Finally, we include a measure of the quality of democracy in the country, i.e. the Polity , and a broader index of the economic development of countries proxied by the logarythm of per capita GDP, and the level of debt to GDP.[25]

Our baseline results are robust to the inclusion of these control variables as both the short-run and the long-run negative effects of CBI on inflation are confirmed for the full sample and for the two sub-samples of advanced and developing countries. The evidence presented in this table gives us some comfort in the specification of our inflation model and that the conditional independence assumption is not violated.

The economic significance of the long-run effect of CBI on inflation is demonstrated as follows. A country moving from the first (0.429) to the fourth quartile (0.72) of the distribution of CBI would experience a long-run reduction of annual inflation of approximately 3.5 percentage points per year. However, for developing countries, the effect is considerably larger, with an average decrease in inflation of around 7.25 percentage points, while for an advanced economy this effect is much smaller, with a reduction of inflation of around 1.5 percentage points per year.[26]

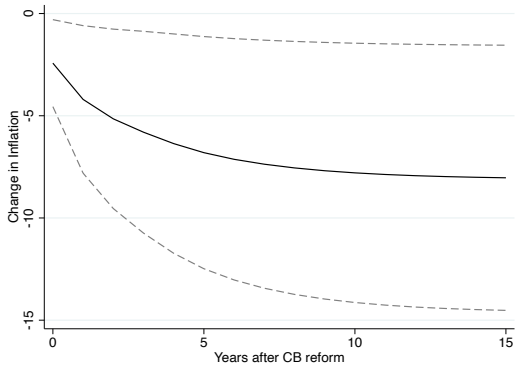
The time path of the effects of central bank reforms on inflation for the saturated

[25] In columns (2), (4), and (6) of Table 1.3, we present the saturated specification with all control variables, while Appendix Tables 1.E.1, 1.E.2 and 1.E.3 present the specifications in which each control is added independently.

[26] For this calculations we use the coefficients of the saturated models in columns (2), (4), and (6), and the corresponding average inflation in each sample, which we report at the bottom of each column. Recall that our models are estimated on a normalized value of inflation. Therefore, in line with previous literature (Acemoglu et al., 2008; Jacome and Vazquez, 2008), we compute the estimated effects by multiplying the coefficients by $(1+\pi)^2$.

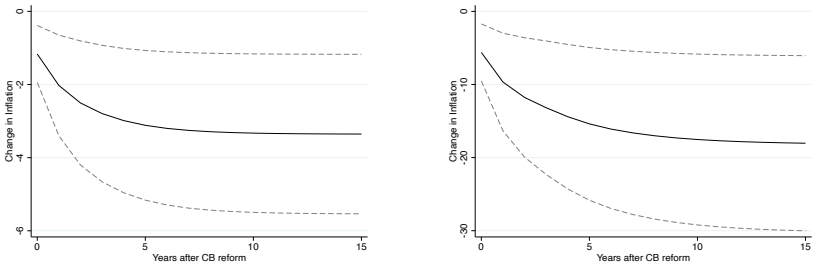
specifications presented in columns (2), (4), and (6) and the corresponding 95% confidence interval are plotted in Figure 1.2 for the full sample and in panel (a) of Figure 1.3 for advanced economies and in panel (b) for developing countries. As already presented in Table 1.3 the graphs show not only the immediate negative effect of a reform in central bank independence on inflation, but also the considerably larger fall in inflation at longer horizons.

FIGURE 1.2: Dynamic effects of CBI on inflation, all countries



Notes: The figure shows the impulse response function of inflation from the dynamic panels model in equation (1.1). See text for details.

FIGURE 1.3: Dynamic effects of CBI on inflation, by development level



(A) Advanced economies (B) Developing countries

Robustness and additional controls

Given that institutional reforms quite often happen in the aftermath of currency, financial or political crises (Gokmen et al., 2021), in Table 1.4 we introduce a set of controls related to crisis episodes. We therefore test that our results are not affected by banking, currency and sovereign debt crisis. We also introduce an index of political instability, as well as a dummy to test the effect of the transition of former

Soviet economies and satellite countries. The results in Table 1.4 are qualitatively similar to our baseline results, with the coefficient of the additional controls having the theoretically expected sign, when significant.

TABLE 1.4: Dynamic effect of CBI, additional controls

	All countries (1)	Advanced countries (2)	Developing countries (3)
CBI_{t-1}	-1.877*	-0.932**	-4.671**
	(1.042)	(0.386)	(1.866)
$Inflation_{t-1}$	0.742**	0.735**	0.732**
	(0.047)	(0.049)	(0.049)
$Inflation_{t-2}$	-0.146**	-0.144**	-0.149**
	(0.046)	(0.055)	(0.048)
$Inflation_{t-3}$	0.091**	0.052	0.090**
	(0.036)	(0.059)	(0.037)
$Inflation_{t-4}$	0.021	0.003	0.026
	(0.031)	(0.023)	(0.032)
Banking crisis	0.562	0.029	1.041
	(0.498)	(0.182)	(0.734)
Currency crisis	7.244**	1.850**	7.370**
	(1.636)	(0.708)	(1.674)
Sovereign debt crisis	1.494		1.095
	(1.662)		(1.945)
Government crisis $_{t-1}$	0.618**	0.246	1.026**
	(0.264)	(0.171)	(0.377)
Transition economies	0.128	-0.050	0.342
	(0.792)	(0.465)	(1.013)
Baseline controls	Yes	Yes	Yes
Effect of CB reform after 10 years	-6.085*	-2.604**	-14.753**
	(3.208)	(1.046)	(5.778)
Long-run effect of CB reform	-6.435*	-2.636**	-15.570**
	(3.331)	(1.056)	(6.057)
Persistence of Inflation process	0.708**	0.647**	0.700**
	(0.041)	(0.035)	(0.042)
Unit root test	-10.469	-4.026	-8.867
p value (reject unit root)	0.000	0.000	0.000
Sample inflation mean	20.443	4.323	27.071
Observations	3542	1032	2510
Countries in sample	120	29	91

Notes: The dependent variable is the normalised level of inflation. Baseline controls included: Output gap, Debt to GDP, Exchange rate regime, Openness to trade, Chinn-Ito index, Log of GDP per capita, and the Polity index. *Transition* are dummies that indicate the years of transition to market economies for post Soviet states and satellites. *Banking*, *Currency*, *Sovereign debt* and *Government* crisis are crises dummies. We have excluded sovereign debt crisis from the estimation of the advanced economies model and there are only two occurrences of sovereign debt crisis among these countries, i.e. in Greece and Cyprus. See definitions for baseline and additional controls in Table 1.B. All models include country and year fixed effect. Levin et al. (2002) unit root test. Driscoll and Kraay (1998) standard errors in parentheses. ***/**/* denote significance at 1, 5 and 10 percent levels, respectively.

A possible challenge to our results is represented by the presence of trends in inflation. Table 1.5 presents specifications with different approaches to control for

trends. In columns (1), (4) and (7) we introduce a linear time trend for the full set of countries as well as the sub-sample of advanced economies and developing countries, while in (2), (5) and (8) we control for both a linear and a quadratic time trend. The results presented in these columns indicate that both the short and long-run effect of CBI on inflation are mainly driven by the sample of developing countries. The negative and statistically significant coefficient for the time trend variable is in line with evidence that suggests that, starting from the beginning of the Great Moderation period, most of the countries worldwide have experienced a progressive decrease in inflation. Finally, in columns (3), (6), and (9), we control for the average level of inflation in any given year. Our conclusions remain robust to these choices.

TABLE 1.5: Dynamic effect of CBI, time controls and trends, all countries

	All countries			Advanced countries			Developing countries		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
CBI_{t-1}	-2.216**	-2.535**	-3.408**	-0.675	-0.825	-1.269**	-4.770**	-5.481**	-6.160**
	(1.063)	(1.077)	(1.113)	(0.535)	(0.519)	(0.519)	(1.967)	(1.988)	(1.998)
$Inflation_{t-1}$	0.719**	0.719**	0.724**	0.711**	0.697**	0.726**	0.711**	0.710**	0.712**
	(0.051)	(0.051)	(0.050)	(0.093)	(0.091)	(0.094)	(0.051)	(0.050)	(0.050)
$Inflation_{t-2}$	-0.140**	-0.141**	-0.138**	-0.102	-0.116	-0.101	-0.142**	-0.142**	-0.141**
	(0.045)	(0.045)	(0.045)	(0.082)	(0.082)	(0.084)	(0.047)	(0.047)	(0.046)
$Inflation_{t-3}$	0.099**	0.099**	0.102**	0.074	0.068	0.080	0.098**	0.097**	0.101**
	(0.037)	(0.037)	(0.036)	(0.057)	(0.056)	(0.058)	(0.037)	(0.037)	(0.037)
$Inflation_{t-4}$	0.010	0.013	0.005	-0.027	-0.015	-0.034	0.012	0.016	0.006
	(0.031)	(0.031)	(0.031)	(0.026)	(0.026)	(0.026)	(0.032)	(0.033)	(0.032)
Time trend	-0.083**	-0.184**		-0.047**	-0.153**		-0.082**	-0.264**	
	(0.022)	(0.076)		(0.014)	(0.052)		(0.024)	(0.105)	
Quadratic time trend		0.002			0.002**			0.004*	
		(0.001)			(0.001)			(0.002)	
World Inflation			0.011**			0.001			0.016**
			(0.002)			(0.001)			(0.003)
Baseline controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Effect of CB reform after 10 years	-6.816**	-7.818**	-10.614**	-1.947	-2.237*	-3.804**	-14.269**	-16.476**	-18.473**
	(3.111)	(3.103)	(3.140)	(1.479)	(1.341)	(1.461)	(5.694)	(5.762)	(5.606)
Long-run effect of CB reform	-7.114**	-8.178**	-11.080**	-1.969	-2.258*	-3.850**	-14.827**	-17.176**	-19.163**
	(3.219)	(3.207)	(3.252)	(1.493)	(1.350)	(1.479)	(5.855)	(5.953)	(5.753)
Persistence of Inflation process	0.688**	0.690**	0.692**	0.657**	0.635**	0.670**	0.678**	0.681**	0.679**
	(0.043)	(0.042)	(0.042)	(0.037)	(0.039)	(0.037)	(0.044)	(0.043)	(0.044)
Unit root test	-10.469	-10.469	-10.469	-4.026	-4.026	-4.026	-8.867	-8.867	-8.867
p value (reject unit root)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Sample inflation mean	19.752	19.752	19.752	4.250	4.250	4.250	26.092	26.092	26.092
Observations	3683	3683	3683	1069	1069	1069	2614	2614	2614
Countries in sample	126	126	126	30	30	30	96	96	96

Notes: The dependent variable is the normalised level of inflation. Baseline controls included: Output gap, Debt to GDP, Exchange rate regime, Openness to trade, Chinn-Ito index, Log of GDP per capita, and the Polity index. All models include country and year fixed effects, except in columns (3), (6), and (9) when the world inflation is included instead of a year fixed effect. Levin et al. (2002) unit root test. Driscoll and Kraay (1998) standard errors in parentheses. ***/**/* denote significance at 1, 5 and 10 percent levels, respectively. See main text for different treatments of time in each of the models.

In Table 1.6 we restrict the estimation sample to guard against our results being driven by a particular group of countries. In particular, in column (1) we exclude from our sample all countries part of a currency union, in column (2) we exclude all hyperinflation years, i.e. those episodes in which the annual change in inflation is higher that 50%, while in column (3) we exclude all countries which have experienced, at least once an hyperinflation episode over the period of our analysis. In column

(4) we exclude former transition countries and in column (5) we exclude all Western European countries.[27] Again our main conclusions remain robust.

TABLE 1.6: Dynamic effect of CBI, sample exclusions - all countries

	(1) No Currency unions	(2) No hyperinflation years	(3) No hyperinflation countries	(4) No Transition	(5) No Western Europe
CBI_{t-1}	-6.242**	-2.165**	-1.661**	-2.147**	-5.475**
	(1.699)	(0.872)	(0.794)	(1.049)	(1.865)
$Inflation_{t-1}$	0.771**	0.419**	0.449**	0.745**	0.723**
	(0.051)	(0.033)	(0.044)	(0.049)	(0.050)
$Inflation_{t-2}$	-0.170**	-0.130**	-0.077**	-0.125**	-0.143**
	(0.053)	(0.023)	(0.028)	(0.053)	(0.047)
$Inflation_{t-3}$	0.085*	0.083**	0.099**	0.081*	0.087**
	(0.045)	(0.025)	(0.040)	(0.044)	(0.038)
$Inflation_{t-4}$	0.021	0.010	0.023	0.016	0.024
	(0.038)	(0.015)	(0.032)	(0.033)	(0.032)
Baseline controls	Yes	Yes	Yes	Yes	Yes
Effect of CB reform after 10 years	-20.319**	-3.500**	-3.251**	-7.147**	-16.855**
	(5.298)	(1.405)	(1.469)	(3.361)	(5.469)
Long-run effect of CB reform	-21.334**	-3.504**	-3.283**	-7.568**	-17.662**
	(5.606)	(1.406)	(1.482)	(3.514)	(5.688)
Persistence of Inflation process	0.707**	0.382**	0.494**	0.716**	0.690**
	(0.041)	(0.037)	(0.067)	(0.040)	(0.043)
Unit root test	-10.480	-10.469	-10.469	-10.480	-10.480
p value (reject unit root)	0.000	0.000	0.000	0.000	0.000
Sample inflation mean	23.313	7.328	6.012	19.586	23.180
Observations	3028	3566	2638	3538	3010
Countries in sample	114	126	88	126	109

Notes: The dependent variable is the normalised level of inflation. Baseline controls included: Output gap, Debt to GDP, Exchange rate regime, Openness to trade, Chinn-Ito index, Log of GDP per capita. All models include country and year fixed effect. Driscoll and Kraay (1998) standard errors in parentheses. ***/**/* denote significance at 1, 5 and 10 percent levels, respectively. In column (1) currency union countries are excluded. In column (2) years with hyperinflation are excluded. In column (3) countries that have experienced hyper-inflationary episodes are excluded. In column (4) former transition countries are excluded. In column (5) Western European countries are excluded. Hyperinflation is defined as a period with annual inflation of more than 50%.

1.5.2 Local projections

This section presents the results of our local projection estimations. We first present the results of a linear/OLS estimation of the long-run effects of CBI on inflation. Next, we use a treatment effects framework to address the potential endogeneity of central bank reforms using the doubly robust local projections method. Finally, we implement an instrumental variables local projections analysis.

Linear local projections estimates

In this first subsection of the results using the local projections methods, our independent variable is the CBI index. In Figure 1.4 we present the estimated effects of CBI on inflation to horizons up to fifteen years and the corresponding 90% confidence intervals for the full sample of countries, while Figure 1.5 focuses on the sub-samples of advanced economies and developing countries. In this baseline specification, we

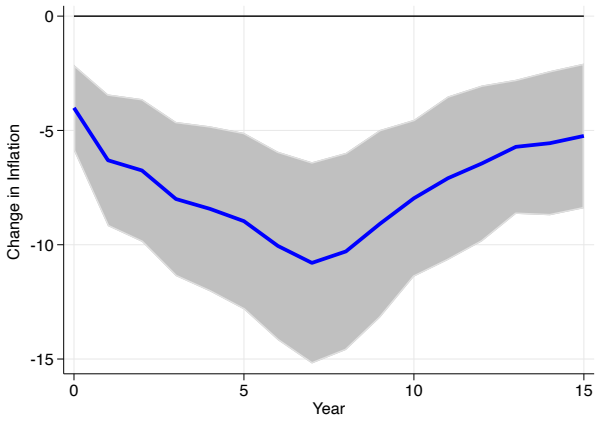
[27] Appendix Tables (1.E.4) and (1.E.5) present the results obtained on the subsamples of advanced economies and developing countries respectively.

include four lags of the dependent variable, the baseline controls from our dynamic panel models, and country fixed effects.[28]

The direct estimation of the long-run effects of CBI using this method confirms the intuition from our dynamic panel model presented in the previous section. The estimated impact effects are of comparable size and the effects of CBI on inflation increase with time. However, the divergence between advanced economies and developing countries is more pronounced with this direct estimation method.

These results give us confidence that the dynamic panel model accurately describes the dynamic effects of CBI on inflation, especially for developing countries.

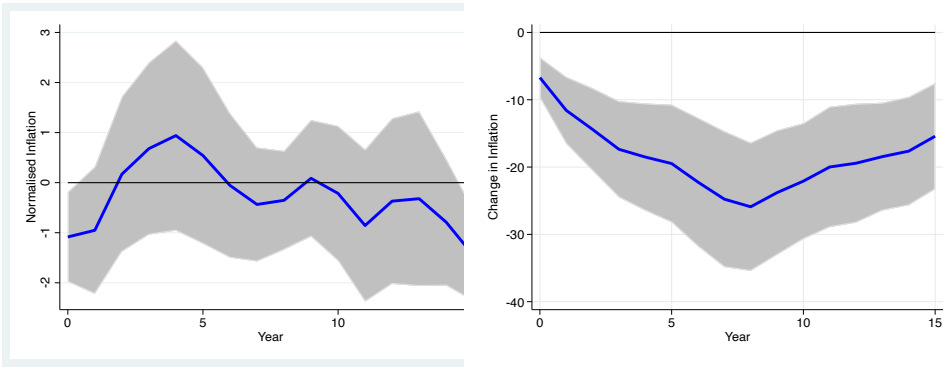
FIGURE 1.4: Local projections of CBI on inflation, all countries



Notes: Local projections of normalised inflation on CBI index. 90% confidence intervals. Baseline controls included: Output gap, Debt to GDP, Exchange rate regime, Openness to trade, Chinn-Ito index, Log of GDP per capita. Country fixed effects included. Driscoll and Kraay (1998) standard errors.

[28] As is common practice in local projections methods in macroeconomics we do not include year fixed effects. We did experiment with a common linear time trend but the results are not different from those presented here.

FIGURE 1.5: Local projections of CBI on inflation, by development level



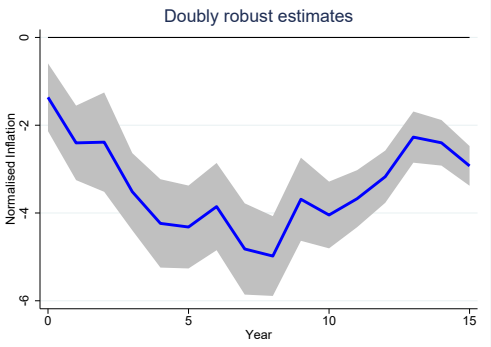
(A) Advanced economies (B) Developing countries

Notes: Local projections of normalised inflation on CBI index. 90% confidence intervals. Baseline controls included: Output gap, Debt to GDP, Exchange rate regime, Openness to trade, Chinn-Ito index, Log of GDP per capita. Country fixed effects included. Driscoll and Kraay (1998) standard errors.

Binary treatment LPs, Doubly robust estimates

This section presents the results of the doubly robust augmented inverse probability weighted estimator of Jordà and Taylor (2016).

FIGURE 1.6: LP-Doubly robust estimates



Notes: Local projections of normalised inflation on CBI reform dummy, doubly robust estimation. Advanced countries controls: output gap, GDP growth, debt to GDP, and GDP per capita. Developed market controls also include FX regime, trade openness and capital account openness, and Polity IV index. Country fixed effects included.

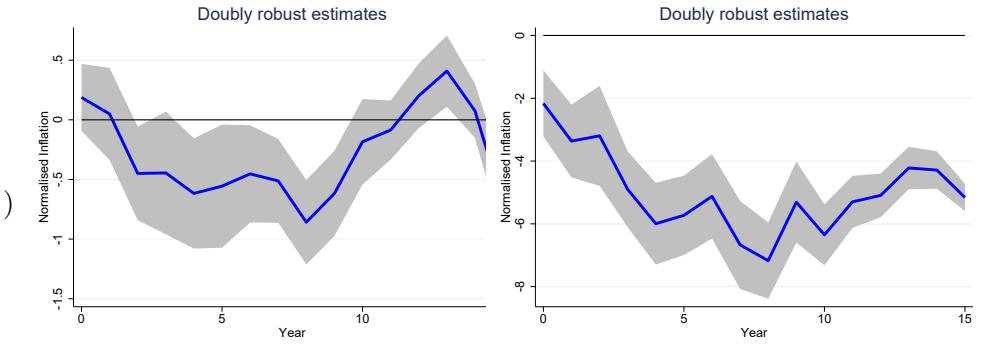
TABLE 1.7: Determinants of CB reform, probit marginal effects

	(1)	(2)	(3)
Inflation$_{t-1}$	0.000	-0.003	0.000
	(0.000)	(0.002)	(0.000)
CBI$_{t-1}$	0.027	-0.020	-0.081**
	(0.031)	(0.050)	(0.041)
GDP Growth$_{t-1}$	-0.000	-0.003	0.000
	(0.001)	(0.002)	(0.001)
Debt to GDP$_{t-1}$	-0.007	-0.018	0.006
	(0.009)	(0.017)	(0.011)
Log of GDP per capita $_{t-1}$	0.000*	-0.000*	0.000
	(0.000)	(0.000)	(0.000)
Currency Union	0.064***	0.000	0.045**
	(0.016)	(.)	(0.019)
Exchange Rate Regime $_{t-1}$	-0.025**	-0.015	-0.034**
	(0.012)	(0.017)	(0.015)
Inflation Crisis$_{t-1}$	0.010	-0.004	0.017
	(0.012)	(0.033)	(0.013)
Regional Peer Pressure$_{t-1}$	0.295***	0.150**	0.487***
	(0.046)	(0.059)	(0.083)
IMF Program	0.010	0.002	0.006
	(0.009)	(0.029)	(0.010)
Observations	2334	724	1601
Model AUC	0.771	0.568	0.782
s.e.	0.0267	0.0378	0.0251

Table presents marginal effects of estimated probit model of CB reform dummy. See text for details. AUC is the area under ROC curve. AUC $\in [0.5, 1]; H0 : AUC = 0.5$.

Table 1.7 presents marginal effect estimates from probit models for the probability of central bank reform in equation (1.4). The main conclusion from these models is to underscore the importance of regional pressure. Like in Romelli (2022) we find that importance of regional waves of central bank reforms as the determinant factor. Overall the predictive capacity of the models are significant.

FIGURE 1.7: LP-Doubly robust estimates, by development level



(A) Advanced economies (B) Developing countries

Notes: Local projections of normalised inflation on CBI reform dummy, doubly robust estimation. Advanced countries controls: output gap, GDP growth, debt to GDP, and GDP per capita. Developed market controls also include FX regime, trade openness and capital account openness, and Polity IV index. Country fixed effects included.

Figure 1.7 confirms the main finding of this study, i.e. the negative long-run effects of central bank reform on inflation. In the case of developing countries, the longer horizon effects seem to be larger than the short-run ones (the confidence interval of the 1-year forward effect is outside the confidence intervals for the effects at the 5-10 year horizon). The estimates for the doubly robust local projection method are qualitatively similar to the estimates from our two other methods. In terms of economic significance, a developing country that reforms its central bank on average experiences an 8.4 percentage points fall in inflation, an effect that if anything is slightly larger than our baseline estimates from the dynamic panel models. This provides further support to the idea that even if central bank reforms have an immediate impact on inflation, their great benefits materialize in the long-run. A possible explanation for such a dynamic rests in the fact that improvements in central bank independence are a signal that is only partially credible initially, as it takes time for central banks to build and maintain their credibility.

Instrumental variables local projections estimates

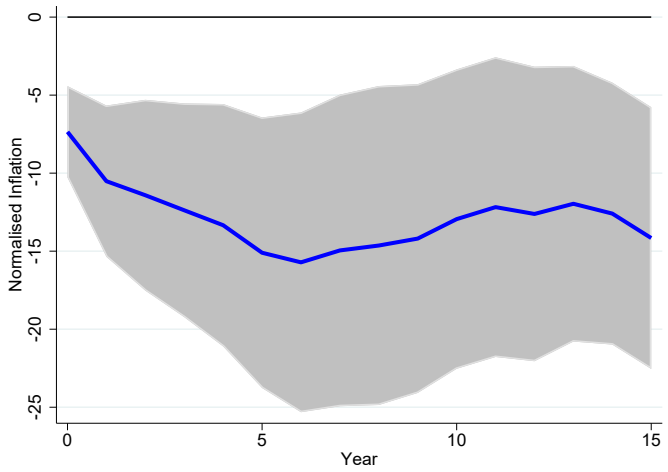
In this subsection of the results we present the estimates of our instrumental variable local projections approach.

In Figure 1.8 we present the estimated effects of CBI on inflation to horizons up to fifteen years and the corresponding 90% confidence intervals for the full sample of

countries, while Figure 1.9 focuses on the sub-samples of advanced and developing countries. We include the same set of controls as in our baseline local projection estimation above.

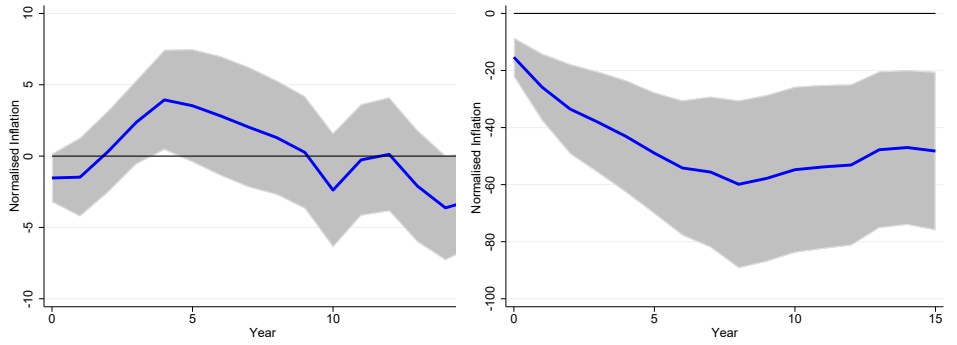
Our IV estimates are if anything larger than the corresponding LP-OLS estimates in the previous section. In Appendix 1.G we show that the instruments are not weak as indicated by the KP statistic which is systematically large across all estimated equations at all horizons. The results for the developing countries are noteworthy, as the instrument we used (regional peer pressure) might be particularly relevant for this group. Overall, our IV estimates confirm our baseline result for a significant and long lasting effect of central bank independence on inflation, particularly for developing countries.

FIGURE 1.8: LP-IV CBIE



Notes: Local projections of normalised inflation on CBI index. 90% confidence intervals. CBIE instrumented by regional peers pressure measure (see text for details of instrument construction). Controls: output gap, debt to GDP, GDP per capita, FX regime, trade openness and capital account openness, and Polity IV index. Country fixed effects included.Driscoll and Kraay (1998) errors corrected for cross sectional dependence.

FIGURE 1.9: LP-IV CBIE, by development level



(A) Advanced (B) Developing

Notes: Local projections of normalised inflation on CBI index. 90% confidence intervals. CBIE instrumented by regional peers pressure measure (see text for details of instrument construction). Controls: output gap, debt to GDP, GDP per capita, FX regime, trade openness and capital account openness, and Polity IV index. Country fixed effects included.Driscoll and Kraay (1998) errors corrected for cross sectional dependence.

1.5.3 Inflation Persistence

In this section we present suggestive evidence of the effects of central bank independence on the persistence of inflation. As the empirical strategy in our baseline dynamic panel models exploits the fact that the dynamics of inflation determines the long-run effects of central bank independence on inflation, we now try to explore a potential mechanism of effects of CBI. We therefore follow the literature (Dincer and Eichengreen (2008), Siklos (2008), Willard (2012)) and estimate the following panel specification for inflation:

$$\pi_{c,t} = \beta_0 + \beta_1 \pi_{c,t-1} + \beta_2 \text{CBI reform}_{c,t} + \beta_3 \text{CBI reform}_{c,t} \times \pi_{c,t-1} + \Theta' X_{c,t} + \alpha_c + \delta_t + \varepsilon_t, \tag{1.5}$$

where $\pi_{c,t}$ is the normalised measure of inflation in country c at time t. *CBI reform* is a dummy variable that takes value one from the year of a reform in central bank design and the following years. In this specification, β_1 is the reduced form estimate of the degree of inflation persistence for all the countries that did not reform their central bank, while $\beta_1 + \beta_2$ is the estimated persistence for reforming countries.

In table 1.8 we first estimate a simple AR(1) process for inflation in column (1). Inflation is a persistent series but in our data it certainly does not have a unit-root. In column (2) we introduce the interaction term of the central bank reform dummy with the first lag of inflation. The estimate of the standalone effect of CBI is negative

and statistically significant as already seen in previous sections. The estimate of the interaction coefficient (marked as *CBI reform* × *Inflation persistence* in the table) is also negative. We interpret this as evidence that the reform of the central bank lowers inflation persistence. In columns (3) and (4) we present the results for advanced economies and developing countries. The results show that the negative effects of central bank reform on the persistence of inflation is not driven by a particular group of countries. Our results indicate that indeed CBI affects the dynamics of inflation. We leave the implications of this finding as an area of future research.

TABLE 1.8: Persistence

	Full sample		Advanced economies	Developing countries
	(1)	(2)	(3)	(4)
Inflation persistence	0.757***	0.713***	0.671***	0.712***
	(0.008)	(0.009)	(0.012)	(0.011)
CBI reform		-2.051***	-1.229***	-2.720***
		(0.280)	(0.220)	(0.416)
CBI reform × Inflation persistence		-0.070***	-0.156**	-0.057*
		(0.020)	(0.057)	(0.024)
Constant	1.840***	2.827***	2.006***	3.253***
	(0.111)	(0.152)	(0.135)	(0.202)
Observations	5539	4977	1311	3666
Countries	147	147	33	114

Notes: Dependent variable is the level of normalized inflation. Inflation persistence is the measure of Inflation persistence extracted from an AR(1) process. CBI reform is dummy that take value equal to one from the year of the central bank reform onward. All models include country fixed effect.

1.6 Conclusion

In this paper we study the long-term effects of central bank independence on inflation. Using three different empirical strategies, we provide plausibly causal evidence that higher central bank independence significantly lowers inflation over the long-run.

Our results highlight the central role played by inflation dynamics in the disinflationary process triggered by central bank reforms, an area of research that has, so far, attracted little attention in the literature. We show that the higher the inflation persistence the more drawn out is the process of inflation converging to its new target (similar arguments have been made by Ball (1995) and Fuhrer (2010)). Additionally, we provide evidence that central bank independence might also lower inflation persistence, further underpinning the efficacy of monetary policy.

Though we cannot claim that our results are symmetrical for countries experiencing reversals in central bank independence, we believe that the evidence in this paper could serve as caution against recently voiced calls for additional controls on central banks by governments. A reversal of either the direct long run effects we document in this paper or the more suggestive indirect effects on the persistence of inflation would certainly made future trade-offs faced by policymakers in an environment of lower central bank independence considerably less favourable.

Appendix

1.A Countries

TABLE 1.A.1: Analyzed countries

Countries, year of first analyzed legislation and development clusters					
Afghanistan	2003	Dev	Dominica	1983	Dev
Albania	1992	Dev	Dominican Republic	1959	Dev
Algeria	1962	Dev	Ecuador	1957	Dev
Angola	1997	Dev	Egypt	1957	Dev
Anguilla	1987	Dev	Equatorial Guinea	1972	Dev
Antigua and Barbuda	1983	Dev	Estonia	1993	Adv
Argentina	1935	Dev	Ethiopia	1994	Dev
Australia	1959	Adv	Finland	1966	Adv
Austria	1955	Adv	France	1936	Adv
Azerbaijan	1996	Dev	Gabon	1972	Dev
Bahrain	1973	Dev	Gambia	1971	Dev
Bangladesh	2003	Dev	Georgia	1995	Dev
Belarus	1990	Dev	Germany	1957	Adv
Belgium	1948	Adv	Ghana	1975	Dev
Benin	1956	Dev	Greece	1959	Adv
Bolivia	1945	Dev	Grenada	1983	Dev
Bosnia and Herzegovina	1997	Dev	Guatemala	1959	Dev
Botswana	1975	Dev	Guinea-Bissau	1956	Dev
Brazil	1964	Dev	Guinea	1994	Dev
Brunei	1984	Dev	Haiti	1979	Dev
Bulgaria	1991	Dev	Hungary	1991	Dev
Burkina Faso	1956	Dev	Iceland	1966	Adv
Burundi	1965	Dev	India	1934	Dev
Cambodia	1954	Dev	Indonesia	1953	Dev
Cameroon	1972	Dev	Iran	1972	Dev
Canada	1954	Adv	Iraq	1964	Dev
Central African Republic	1972	Dev	Ireland	1942	Adv
Chad	1972	Dev	Italy	1948	Adv
Chile	1953	Dev	Ivory Coast	1956	Dev
China	1995	Dev	Jamaica	1992	Dev
Colombia	1923	Dev	Japan	1957	Adv
Comoros	1987	Dev	Jordan	1971	Dev
Costa Rica	1953	Dev	Kazakhstan	1993	Dev
Croatia	1991	Dev	Kenya	1984	Dev
Cuba	1959	Dev	Kuwait	1968	Dev
Cyprus	1963	Adv	Kyrgyzstan	1992	Dev
Czech Republic	1991	Adv	Laos	1995	Dev
Democratic Rep. of the Congo	1993	Dev	Latvia	1992	Adv
Denmark	1942	Adv	Lebanon	1969	Dev

Notes: The table reports information on the list of analysed countries, the first year of availability of the CBI index and their developmental cluster, i.e. Adv for advanced economics and Dev for developing countries.

Table 2.A.1 Continued: Analyzed countries

Countries, year of first analyzed legislation and region group					
Liberia	1974	Dev	Saint Kitts and Nevis	1983	Dev
Libya	1996	Dev	Saint Lucia	1983	Dev
Lithuania	1994	Adv	St. Vincent and the Grenadines	1983	Dev
Luxembourg	1983	Adv	Saudi Arabia	1957	Dev
Macao S.A.R	2000	Dev	Senegal	1956	Dev
Macedonia	1992	Dev	Seychelles	1986	Dev
Malawi	1989	Dev	Sierra Leone	1963	Dev
Malaysia	1982	Dev	Singapore	1991	Adv
Maldives	1982	Dev	Slovakia	1992	Adv
Mali	1984	Dev	Slovenia	1991	Adv
Malta	1994	Adv	Somalia	1960	Dev
Mauritania	1956	Dev	South AFR	1956	Dev
Mauritius	1966	Dev	South Korea	1950	Adv
Mexico	1960	Dev	Spain	1962	Adv
Moldova	1992	Dev	Sri Lanka	1953	Dev
Mongolia	1996	Dev	Sweden	1966	Adv
Montenegro	2005	Dev	Switzerland	1953	Adv
Morocco	1959	Dev	Taiwan	1979	Adv
Myanmar	1952	Dev	Thailand	1942	Dev
Namibia	1990	Dev	The Bahamas	1974	Dev
Nepal	1955	Dev	Togo	1956	Dev
Netherlands	1948	Adv	Trinidad and Tobago	1964	Dev
New Zealand	1933	Adv	Tunisia	1958	Dev
Niger	1956	Dev	Turkey	1970	Dev
Nigeria	1969	Dev	Turkmenistan	1994	Dev
Norway	1966	Adv	Uganda	1966	Dev
Oman	2000	Dev	Ukraine	1991	Dev
Pakistan	1972	Dev	United Arab Emirates	1980	Dev
Panama	1941	Dev	United Kingdom	1946	Adv
Paraguay	1952	Dev	United Republic of Tanzania	1966	Dev
Peru	1962	Dev	United States of America	1951	Adv
Philippines	1948	Dev	Uruguay	1938	Dev
Poland	1997	Dev	Uzbekistan	2000	Dev
Portugal	1962	Adv	Venezuela	1939	Dev
Qatar	1993	Dev	Vietnam	1990	Dev
Republic of Congo	1972	Dev	Yemen	1971	Dev
Romania	1991	Dev	Zambia	1971	Dev
Russia	1992	Dev	Zimbabwe	1956	Dev
Rwanda	1997	Dev			

Notes: The table reports information on the list of analysed countries, the year of the first analysed legislation and the regional clusters. AFR: Africa, EAP: East Asia and the Pacific, EECA Eastern Europe and Central Asia, LAC: Latin America and the Caribbean, MENA: Middle East and the North of Africa, SA: South Asia and WEOD: Western Europe and other developed countries.

1.B Data

TABLE 1.B.1: Data and data sources

Variable	Definition	Data sources
	Dependent variable	
Inflation	Annual percentage change of consumer price index re-scaled using the formula: $\pi_{c,t} = \frac{inflation_{c,t}}{1+inflation_{c,t}}$	World Bank: FP.CPI.TOTL.ZG
	Explanatory variables	
CBIE	Central Bank Independence - Extended (CBIE) index	Romelli (2022)
Output gap	Deviations of real GDP from HP trend.	World Bank: NY.GDP.MKTP.KD
Debt to GDP	Variable that captures the level of gross government debt-to-GDP. Following Abbas et al. (2010), updated to 2017 using the data on Debt to GDP provided in the IMF World Economic Outlook (WEO).	Abbas et al. (2010) and authors
Exchange rate regime	Dummy variable that takes the value of one in countries adopting a fixed exchange rate regime.	Authors following Ilzetzki et al. (2019)
Openness to trade	Degree of openness to trade of a country. $Opnness_{c,t} = \frac{Imports_{c,t}+Exports_{c,t}}{GDP_{c,t}}$.	World Bank
Chinn-Ito index	Index of capital account openness, with higher values suggesting greater openness.	Chinn and Ito (2008)
Log of GDP per capita	Log of per capita GDP	World Bank: NY.GDP.MKTP.KD
Polity	Index that measures the difference between the democratic and the autocratic score of a country, ranging from +10 (strongly democratic) to -10 (strongly autocratic).	PolityIV (2014)
Banking crisis	Dummy variable that takes the value of one in the two years following a systemic banking crisis.	Authors following Laeven and Valencia (2012)
Currency crisis	Dummy variable that takes the value of one in the two years following a systemic sovereign debt crisis.	Authors following Laeven and Valencia (2012)
Sovereign debt crisis	Dummy variable that takes the value of one in the two years following a systemic sovereign debt crisis.	Authors following Laeven and Valencia (2012)
Government crisis	Dummy that takes the value of one if a situation which could lead to the downfall of the ruling government takes place in a country.	Banks and Wilson (2021)
Transition economies	Dummy variable that takes the value of one for transition economies.	Authors following Acemoglu et al. (2019)

TABLE 1.B.2: Summary statistics

Variable	Obs	Mean	Std. Dev.	Min	Max
Inflation	5091	8.39	12.176	-21.419	99.581
CBIE index	5877	.548	.173	.099	.929
GMT index	5877	.459	.222	.063	1
CWN (unweighted) index	5877	.538	.239	.041	.987
Output gap	5535	0	.048	-.652	.474
Debt to GDP	5443	.556	.423	0	5.234
Exchange rate regime	5637	.355	.478	0	1
Openness to trade	5418	76.628	46.584	.021	437.327
Chinn-Ito index	5394	.128	1.548	-1.917	2.347
Log of GDP per capita	5570	8.46542	1.53136	5.08596	11.66335
Polity	5313	2.493	7.17	-10	10
Banking crisis	5278	.077	.267	0	1
Currency crisis	5278	.033	.179	0	1
Sovereign debt crisis	5278	.011	.102	0	1
Government crisis	5708	.142	.434	0	5
Transition economies	5877	.04	.196	0	1

1.C Dynamic panel models: specification analysis

In order to estimate the dynamic effects of CBI on inflation, we followed the three main specification choices needed for this type of analysis.[29] The first one requires the identification of the correct specification of the dynamic structure of the model, i.e. the choice of the lag structure for the dependent and the main explanatory variables. The second consists in identifying the specification of the conditional mean function, i.e. the selection of the exogenous controls to include in the model. Finally, given the stochastic structure of the data, we needed to select the appropriate robust estimator. In this section we briefly describe the process of selecting our preferred model.

To decide on the dynamic specification we applied the general-to-simple approach of Hendry and Mizon (1978), and Mizon (1984). In particular, we start from a saturated ARDL(p,q,n) model with p and q lags of the dependent and independent variables, respectively, and n weakly exogenous independent variables. The inclusion of p lags of the dependent variable characterises the dynamics of inflation, while the q lags of the independent variables describe the timing of the impact of our variable of interest, i.e. CBI.

Specifically we start from this general model:

$$\pi_t = \alpha_0 + \sum_{i=1}^{p} \alpha_i y_{t-i} + \sum_{k=0}^{q} \beta_q \, CBI_{t-q} + \sum_{j=1}^{n-1} \sum_{k=0}^{q} \beta_{jk} \, X_{t-q} + \varepsilon_t, \tag{1.6}$$

where π_t is the outcome of interest, i.e. inflation, CBI is the CBIE index of central bank independence, and X_t is a vector of n weakly exogenous predetermined variables, for which we make the sequential exogeneity assumption that $E(\varepsilon_t, X_{j,s}) = 0 \; \forall t, s, j$, with s being all lags from $t_0 \geq 0$ to t. In our context, the sequential exogeneity assumption implies that past values of the independent variables are orthogonal to contemporaneous and future shocks to inflation, and that the error terms ε_t are serially uncorrelated. The coefficients of interest is β_q on the index of central bank independence CBI_{t-q}. In this specification, we assume that this variable is also weakly exogenous, and we will return to this issue in section 1.4.3.

[29] For a practitioners perspective on specification selection for dynamic panels see the discussion in Beck and Katz (2011) and De Boef and Keele (2008).

In our specification analysis, in order to identify the most appropriate model to use given our data, we first tested the coefficient constraints of three models nested in the ARDL linear dynamic model: i) the partial adjustment model (also known as the Koyck model), ii) a model with serially correlated errors (also called the common factor model), and iii) the 'dead start' model where only lags of the CBI variable are included but not its contemporaneous values.[30] Our specification analysis results suggest that we cannot reject the partial adjustment model but we can reject the need to include *both* the contemporaneous value of the CBI index and its lagged value in the specification. Indeed, the CBI index, is a very persistent variable. When a reform takes place the CBI index remains at its new (almost always higher) level until the adoption of a reform able to change the degree of independence of the analyzed central bank. From the perspective of dynamics, lags of very persistent variables contribute little in substance, as the sum of the coefficients of all lags is often not far from the contemporaneous coefficient, which is also the case in our data.[31] We do not run models with no lags of the dependent variable, i.e. distributed lag models with no auto-regressive component, as this would imply that inflation persistence is not important, a view that we do not explore on the basis of theoretical grounds suggesting the possibility of backward looking expectations.

In the following subsections, we provide a discussion of the tests implemented in our specification search.

1.C.1 Stationarity

We carried out several tests to address questions of stationarity in the series we analyse. In Culver and Papell's (1997) classic study of panel unit root test, the authors easily reject the non-stationarity of inflation in a panel of 13 OECD countries. The results of the first-generation unit root tests run for inflation, i.e. the Im et al.

[30] The 'dead start' model assumes that the contemporaneous effect of the variable of interest is zero, hence the name of the model, but lagged effects are significant.

[31] In our panel of annual data, we lag the treatment variable by one period to address timing concerns, but estimates with the contemporaneous values are essentially identical. We also assume that we can adequately capture the effects of slow moving (mostly political economy) variables without the need of including their lags. This assumption proved innocuous in tests that we do not report, but are available upon request, as they did not affect the coefficients of the variables of interest.

(2003) one as well as the Fisher test implemented by Maddala and Wu (1999), allow us to comfortably reject the presence of unit roots.

We also run the second-generation panel unit root test of Pesaran (2007). This test allows for cross-sectional spatial dependence in the data, where the pairwise correlations are not the same across the panel series. The Pesaran (2004) post estimation tests for cross-sectional dependence indicate that our models are spatially dependent. In light of this finding, for robustness we estimate our models using the Driscoll and Kraay (1998) estimator.

As the most important independent variables in our analysis, i.e. the CBI index is bounded between 0 and -1, we therefore believe that its inclusion in our models is not a cause for spurious correlations (see Beck and Katz, 2011, for a discussion on the non-stationary of bounded variables).

However, the issue of interest here is not necessarily the stationarity of the individual series, but rather the stochastic properties of our variable of interest, i.e. inflation conditional on observes covariates. To that end, we used the Levin et al. (2002) test including covariates, whose results, reported at the bottom of each one of the results tables, indicate that we can reject the null of a unit root in inflation.

1.C.2 Serial correlation

Standard tests for serial correlation in linear panel-data models reject the no serial correlation null. However, the bias-corrected test introduced in Born and Breitung (2016) does not reject the no AR1 correlation hypothesis. This squares with the common intuition that lagged dependent variable models address the serial correlation issue. Nevertheless, in our specifications we will assume an AR1 model.

1.C.3 Cross-sectional dependence and heteroskedasticity

The Pesaran (2004) test rejects cross-sectional (spatial) independence even in the presence of year fixed effects. The average cross-sectional correlation is around .24 in our data, a reasonable value for cross-national data like ours. The data are also heteroskedastic according to a modified Wald test for groupwise heteroskedasticity following Greene (2000).

Given the N>T shape of our data, we therefore use an OLS estimator with the spatial correlation consistent errors proposed by Driscoll and Kraay (1998).

1.D Modeling of inflation dynamics

This section presents the results of a linear dynamic panel model of inflation where we estimate the effects of CBI on inflation only accounting for the dynamics of inflation and without any additional controls. The objective of Table 1.D.1 is to present the sensitivity of our baseline results to different lag specifications.

Columns (1)-(4) of Table 1.D.1 present the results obtained for the full sample of countries, columns (5)-(8) focus on the sub-sample of advanced economies, while columns (9)-(12) are centred on developing countries. In columns (1), (5), and (9), we only include one lag of inflation and in the following columns we progressively increase the number of lags to two, four, and eight. We only report the coefficient estimates for the first four lags, and report the p-values for the test of the joint significance of lags 5 to 8.[32] On the balance of evidence, we choose the specification with four lags of inflation as the preferred model.

TABLE 1.D.1: Modeling inflation dynamics

	All countries				Advanced economies				Developing countries			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
CBI_{t-1}	-2.813**	-2.364**	-2.218*	-1.390	-1.192**	-1.367**	-1.149**	-1.065*	-6.145**	-5.355**	-5.033**	-3.878**
	(1.029)	(1.162)	(1.105)	(0.913)	(0.489)	(0.516)	(0.491)	(0.597)	(2.082)	(2.184)	(2.141)	(1.894)
$Inflation_{t-1}$	0.715**	0.734**	0.705**	0.750**	0.660**	0.618**	0.763**	0.763**	0.712**	0.733**	0.699**	0.746**
	(0.040)	(0.041)	(0.046)	(0.053)	(0.067)	(0.112)	(0.086)	(0.049)	(0.044)	(0.045)	(0.048)	(0.056)
$Inflation_{t-2}$		-0.037	-0.092**	-0.097**		0.002	-0.031	-0.078		-0.039	-0.095**	-0.100**
		(0.029)	(0.039)	(0.045)		(0.045)	(0.073)	(0.071)		(0.030)	(0.040)	(0.049)
$Inflation_{t-3}$			0.060	0.067*			0.034	0.038			0.059	0.066*
			(0.036)	(0.037)			(0.042)	(0.053)			(0.038)	(0.038)
$Inflation_{t-4}$			0.045	0.049			-0.022	-0.043			0.048	0.051
			(0.028)	(0.032)			(0.022)	(0.039)			(0.030)	(0.032)
p-value lags 5 to 8				[0.021]				[0.130]				[0.026]
Effect of CB reform after 10 years	-9.536**	-7.636**	-7.278**	-5.258	-3.455**	-3.561**	-4.291**	-3.324*	-20.630**	-17.115**	-16.187**	-14.424**
	(3.249)	(3.453)	(3.430)	(3.440)	(1.663)	(1.334)	(1.921)	(1.868)	(6.814)	(6.403)	(6.496)	(6.939)
Long-run effect of CB reform	-9.883**	-7.805**	-7.850**	-5.996	-3.511**	-3.591**	-4.491**	-3.327*	-21.345**	-17.466**	-17.396**	-16.347**
	(3.366)	(3.515)	(3.677)	(3.923)	(1.722)	(1.351)	(2.040)	(1.881)	(7.128)	(6.512)	(6.954)	(7.899)
Persistence of Inflation process	0.715**	0.697**	0.717**	0.768**	0.660**	0.619**	0.744**	0.680**	0.712**	0.693**	0.711**	0.763**
	(0.040)	(0.042)	(0.046)	(0.040)	(0.067)	(0.074)	(0.042)	(0.049)	(0.044)	(0.046)	(0.049)	(0.042)
Unit root test	-16.752	-15.414	-15.361	-8.966	-18.661	-14.060	-6.733	-3.832	-10.941	-9.662	-10.992	-8.722
p value (reject unit root)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Sample inflation mean	24.891	18.859	17.534	17.024	5.418	4.999	4.437	3.716	31.888	23.875	22.347	22.102
Observations	4941	4791	4491	3892	1306	1273	1207	1075	3635	3518	3284	2817
Countries in sample	147	147	147	145	33	33	33	33	114	114	114	112

Notes: The dependent variable is the normalised level of inflation. CBI is the Central Bank Independence - Extended index introduced in Romelli (2022). All models include country and year fixed effect. Levin et al. (2002) unit root test. Driscoll and Kraay (1998) standard errors in parentheses. ***/**/* denote significance at 1, 5 and 10 percent levels, respectively.

[32] While this joint test indicates that lags 5 to 8 are jointly significant for the full sample and the sample of developing countries, this result is driven by lag 7 which is the only one which is statistically significant.

1.E Dynamic panel additional results

Table 1.E.1 expands the results presented in Table 1.3 for the full sample of countries. The first and last columns reproduce the results in Table 1.3, columns (1) and (2), while the rest of the table introduces the control variables individually.

TABLE 1.E.1: Dynamic effects of CBI, all countries

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
CBI_{t-1}	-2.218*	-2.104*	-1.932*	-2.776**	-2.966**	-1.802*	-2.138*	-1.999*	-2.426**
	(1.105)	(1.090)	(1.051)	(1.142)	(1.171)	(1.057)	(1.118)	(1.167)	(1.085)
$Inflation_{t-1}$	0.705**	0.702**	0.728**	0.700**	0.699**	0.742**	0.703**	0.715**	0.731**
	(0.046)	(0.046)	(0.046)	(0.046)	(0.047)	(0.045)	(0.046)	(0.048)	(0.050)
$Inflation_{t-2}$	-0.092**	-0.092**	-0.117**	-0.094**	-0.092**	-0.134**	-0.094**	-0.100**	-0.142**
	(0.039)	(0.038)	(0.044)	(0.039)	(0.040)	(0.042)	(0.038)	(0.040)	(0.046)
$Inflation_{t-3}$	0.060	0.061	0.077**	0.059	0.057	0.089**	0.061*	0.058	0.087**
	(0.036)	(0.037)	(0.038)	(0.036)	(0.036)	(0.036)	(0.036)	(0.038)	(0.038)
$Inflation_{t-4}$	0.045	0.044	0.032	0.042	0.046	0.026	0.045	0.049*	0.026
	(0.028)	(0.029)	(0.029)	(0.028)	(0.028)	(0.030)	(0.028)	(0.029)	(0.031)
Output gap		-3.935							-4.140
		(3.377)							(3.730)
Debt to GDP			2.269**						2.306**
			(0.641)						(0.710)
Exchange Rate Regime				-1.404**					-1.144**
				(0.323)					(0.288)
Openness to trade					0.020**				0.012*
					(0.006)				(0.006)
Chinn-Ito index						-0.639**			-0.633**
						(0.126)			(0.157)
Log of GDP per capita							-0.001		0.007
							(0.005)		(0.007)
Polity								0.047	0.032
								(0.040)	(0.043)
Effect of CB reform after 10 years	-7.278**	-6.850**	-6.426*	-8.876**	-9.523**	-6.057*	-6.986**	-6.633*	-7.689**
	(3.430)	(3.365)	(3.352)	(3.446)	(3.545)	(3.346)	(3.472)	(3.670)	(3.202)
Long-run effect of CB reform	-7.850**	-7.373**	-6.900*	-9.482**	-10.209**	-6.500*	-7.531**	-7.177*	-8.112**
	(3.677)	(3.600)	(3.571)	(3.676)	(3.792)	(3.529)	(3.723)	(3.944)	(3.329)
Persistence of Inflation process	0.717**	0.715**	0.720**	0.707**	0.709**	0.723**	0.716**	0.721**	0.701**
	(0.046)	(0.046)	(0.044)	(0.047)	(0.046)	(0.039)	(0.047)	(0.048)	(0.042)
Unit root test	-15.361	-14.847	-12.780	-15.319	-16.869	-10.092	-15.185	-14.715	-10.469
p value (reject unit root)									
Sample inflation mean	17.534	17.572	17.667	17.898	17.545	17.965	17.507	18.749	19.752
Observations	4491	4428	4386	4371	4343	4325	4453	4118	3683
Countries in sample	147	146	146	147	145	142	147	133	126

Notes: The dependent variable is the normalised level of inflation. CBI is the Central Bank Independence - Extended index introduced in Romelli (2022). *Output gap* is the deviation of real GDP from the Hodrick-Prescott filter. *Debt to GDP* is the Debt to GPD ratio of a country. *Exchange rate regime* is a dummy equal to one for countries adopting a fixed exchange rate regime. *Openness to trade* is the degree of trade openness of a country measured as the ratio of imports plus exports over GDP. *Chinn-Ito index* is the Chinn and Ito (2008) index of financial openness. *Log of GDP per capita* is the logorithm of the level of GDP per capita of a country. *Polity* is the Polity index of democracy. All models include country and year fixed effect. Levin et al. (2002) unit root test. Driscoll and Kraay (1998) standard errors in parentheses. ***/**/* denote significance at 1, 5 and 10 percent levels, respectively.

Table 1.E.2 and Table 1.E.3 below replicate the estimations presented in Table 1.3, columns (3)-(4) and (5)-(6), respectively by introducing the control variables individually. The main conclusions from table 1.3 follow through.

TABLE 1.E.2: Dynamic effect of CBI, advanced economies

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
CBI_{t-1}	-1.149**	-1.239**	-1.212**	-1.415**	-1.330**	-0.655	-1.096**	-1.444**	-1.166**
	(0.491)	(0.437)	(0.497)	(0.534)	(0.479)	(0.431)	(0.472)	(0.486)	(0.398)
$Inflation_{t-1}$	0.763**	0.732**	0.758**	0.761**	0.762**	0.744**	0.757**	0.812**	0.738**
	(0.086)	(0.081)	(0.088)	(0.087)	(0.086)	(0.088)	(0.085)	(0.046)	(0.049)
$Inflation_{t-2}$	-0.031	-0.005	-0.031	-0.029	-0.032	-0.055	-0.025	-0.137**	-0.133**
	(0.073)	(0.069)	(0.075)	(0.072)	(0.073)	(0.076)	(0.070)	(0.055)	(0.056)
$Inflation_{t-3}$	0.034	0.032	0.035	0.033	0.034	0.060	0.032	0.027	0.043
	(0.042)	(0.043)	(0.044)	(0.043)	(0.042)	(0.049)	(0.042)	(0.043)	(0.057)
$Inflation_{t-4}$	-0.022	-0.017	-0.022	-0.023	-0.021	-0.025	-0.014	-0.006	0.005
	(0.022)	(0.021)	(0.022)	(0.022)	(0.022)	(0.022)	(0.020)	(0.023)	(0.022)
Output gap		16.621**							14.380**
		(2.691)							(2.811)
Debt to GDP			-0.587**						-0.152
			(0.196)						(0.217)
Exchange Rate Regime				-0.295*					-0.207
				(0.166)					(0.136)
Openness to trade					0.005**				0.002
					(0.002)				(0.004)
Chinn-Ito index						-0.249**			-0.375**
						(0.089)			(0.094)
Log of GDP per capita							0.012*		0.009
							(0.007)		(0.006)
Polity								-0.047	-0.101
								(0.079)	(0.089)
Effect of CB reform after 10 years	-4.291**	-4.571**	-4.461**	-5.262**	-4.945**	-2.286	-4.136**	-4.690**	-3.314**
	(1.921)	(1.664)	(1.907)	(2.073)	(1.909)	(1.570)	(1.862)	(1.570)	(1.101)
Long-run effect of CB reform	-4.491**	-4.827**	-4.653**	-5.498**	-5.171**	-2.373	-4.375**	-4.753**	-3.358**
	(2.040)	(1.791)	(2.016)	(2.200)	(2.043)	(1.653)	(2.014)	(1.588)	(1.114)
Persistence of Inflation process	0.744**	0.743**	0.739**	0.743**	0.743**	0.724**	0.749**	0.696**	0.653**
	(0.042)	(0.042)	(0.043)	(0.042)	(0.042)	(0.048)	(0.044)	(0.026)	(0.032)
Unit root test	-6.733	-7.556	-6.477	-7.129	-6.983	-4.998	-6.452	-5.951	-4.026
p value (reject unit root)									
Sample inflation mean	4.437	4.437	4.380	4.470	4.437	4.510	4.437	4.216	4.250
Observations	1207	1207	1196	1193	1207	1150	1207	1150	1069
Countries in sample	33	33	33	33	33	32	33	31	30

Notes: The dependent variable is the normalised level of inflation. *CBI* is the Central Bank Independence - Extended index introduced in Romelli (2022). *Output gap* is the deviation of real GDP from the Hodrick-Prescott filter. *Debt to GDP* is the Debt to GPD ratio of a country. *Exchange rate regime* is a dummy equal to one for countries adopting a fixed exchange rate regime. *Openness to trade* is the degree of trade openness of a country measured as the ratio of imports plus exports over GDP. *Chinn-Ito index* is the Chinn and Ito (2008) index of financial openness. *Log of GDP per capita* is the logorithm of the level of GDP per capita of a country. *Polity* is the Polity index of democracy. All models include country and year fixed effect. Levin et al. (2002) unit root test. Driscoll and Kraay (1998) standard errors in parentheses. ***/**/* denote significance at 1, 5 and 10 percent levels, respectively.

TABLE 1.E.3: Dynamic effect of CBI, developing countries

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
CBI_{t-1}	-5.033**	-4.902**	-3.728*	-5.249**	-5.706**	-5.757**	-4.921**	-5.184**	-5.612**
	(2.141)	(2.127)	(1.940)	(2.227)	(2.165)	(2.032)	(2.139)	(2.206)	(1.987)
$Inflation_{t-1}$	0.699**	0.695**	0.722**	0.694**	0.693**	0.733**	0.697**	0.707**	0.722**
	(0.048)	(0.048)	(0.048)	(0.048)	(0.050)	(0.046)	(0.048)	(0.049)	(0.051)
$Inflation_{t-2}$	-0.095**	-0.097**	-0.122**	-0.098**	-0.096**	-0.139**	-0.097**	-0.102**	-0.146**
	(0.040)	(0.040)	(0.046)	(0.040)	(0.041)	(0.044)	(0.040)	(0.042)	(0.048)
$Inflation_{t-3}$	0.059	0.061	0.078*	0.059	0.057	0.088**	0.061	0.058	0.086**
	(0.038)	(0.038)	(0.039)	(0.037)	(0.037)	(0.037)	(0.037)	(0.038)	(0.038)
$Inflation_{t-4}$	0.048	0.047	0.037	0.046	0.050	0.028	0.048	0.052*	0.029
	(0.030)	(0.030)	(0.030)	(0.030)	(0.030)	(0.031)	(0.030)	(0.030)	(0.033)
Output gap		-5.888							-5.901
		(3.642)							(3.998)
Debt to GDP			2.753**						2.756**
			(0.757)						(0.883)
Exchange Rate Regime				-1.740**					-1.368**
				(0.495)					(0.476)
Openness to trade					0.022**				0.014
					(0.009)				(0.008)
Chinn-Ito index						-0.886**			-0.780**
						(0.182)			(0.231)
Log of GDP per capita							-0.003		0.003
							(0.005)		(0.008)
Polity								0.092*	0.065
								(0.046)	(0.045)
Effect of CB reform after 10 years	-16.187**	-15.585**	-12.182**	-16.475**	-18.000**	-18.656**	-15.752**	-16.863**	-17.304**
	(6.496)	(6.385)	(6.038)	(6.603)	(6.453)	(6.159)	(6.474)	(6.798)	(5.897)
Long-run effect of CB reform	-17.396**	-16.698**	-13.058**	-17.555**	-19.250**	-19.840**	-16.915**	-18.200**	-18.191**
	(6.954)	(6.806)	(6.412)	(7.006)	(6.885)	(6.475)	(6.923)	(7.332)	(6.159)
Persistence of Inflation process	0.711**	0.706**	0.715**	0.701**	0.704**	0.710**	0.709**	0.715**	0.692**
	(0.049)	(0.050)	(0.047)	(0.050)	(0.049)	(0.042)	(0.050)	(0.050)	(0.044)
Unit root test	-10.992	-10.657	-8.842	-10.902	-11.689	-7.921	-11.009	-10.031	-8.867
p value (reject unit root)									
Sample inflation mean	22.347	22.494	22.648	22.938	22.590	22.838	22.367	24.380	26.092
Observations	3284	3221	3190	3178	3136	3175	3246	2968	2614
Countries in sample	114	113	113	114	112	110	114	102	96

Notes: The dependent variable is the normalised level of inflation. CBI is the Central Bank Independence - Extended index introduced in Romelli (2022). *Output gap* is the deviation of real GDP from the Hodrick-Prescott filter. *Debt to GDP* is the Debt to GPD ratio of a country. *Exchange rate regime* is a dummy equal to one for countries adopting a fixed exchange rate regime. *Openness to trade* is the degree of trade openness of a country measured as the ratio of imports plus exports over GDP. *Chinn-Ito index* is the Chinn and Ito (2008) index of financial openness. *Log of GDP per capita* is the logorithm of the level of GDP per capita of a country. *Polity* is the Polity index of democracy. All models include country and year fixed effect. Levin et al. (2002) unit root test. Driscoll and Kraay (1998) standard errors in parentheses. ***/**/* denote significance at 1, 5 and 10 percent levels, respectively.

TABLE 1.E.4: Dynamic effect of CBI, sample exclusions - advanced economies

	(1) No Currency unions	(2) No hyperinflation years	(3) No hyperinflation countries	(4) No Transition	(5) No Western Europe
CBI_{t-1}	-1.569**	-1.166**	-0.901**	-1.187**	-8.341**
	(0.710)	(0.398)	(0.414)	(0.404)	(1.693)
$Inflation_{t-1}$	0.691**	0.738**	0.756**	0.758**	0.599**
	(0.046)	(0.049)	(0.048)	(0.050)	(0.069)
$Inflation_{t-2}$	-0.144**	-0.133**	-0.121*	-0.135**	-0.170**
	(0.057)	(0.056)	(0.063)	(0.057)	(0.066)
$Inflation_{t-3}$	0.024	0.043	0.005	0.049	0.076
	(0.058)	(0.057)	(0.068)	(0.061)	(0.063)
$Inflation_{t-4}$	0.013	0.005	0.081**	0.030	0.001
	(0.023)	(0.022)	(0.040)	(0.025)	(0.027)
Baseline controls	Yes	Yes	Yes	Yes	Yes
Effect of CB reform after 10 years	-3.752**	-3.314**	-2.995**	-3.809**	-16.860**
	(1.649)	(1.101)	(1.316)	(1.244)	(3.480)
Long-run effect of CB reform	-3.766**	-3.358**	-3.224**	-3.981**	-16.893**
	(1.651)	(1.114)	(1.383)	(1.287)	(3.483)
Persistence of Inflation process	0.583**	0.653**	0.721**	0.702**	0.506**
	(0.027)	(0.032)	(0.033)	(0.035)	(0.055)
Unit root test	-4.728	-4.026	-4.026	-4.728	-4.728
p value (reject unit root)	0.000	0.000	0.000	0.000	0.000
Sample inflation mean	5.061	4.250	4.288	4.250	3.959
Observations	808	1069	984	1032	396
Countries in sample	30	30	26	30	13

Notes: Dependent variable is normalised inflation. All models include country and year fixed effect. Driscoll and Kraay (1998) standard errors in parentheses. ***/**/* denote significance at 1, 5 and 10 percent levels, respectively. In column (1) currency union periods are excluded. In column (2) years with hyperinflation are excluded. In column (3) countries that have experienced hyper-inflationary episodes in the years of our sample are excluded. In column (4) former transition countries are excluded. In column (5) EMU countries are excluded. Hyperinflation is defined as a period with inflation of more than 50%.

TABLE 1.E.5: Dynamic effect of CBI, sample exclusions - developing countries

	(1) No Currency unions	(2) No hyperinflation years	(3) No hyperinflation countries	(4) No Transition	(5) No Western Europe
CBI_{t-1}	-8.950**	-3.001**	-3.313**	-5.265**	-5.612**
	(2.407)	(1.318)	(1.419)	(1.994)	(1.987)
$Inflation_{t-1}$	0.763**	0.398**	0.405**	0.735**	0.722**
	(0.053)	(0.034)	(0.052)	(0.050)	(0.051)
$Inflation_{t-2}$	-0.172**	-0.132**	-0.087**	-0.127**	-0.146**
	(0.055)	(0.025)	(0.031)	(0.056)	(0.048)
$Inflation_{t-3}$	0.085*	0.083**	0.105**	0.083*	0.086**
	(0.046)	(0.025)	(0.043)	(0.046)	(0.038)
$Inflation_{t-4}$	0.023	0.011	0.027	0.016	0.029
	(0.040)	(0.016)	(0.034)	(0.035)	(0.033)
Baseline controls	Yes	Yes	Yes	Yes	Yes
Effect of CB reform after 10 years	-28.403**	-4.681**	-5.976**	-17.036**	-17.304**
	(7.257)	(2.013)	(2.015)	(6.340)	(5.897)
Long-run effect of CB reform	-29.721**	-4.686**	-6.020**	-17.946**	-18.191**
	(7.558)	(2.016)	(2.006)	(6.682)	(6.159)
Persistence of Inflation process	0.699**	0.359**	0.450**	0.707**	0.692**
	(0.043)	(0.039)	(0.089)	(0.041)	(0.044)
Unit root test	-8.543	-8.867	-8.867	-8.543	-8.543
p value (reject unit root)	0.000	0.000	0.000	0.000	0.000
Sample inflation mean	29.956	8.646	7.038	25.901	26.092
Observations	2220	2497	1654	2506	2614
Countries in sample	84	96	62	96	96

Notes: Dependent variable is normalised inflation. All models include country and year fixed effect. Driscoll and Kraay (1998) standard errors in parentheses. ***/**/* denote significance at 1, 5 and 10 percent levels, respectively. In column (1) currency union periods are excluded. In column (2) years with hyperinflation are excluded. In column (3) countries that have experienced hyper-inflationary episodes in the years of our sample are excluded. In column (4) former transition countries are excluded. In column (5) EMU countries are excluded. Hyperinflation is defined as a period with inflation of more than 50%.

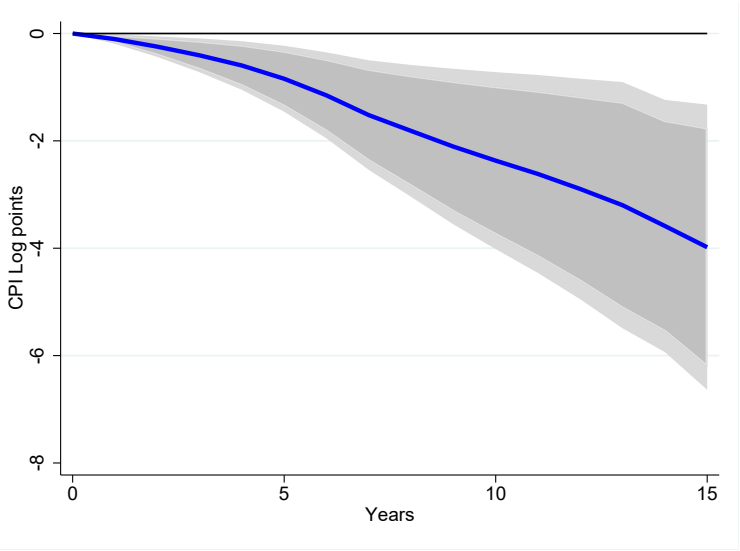
1.F Cumulative effects of CBI on CPI

This section presents alternative specifications for the effects of CBI on inflation. First it presents local projection estimates of the cumulative effect of CBI on CPI, and then it presents an estimate of the cumulative effect on CPI based on the dynamic panel estimates in section 1.5.1.

Linear LP-OLS with long-run LnCPI cumulative changes Figure 1.F.1 presents the cumulative effect of CBI on CPI for all countries in the dataset. To be precise, in the estimation of equation (1.3) the dependent variable here is the cumulative change in the log of CPI over the horizon periods. In Figure 1.F.2a we present the cumulative effects by development level. As in the main LP results presented, the effects on the price level are not significant for advanced countries but are important for developing countries.

FIGURE 1.F.1: Cumulative effects of CBI on CPI, all countries

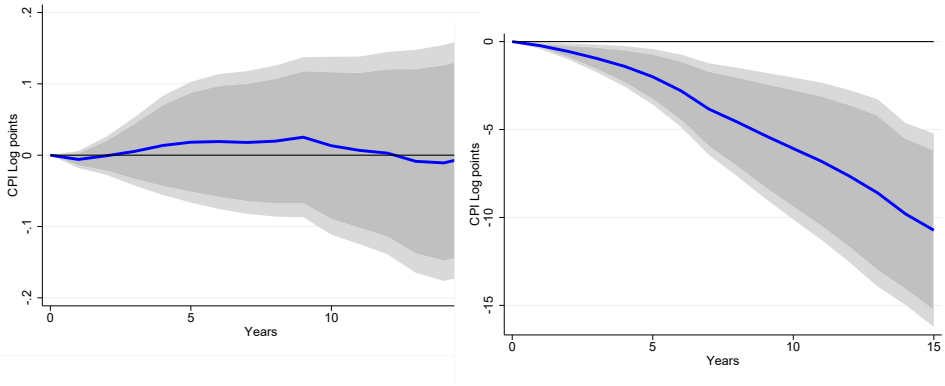
(A) Cumulative LnCPI changes.



Notes: Local projections of normalised inflation on CBI index. The dependent variable here is the cumulative change in the log of CPI over the horizon periods. 90% confidence intervals. Controls: output gap, debt to GDP, GDP per capita, FX regime, trade openness and capital account openness, and Polity IV index. Country fixed effects included.Driscoll and Kraay (1998) errors corrected for cross sectional dependence.

FIGURE 1.F.2: Cumulative effects of CBI on CPI, by development level

(A) Cumulative LnCPI changes.

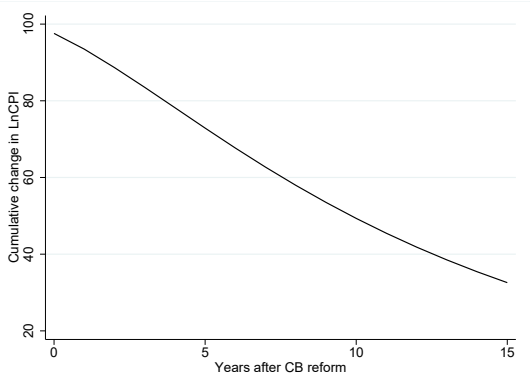


(B) Advanced economies

(C) Developing countries

Long-run cumulative changes of CPI index from dynamic panel estimates: Figure 1.F.3 presents an estimate of the cumulative differential effect of CBI on CPI. The interpretation of the graph is as follows: For an untreated country which has 0% inflation for 15 years, so has a constant CPI at 100, a country with CBI would have a CPI index of 32 after 15 years. Alternative we can assume say a 2% inflation for the untreated country and the estimate the differential effect from that CPI path. Note that we do not estimate a confidence interval for this graph.

FIGURE 1.F.3: Cumulative effects of CBI on CPI, all countries



1.G IV Local projection estimation

Table 2.E.1 presents the first stage of our IV estimation. We construct the instrument from the 75th percentile of the regional distribution of CBI. We use the regional classification from Acemoglu et al. (2019).

TABLE 1.G.1: IV First stage estimates

	1
Regional peer pressure t-1	0.491**
	(0.096)
Regional peer pressure t-2	0.193**
	(0.064)
$\text{Inflation}_{i,t-1}$	-0.000
	(0.000)
$\text{Inflation}_{i,t-2}$	0.000
	(0.000)
$\text{Inflation}_{i,t-3}$	-0.000
	(0.000)
$\text{Inflation}_{i,t-4}$	-0.000
	(0.000)
Output gap	-0.062
	(0.051)
Debt to GDP	0.004
	(0.021)
Exchange Rate Regime	-0.021
	(0.019)
Openness to trade	0.000*
	(0.000)
Chinn-Ito index	0.006
	(0.007)
Log of GDP per capita	0.000
	(0.000)
Polity	0.003
	(0.002)
KP weak IV	23.72
Observations	3688
Countries in sample	126

Notes: The table shows the first stage results of the IV estimation. We instrument the CBIE index of central bank independence introduced in Romelli (2022) with a measure of regional peer pressure (see text for details). KP weak IV refers to the Kleibergen and Paap (2006) Wald rk F-statistic.

Chapter 2

Central Bank Government Lending restrictions increase fiscal space

> "Je veux que la Banque soit assez dans les mains du Gouvernement et n'y soit pas trop"
> "I want the Bank [of France] to be enough in the hands of the Government, but not too much [...]"
>
> *Napoleon Bonaparte, 1806*

2.1 Introduction

The relationship between the central bank and the government has always been fraught with ambiguity.[1] While the effects of central bank independence on monetary matters can easily be summarised by its association with the inflation dynamics of a country, the relationship between the central bank and the treasury has remained a topic of active methodological debate. Numerous strands of literature analyse the interaction between the central bank and the fiscal authority, and the consequences of this coordination game on fiscal policy, government debt, and the cost of debt in terms of interest rates. A partial listing of competing or complementing analytical frameworks includes: the classical lender of last resort of Bagehot (1873) and Thornton (1802), debt sustainability analyses usually undertaken by international

[1] "I want the Bank [of France] to be enough in the hands of the Government, but not too much [...]" (von Bonin, 1979; Ramon, 1929; Yasuo, 2011).

institutions (IMF, 2013), Bohn's (1998) fiscal reaction function approach, concepts of fiscal space (Ghosh et al., 2013), coordination and fiscal dominance (Leeper, 1991), the effects of r<g (Blanchard, 2019), and even "modern monetary theory".[2] In some of these analytical schemes the central bank is front and center and in some it plays a supporting role. This article provides novel evidence of the importance of central bank institutional design on fiscal matters.

While modern central banks owe their existence to operational independence on monetary policy, at their origin many central banks were initially conceived of as fiscal agents to the powerful and occasionally profligate sovereign (Riksbank in 1668, the Bank of England in 1694, and the Banque de France in 1800).[3] As Bordo and Siklos (2015) show, financing war has been the driver for the creation of many central banks in the 19th century.[4] During the Great Moderation from the mid-1980s to 2007 the interest in the fiscal effects of central bank financing to the government has been superseded by the extensive literature on the central bank independence-inflation nexus.

More recently a few papers have contributed to the study of the fiscal dimension of central bank independence. Bodea (2013) shows that central bank independence (CBI, hereafter) can restrain government deficits in democracies.[5] However Bodea and Higashijima (2017) find that the central bank does not react to government deficits in an optimal, counter-cyclical fashion, and therefore the authors fail to find effects on the cyclicality of fiscal deficits, a mechanism we explore in this paper. Hooley et al. (2021) show that CBI reduces direct lending to the government in Sub-Saharan Africa. Jacome and Pienknagura (2022a) discuss the evolution of CBI in

[2]In practice monetary and fiscal policies are related through quantitative easing, targeted policy interventions like yield curve control, or spread targeting policies like the ECB's OMT and Transmission protection instruments. Rogoff (2021) discusses the ambiguous distinction between "alternative monetary instruments" and fiscal policy, and the risks inherent in this ambiguity.

[3]The theoretical underpinnings of central bank independence are the seminal contributions of Kydland and Prescott (1977),Barro and Gordon (1983b), and Rogoff (1985). The vast empirical literature initiated by Grilli et al. (1991), Cukierman (1992), and Alesina and Summers (1993) continues to provide insights into the benefits and costs of the central bank independence.

[4]See also Carli and Peluffo (1993) for a more personal account of central banking before the macroeconomics revolution of the 1970s.

[5]An early study by Sikken and Haan (1998) found no relationship between central bank independence and the level of deficits, though monetization of deficits was negatively related to central bank independence. Alpanda and Honig (2009) found that the lack of central bank independence in developing countries can lead to political monetary cycles, though they find no evidence that deficit monetization was part of the mechanism. They speculate that pressure to exploit the short-term Philips curve might be the primary mechanism.

Latin America over the last 100 years. They document how central bank financing to the government became entrenched in the environment of expansionary fiscal policies between the end of the Second World War and the early 1990s. Closer to our study, Du et al. (2020) show that a lack of monetary policy credibility in emerging economies keeps the cost of local currency debt too high and prevents the development of markets for local currency government bonds, depriving the government of the benefits of borrowing in its own currency. Nöh (2019) shows that higher central bank independence lengthens the average maturity of government debt suggesting that investors view debt as increasingly sustainable. We contribute to this literature by showing the effects that tighter restrictions on central bank lending to the government have on public debt and interest costs.

Our study is motivated, among other things, by the scale of the expansionary monetary and fiscal policies adopted by many countries during the COVID-19 pandemic, which have strengthened the belief that direct *quantitative* approaches to macroeconomic stabilisation can be powerful and effective. The remarkable fall of interest rates since the early 2000s has increasingly been seen as the consequence of largely exogenous long-term structural causes (like demographics and inequality), rather than the result of endogenous macroeconomic policy management. In an environment of seemingly permanent r<g some prominent macroeconomists have called for the re-examination of the usefulness of monetary financing of government interventions (Galí, 2020b; Blanchard and Pisani-Ferry, 2020), "breaking the taboo" of helicopter money (Yashiv, 2020), and suggesting that monetary financing could become a permanent instrument in the macroeconomic policy toolkit (Galí, 2020a; Blanchard, 2019).[6]

A different strand of literature has more recently theorized the role that a more independent central bank plays in explaining why some countries are able to issue more debt than others. As Willems and Zettelmeyer (2022) remark " [c]ross-country differences in central bank credibility could be part of the explanation why all countries do not seem to be created equal when it comes to sustaining a given debt level. Countries that wish to enjoy greater fiscal space should invest in building central bank

[6]See Adrian et al. (2021), on the risks posed by the asset purchase programs implemented by emerging and developing countries' central banks during the COVID-19 pandemic.

credibility". Reis (2019) finds that central banks have limited scope to lower fiscal burdens directly, but Reis (2022) argues that "governments can avoid sovereign debt crises without sharp turns of austerity as long as public debt is seen as special [...] This requires central banks to be more independent, not less so". The large increase of government debt in the wake of pandemic interventions has raised concerns that a significantly deteriorating fiscal situation threatens to erase several years of progress on development agendas in many emerging economies. According to the World Bank, almost 60 percent of the poorest countries were either in or at high risk of debt distress in 2022, a proportion that has almost doubled since 2015.[7] Our study uses the legal limits on central bank lending to the government to provide novel evidence on the link between central bank independence and a country's fiscal space.

Assuming an unchanged fiscal policy, the *direct* effect of restrictions on central bank lending to the government is to increase the government's demand for funding from the private sector. This extra demand for funding should put upward pressure on the cost of government debt. For example, in models where seignorage (commonly defined as the rate of change of the monetary base) is a considerable source of government income a reduction of monetary financing would theoretically induce a higher interest rate on the market borrowing of the government.[8] However, it is the *indirect* effects through the enhanced credibility of the central bank that are central to our argument. To the extent that the reduction in monetisation is perceived by investors as reducing the risk of inflation, quantitative restrictions on the amount of lending from the central bank to the government could increase the supply of private sector funds to the government and could lower the interest rate required.[9] With this second *indirect* expectations channel, the effect of lowering central bank lending to the government is a priori uncertain.[10]

In our empirical analysis we provide evidence of a fall in the interest cost for the

[7] World Bank,Debt-Service Payments Put Biggest Squeeze on Poor Countries,December-2022

[8] However, when the monetary base is a small part of government liabilities, and when interest is paid on reserves this channel would be less relevant.

[9] A second important channel though which an independent central bank can increase demand for government debt is through a credibly counter-cyclical monetary policy. Interest rate cuts in a recession generate capital gains for investors when marginal utility is high, making government bonds a "negative beta" asset and creating a hedging demand (Brunnermeier et al., 2020). Farhi and Maggiori (2018) show however that the self-fulfilling nature of negative beta demand for a safe asset can be vulnerable to increasing over-indebtedness by the issuer of such an asset.

[10] See Mian et al. (2017) for a similar argument on the effects of supply vs. demand on the cost of funding for housing in the context of the Global Financial Crisis.

government following a reform restricting central bank lending to the government and argue that this suggests that the credibility channel is stronger than the direct quantitative effect. Our argument is simple. Contrary to the recent suggestions that monetary financing and direct lending to governments can increase fiscal capacity, we claim that it is indeed the commitment of the central bank *not* to lend to the government that actually increases fiscal space by reducing the inflation default risk, increasing the supply of private funding to the government, and therefore lowering the required interest rate. The converse of our claim would be that policies that question the independence of the central bank and call for increased purchases of government debt by the central bank might prove self-defeating.

The role of the central bank in increasing the capacity of the government to safely issue debt is well understood since at least Sachs (1983) and Calvo (1988). There are two types of mechanisms involved, lender of last resort and quantity effects on the one side, and effects on expectations on the other. Sachs (1983) shows how the central bank can act as the lender of last resort to avert a self-fulfilling debt rollover crisis. Similarly Calvo (1988) shows how the central bank can keep the cost of debt low and dissuade the govt from voluntary default.[11] Critically, the quantitative argument is predicated on the assumption of central bank credibility and the effects of this credibility on expectations about future default through higher inflation. If monetary financing and quantitative interventions by the central bank to assist the government are deemed to be inconsistent with monetary stability then investors would not want to hold government debt as its value would be eroded by future inflation.[12] In the short run fiscal policies can be facilitated by quantitative interventions by the central bank, but in the long run it is the independence of the central bank that makes the debt ultimately sustainable.

In this paper, we underscore the importance of adherence to clearly specified rules. We demonstrate that limits to monetary financing have strong positive effects in the long run. Our analysis shows that defined numerical restrictions on government lending by the central bank increase the fiscal space of the government. Countries

[11] Lorenzoni and Werning (2019) extend the arguments to the case of long-term debt and describe the dynamics of slow-moving debt crises.

[12] See also Buiter (1985) on the link between debt sustainability and the consistency of fiscal policy with inflation objectives.

where the central bank is largely restricted from financing the government (see the measurement of the strictness of this prohibition in section 2.2.1) are able to carry larger public debts to GDP without the need for a higher interest rate. [13]

Our results bring a word of caution to recent discussions about the future of macroeconomic management. Intuitively, it is always the credibility of the macro policy framework that underwrites any large "ad hoc" or "emergency" policy interventions, be they quantitative easing as in the decade since the Great Financial Crisis, or monetary financing as it might be in the decade to come. But therein lies the paradox that credibility can be depleted uncomfortably fast, and can take a long time to be re-established.[14]

More broadly, the increase of debt worldwide and the fall of interest rates are well-documented phenomena (see Mbaye et al., 2018, and recent updates in IMF-Global Debt Monitor, 2022). The evidence we present in this paper makes it all the more critical to understand the driving forces behind these global developments. To the extent that central bank independence and credibility are contributing factors to the increase of debt and the fall in interest rates any recent policy proposals to increase the use of monetary financing and quantitative easing strategies should be judged against the risk that such policies could undermine central bank independence and endanger the increased fiscal space gained in the recent decades.[15] As Willems and Zettelmeyer (2022) put it, central bank independence is a "fiscal asset" that can enhance state capacity but which is also vulnerable to the effects of other policies. The large increase of debt worldwide in recent decades makes understanding the interaction of fiscal and monetary policies even more central. This article hopes to provide some relevant evidence.

[13] See Cottarelli (1993) for an early survey of limits to central bank credit to the government. Jácome et al. (2012) provide an update with more recent developments on the institutional design of limitations on lending to governments.

[14] The recent experience of Ghana is telling. A COVID-19 related asset purchase program was implemented in May 2020. Although it is hard to disentangle the effects of the various economic shocks, inflation in Ghana subsequently increased to over 100% in early 2023 and the currency has devalued substantially.

[15] Indeed as Martin (2015) shows, the increased debt and state capacity that central bank reform and lower inflation initially allow can be a powerful weapon in a future conflict between the treasury and the central bank during a crisis. In such a situation the higher the accumulated debt is the stronger the pressure on the bank to monetise this debt during a shock and therefore the higher the risk of fiscal dominance. Eventually, the value of debt would adjusts downwards as inflation reverts to its pre-reform level.

Our study uses the central bank independence index introduced in Romelli (2022), i.e. a *de-jure* index of central bank independence based on the codification of the central bank legislation of 154 countries over the period of 1972-2017. We exploit information about restrictions on lending to the government that is included in the central bank legislation to analyse the effects of central bank independence on government debt and interest rate costs. The index assigns a high degree of independence to a central bank that is prohibited from providing advances and loans to the government and has a limited scope of participation in primary or secondary markets (see section 2.2.1 for more details on the index). Our study is based on *de jure* measures of central bank independence using legal limits on credit from the central bank to the government. There might be well known arguments in support of the idea that such limits might not be binding.[16] However, recent evidence by Hooley et al. (2021) shows that when limits to central bank lending are in place central bank financing to the government is limited when government deficits rise. As the authors remark, legal restrictions seem to constrain behaviour much in the same way that speed limits constrain car drivers: "the limits are often exceeded, but rarely by an excessive amount".

We contribute to the literature on the effects of central bank independence in two distinct ways. First, we provide evidence for the dynamic association between central bank independence and both debt to GDP and interest rates on public debt. Second, we provide suggestive evidence of the effects of central bank independence on the cyclicality of fiscal spending.

To preview our results, we find that tighter restrictions on central bank lending to the government allows a country to issue more debt without the need to pay higher interest rates. These effects are concentrated in developing economies however. For the typical increase in the index of central bank independence for a developing country the debt to GDP ratio increases by 10 percentage points at a ten year horizon, while at the same time the cost of debt falls by one percentage point. We also investigate a possible mechanism through which central bank independence expands the fiscal space of the government. We provide suggestive evidence that higher central bank

[16] In any case such limits can be removed in extremis, as Hawtrey (1970) remarked in 1932. Jacome and Pienknagura (2022b) provide and historical account of the Latin American experience in the 1930s in the wake of the Great Depression.

independence lowers the pro-cyclicality of fiscal policy, allowing the government to pursue counter-cyclical macroeconomic stabilisation policies. Taken together, our results support the view that the positive effects of central bank independence extend to the fiscal domain, by influencing fiscal capacity in terms of debt-carrying ability, and by facilitating counter-cyclical fiscal policy. In the terminology of Frankel et al. (2013) central bank independence is one of the determinants of "graduating" from emerging economy status to a developed economy one.

Finally, this paper is related to the large literature initiated by Barro (1979) on the determinants of government debt and the smoothing of taxes by the government. More broadly this paper is also related to the literature on the economic effects of institutions.[17]

The rest of the paper is organized as follows. In section 2.2 we describe our data, while section 2.3 presents the empirical strategies employed in the paper. Section 2.4 presents the results and section 2.5 concludes.

2.2 Data and descriptive statistics

This section describes the data used in the analysis. The index of central bank independence used in the paper is presented in Section 2.2.1. Section 2.2.2 discusses our dependent variables, i.e. the debt to GDP ratio and the interest rate on government debt, while Section 2.2.3 describes the additional control variables used in the analysis.

2.2.1 Index of central bank lending to the government

In this paper we use information from the Central Bank Independence - Extended (CBIE) index introduced in Romelli (2022) for a sample of 154 countries, over the period 1972 to 2017. This index uses the classical indices of central bank independence, i.e. the Grilli et al. (1991) and Cukierman et al. (1992) indices, to develop a comprehensive index of central bank independence that covers a wider range of central bank characteristics. In its most disaggregated format, this new index provides information on 42 criteria of central bank institutional design.

[17] A seminal contribution in this literature is North and Weingast's (1989) account of the creation of the Bank of England.

In our empirical analysis, we use the sub-index of CBIE that refers to the limitations on central bank lending to the government (CBIE Lending, hereafter). This index codifies central bank legislation on eight criteria: i) limitations on advances to the government, ii) limitation on lending to the government in the primary or secondary market for government securities, iii) restriction on trading in these markets, iv) decision making power with respect to the terms and conditions of any lending, v) government-related entities that can benefit from central bank lending, vi) definitions of the limits to lending, vii) maturity, and viii) interest rate conditions to lending. Exact coding rules are defined for each category and a rating between zero and one is assigned in each sub-component. A simple average of the eight criteria determines the degree of central bank independence in relation to lending to the government.[18]

Table 2.1 provides an overview of the evolution of the CBIE Lending index over time. As central banks became increasingly independent, the limitations on lending to the government increased. The average level of the index rises throughout the period of the sample. The limited number of reversals underscores the broad-based acceptance of the need to restrict monetary financing of the government across the world.

Figure 2.1 shows the distribution of reforms over time. Throughout the period, reforms bringing tighter restrictions on lending to government are steadily implemented. In the period since the Global Financial Crisis however some reform reversals can be observe.[19]

2.2.2 Government debt and interest rates

In this analysis we are focusing on two outcomes of interest, the government debt to GDP ratio and the interest cost of the debt. The main source of data is the Public Finance in Modern History database from the IMF, which is presented in detail in Mauro et al. (2015). We have information on government debt and interest expense for 144 countries over the period of 1985 to 2017. As is standard in the literature we are using data on the notional value of general government gross debt, normalised

[18] Appendix 2.B provides the coding of the 8 criteria used in the construction of the sub-index on limitations on lending to the government.

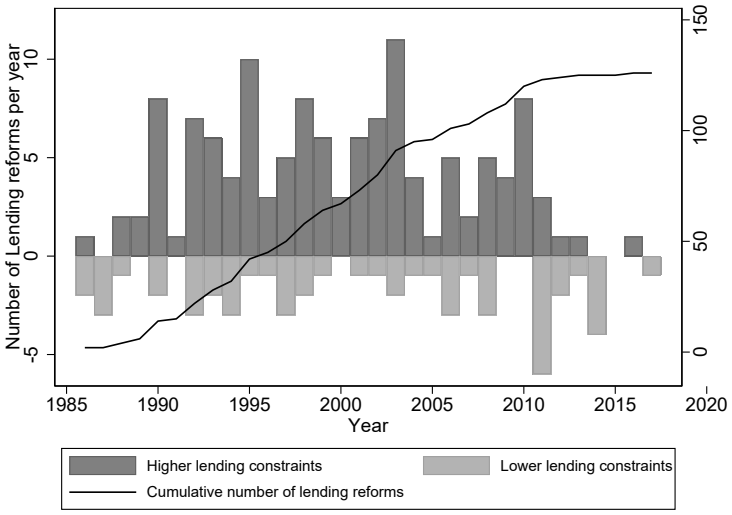
[19] As documented in Romelli (2022) improvements in the overall CBI stalled since the GFC, with the increasing involvement of central banks in banking supervision.

TABLE 2.1: Summary statistics on the evolution of the CBIE Lending index

Period	Countries	# of Obs	# of Reforms	# of Reversals	Mean	Min	Max
			Full sample				
1972-1979	93	719	11	3	0.395275	0	1
1980-1989	110	1034	7	4	0.384308	0	1
1990-1999	148	1363	59	9	0.443322	0	1
2000-2009	154	1529	48	7	0.573582	0	1
2010-2017	154	1232	14	1	0.640351	0	1
			Advanced economies				
1972-1979	25	193	4	1	0.35987	0	0.9375
1980-1989	26	257	4	3	0.344284	0	0.9375
1990-1999	34	322	15	0	0.482315	0	1
2000-2009	34	340	8	0	0.731562	0	1
2010-2017	34	272	0	0	0.761662	0	1
			Developing economies				
1972-1979	68	526	7	2	0.408266	0	1
1980-1989	84	777	3	1	0.397546	0	1
1990-1999	114	1041	44	9	0.431261	0	1
2000-2009	120	1189	40	7	0.528407	0	1
2010-2017	120	960	14	1	0.605979	0	1

Notes: Table provides summary statistics for the CBIE Lending index of limitation on central bank lending to the government from Romelli (2022). The sample of Advanced economies includes all OECD member countries in 2020. The sample of Developing countries includes all non-OECD member countries in 2020.

FIGURE 2.1: Central Bank legislative reforms (1985-2017)



Notes: The figure shows the frequency of reforms that decrease/increase lending limits to the government, together with the cumulative number of reforms in central bank independence between 1985 and 2017.
Source: Romelli (2022).

by nominal GDP. Information about government interest expense as a percentage of GDP is used to estimate the implied cost of government debt. Table 2.2 provides some descriptive statistics of the data.

TABLE 2.2: Summary statistics

Variable	Obs	Mean	Std. Dev.	Min	Max
Debt to GDP					
All countries	5509	55.671	42.299	.025	523.382
Advanced economies	1358	52.478	35.16	1.717	249.114
Developing countries	4151	56.716	44.34	.025	523.382
Interest rate					
All countries	3855	.054	.041	0	.651
Advanced economies	1172	.066	.041	.001	.308
Developing countries	2683	.048	.04	0	.651

Notes: Summary statistics for government debt and the interest costs of debt compiled in Mauro et al. (2015). Interest rate is estimated as the ratio of interest expense to debt.

2.2.3 Additional control variables

A set of additional control variables is included in our analysis with the aim of capturing possible confounding effects. We broadly cluster these controls in three groups: business cycle, economic openness, and economic structure and development level.[20]

First, to account for cyclical effects, in our models for both government debt to GDP and interest rate we include GDP growth and inflation in all estimations. Additionally, in the debt to GDP ratio models we also include government expenditure as a percentage of GDP, fixed capital formation, and final consumption as explanatory variables. These variables account for the overall business cycle environment. Second, two variables are used to capture the international dimension of the economy: the degree of openness to trade of a country, calculated as the sum of imports and exports divided by GDP, and foreign direct investment. Finally, to capture the level of institutional and economic development in a country we include three variables: the overall PolityIV (2014) index, the index of constraints on the executive from the same dataset (following Acemoglu et al., 2008), and the log of per capita GDP. We also include information on population growth.

[20]The definitions and data sources for all the variables used in the paper are provided in Appendix 2.C, while Appendix Table 2.C.2 provides summary statistics.

2.3 Empirical Strategy

This section provides the details of our empirical strategy. In the first part of this paper we estimate the effects of tighter controls on central bank lending to the government on the ratio of public debt to GDP and on the implied interest rate on public debt. Specifically, we use the index on limitations on central bank lending to the government by Romelli (2022) presented above.

2.3.1 Local projections

We estimate the dynamic effects of restrictions on central bank lending to the government applying Jorda's (2005) local projections approach. This method directly estimates the effects on the outcome variables at multiple horizon dates separately: horizon $t+h$ outcomes are projected on time t values.

Specifically, we estimate the following system of h equations:

$$\begin{aligned} y_{c,t+h} - y_{c,t-1} = \; & \alpha_c^h + \Lambda^h CBI_{c,t} + \beta_{1lh} \sum_{l=0}^{l=p} (y_{c,t-l} - y_{c,t-1-l}) \\ & + \beta_{2fh} \sum_{f=0}^{f=h} CBI_{c,t+f} + \beta'_{3h} \, X_{c,t} + u_{c,t+h} \end{aligned} \tag{2.1}$$

where c are countries in our sample and h= 1,2,..,10 are the forecast horizons.

Our dependent variables, $y_{i,t+h} - y_{i,t-1}$, are the government debt to GDP ratio and the interest rate on government debt. These variables are expressed in cumulative changes over the horizon period h. *CBI* is the index of restrictions on central bank lending to the government in country c at time t. The coefficients of interest are therefore Λ^h.

In our baseline linear local projections analysis the CBI variable is the CBIE Lending sub-index from Romelli (2022). This is a continuously valued index in {0,1}, with higher values of the index representing tighter restrictions on central bank lending to government and therefore higher central bank independence. The estimated coefficients show the effects of restricting central bank lending to the government. The hypotheses we are testing are whether tighter restrictions lead to higher debt to GDP ratio and lower interest rate costs.

As Jorda (2005) points out, consistency of the estimated coefficients does not require a joint estimation of the sequence of the h system of equations. Rather, the impulse response of each outcome variable can be estimated separately for each horizon. As shown in Montiel Olea and Plagborg-Møller (2021), the local projections method estimates are the same as the vector auto-regression ones, so our models naturally include auto-regressive terms. [21]

In our specification we include the leads of the treatment variable to addresses the downwards bias induced by overlapping forecast horizons.[22] In this we follow the suggestion of Teulings and Zubanov (2014) who provide Monte Carlo evidence of the performance of this correction. More recently, Alloza et al. (2020) formalize the equivalence of local projections and distributed lag models in the presence of persistence shocks, like in our case.[23]

Country-specific intercepts, α_c, absorb the impact of any time-invariant country characteristics. On the other hand, the vector $X_{i,t}$ includes time-varying controls that we want to account for in our models.

The model for the debt to GDP ratio includes a rich set of cyclical and structural factors. Specifically, we include real GDP growth and inflation to capture cycle effects. Additional macro variables we also include are government expenditure, gross fixed capital formation, and total consumption expenditure, all expressed as percentages of GDP, along with population growth. We include two dimensions of the international linkages of an economy, i.e. the degree of openness to trade proxied by the the sum of imports and exports as a percentage of GDP and foreign direct investment as a

[21] Note however that the maximum lag length for our two estimations does not need to be the same. In particular, the lag length in the debt equations is set to 2, while the interest rate equations have a lag length equal to h.

[22] The direction of the bias that the inclusion of forwards of the treatment value addresses depends on the particular situation. In our case, overlapping forecast horizons bias downwards our estimates of the treatment effects of central bank reform. Untreated observations just prior to a reform have higher average outcomes (due to the positive effect of the subsequent treatment), while the outcomes for treated observations are not contaminated by additional subsequent central bank reforms because any such reforms (if they happen at all) are outside our longest forecasting horizon. To see the effects of the forwards of the treatment variable in our case, consider a treatment effects framework of central bank reform when a reform takes place at time t and is not reversed thereafter. For an observation immediately prior to treatment, i.e. a control observation at time *t-1*, the outcome values at horizon *t-1+h* mechanically overlaps with the subsequent treatment (within the forecast horizon h). The leads of the treatment variable therefore account for the effect any such subsequent reforms within the horizon h have on the outcome at that horizon h from an untreated observation.

[23] In our specifications we do not include lags of the treatment variable, as is sometimes the case in the literature on the effects of structural reforms. Contrary to the reasoning for the inclusion of leads of the treatment variable, inclusion of treatment lags is an empirical matter (see for instance de Haan and Wiese, 2022). In our analysis lags of the treatment variable do not affect our results.

percentage of GDP. To capture the level of institutional and economic development we also include the Polity index of democratic institutions of Cheibub et al. (2010), an index of constraints on executive power, the log of real GDP per capita. Controls enter the models contemporaneously, though given the persistence of some of the included variables, adding lags of these controls produces substantively similar estimates. For the interest rate models we adopt a more parsimonious approach and include GDP growth and inflation along with the level of the variables of economic and institutional development used in the debt to GDP estimations.

While the local projections approach estimates each model (and for each horizon) separately, we include our two outcome variables as additional controls in the models applying a theoretically motivated lag structure. Specifically, in the interest rate models the debt to GDP ratio enters contemporaneously, implying that a debt shock has an immediate effect on the interest rate. In the model for the debt to GDP ratio the interest rate enters with a lag, implying that the stock of debt reacts with a lag to changes in interest rates. In both the debt and the interest rate models we also include a common time trend, to capture the secular worldwide movements in the outcome variables.

Finally, to account for the potential cross-sectional (spatial) correlation, inference is based on the spatial correlation corrected errors proposed by Driscoll and Kraay (1998).[24]

State dependent local projections

The local projections models presented so far assume that the effects of tighter restrictions on lending to the government are the same on average across countries. However, these effects might be state dependent, i.e. conditional on some dimension of the economy. Local projections provide a flexible framework to test such hypotheses.[25]

[24] Montiel Olea and Plagborg-Møller (2021) argue that a lag-augmentation in local projection specifications obviates the need for an auto-correlation correction, and therefore suggest that standard heteroskedasticity robust (Eicker-Huber-White) errors suffice. In our application differences in error estimation do not affect our inference.

[25] State dependent local projections have recently gained popularity in macroeconomic research and have extensively been applied for example to the analysis of the effects of austerity (Auerbach and Gorodnichenko, 2012; Ramey and Zubairy, 2018). de Haan and Wiese (2022) applied state-dependent models to estimate the effects of structural reforms.

Equation 2.2 presents the state dependent local projections specification we apply:

$$y_{c,t+h} - y_{c,t} = S_{c,t} \Bigg[\alpha_c^h + \Lambda^h CBI_{c,t} + \beta_{1lh} \sum_{l=0}^{l=p} (y_{c,t-l} - y_{c,t-1-l}) + \beta_{2lh} \sum_{f=0}^{f=h} CBI_{c,t+f} + \beta'_{3h} X_{c,t} \Bigg] + u_{i,t+h} \tag{2.2}$$

where $S_{c,t}$ is a dummy variable indicating the state of the economy while the rest of the equation is as before. In our analysis we present results for two state variables. First, we test if the level of inflation at time t makes the effects of central bank independence stronger. Second, we test if the presence of an IMF program changes the effects of higher central bank independence.

2.3.2 Estimation with a binary treatment

The estimation strategy presented so far uses the CBIE Lending index in Romelli (2022), which is a continuous variable. The interpretation of the coefficients is therefore the usual ceteris paribus measure of the partial derivative of the outcome variable for a small change of the independent variable.

Arguably, however, structural reforms are discontinuous events. In our sample of 154 countries for which we have information on conditions on central bank lending to the government, we find 101 countries that have reformed these conditions since since 1985. These countries have implemented 106 reforms which tightened restrictions on lending to the government and 21 reforms that relaxed such conditions.

To better capture the discontinuous nature of reforms, we introduce here a binary version of the CBIE Lending index, and a treatment effect interpretation of our results. Appendix 2.D presents the time evolution of the CBIE Lending index for the countries in the sample. As can be seen in Appendix Figures (2.D.1)-(2.D.3), a binary variable transformation of the CBIE Lending index does not induce a significant loss of information. Central bank reforms tend to be discontinuous in time, relatively large in size (average/median CBIE Lending reform is 0.60) and happen essentially once in each country. We therefore construct two binary indices of central bank reforms: one that accounts for the largest reform in a country, i.e. ignoring marginal reforms that might result from minor changes in language or parameter values. The second one

only accounts for large reforms, by focusing on the subset of reforms that are larger that the median value of the change in the CBIE Lending in the years of a reform.

The binary indexes are coded as staggered treatments in the language of experimental design. Once a country is treated it is considered to remain treated henceforth. This coding is more appropriate in our analysis, as it corresponds to the more permanent nature of structural reforms.

Instrumental variables local projections

In this section we present an instrumental variables estimator to address the potential endogeneity of central bank reforms. Romelli (2022) shows that one of the main determinants of central bank reform is peer pressure, as countries that are further away from their regional peers in terms of central bank design are more likely to adopt reforms that increase their level of independence.[26] We define our instrument of peer pressure as the 75th percentile of the distribution of the CBIE Lending index in a region in a given year, excluding the own-country observation. Regional peer countries are identified using the classification in Acemoglu et al. (2019). The exclusion restriction implicit in our choice of instrument is that the level of central bank independence of regional leaders does not have an effect on the inflation of neighbours. On the other hand, regional neighbours with more independent central banks might incite a country to reform its own central bank. In the estimates of the first stage regressions reported in Appendix 2.E we show that our instrument is indeed highly correlated with the level of CBIE Lending. In our IV local projections specifications we include the same set of time varying controls that we use in the OLS local projections estimates.

2.4 Results

This section presents the results of the analysis. We start in section 2.4.1 with our main local projections results, while section 2.4.2 presents the results for central bank reform. Section 2.4.3 presents an IV estimate of the effects of central bank reform.

[26] A similar notion has been used by Acemoglu et al. (2019), who exploit waves of democratisation in the construction of their instrument. See also Bodea and Hicks (2015b) and Athanasopoulos et al. (2023).

2.4.1 Baseline local projection estimates

Linear models

In figures 2.1, 2.2, and 2.3 we report the main finding of our analysis. In these graphs we present the local projections estimates of coefficients Λ^h in equation (2.1) at horizons h= 1,2,..,10 for the debt to GDP ratio in the left panels and the implied interest rate on the right panels for the full sample of countries in our analysis, for the advanced economies, and for the developing countries respectively. Using the full sample of countries in figure 2.1 the analysis indicates that tighter restrictions on central bank lending to governments are associated with higher public debt, but there is no significant effect on the required interest rate.

However, when we analyse advanced economies and developing countries separately, an important divergence arises when we compare figures 2.2 and 2.3. For advanced economies, figure 2.2 shows that there does not seem to be a systematic relationship. A small temporary decrease in the public debt to GDP ratio in the left panel is reversed by the end of the horizon of our analysis.

For developing countries however we find that an increase of the CBIE Lending index (*i.e.* a tightening of the lending conditions to the government) is associated with an increase of the debt to GDP ratio in the medium term (left panel) while the interest rate costs is actually reduced (right panel).

We interpret these result as indicating that in the case of developing economies, the reform of the central bank is an important indicator of institutional convergence and allows a country to carry more debt without the need for a higher interest rate. Our results are in line with the recent literature that increasingly shows that central bank independence has larger effects in emerging economies than in developed economies; see for example Garriga and Rodriguez (2020) on the effects of central bank independence on inflation and Klomp and De Haan (2009) for the case of financial instability.[27]

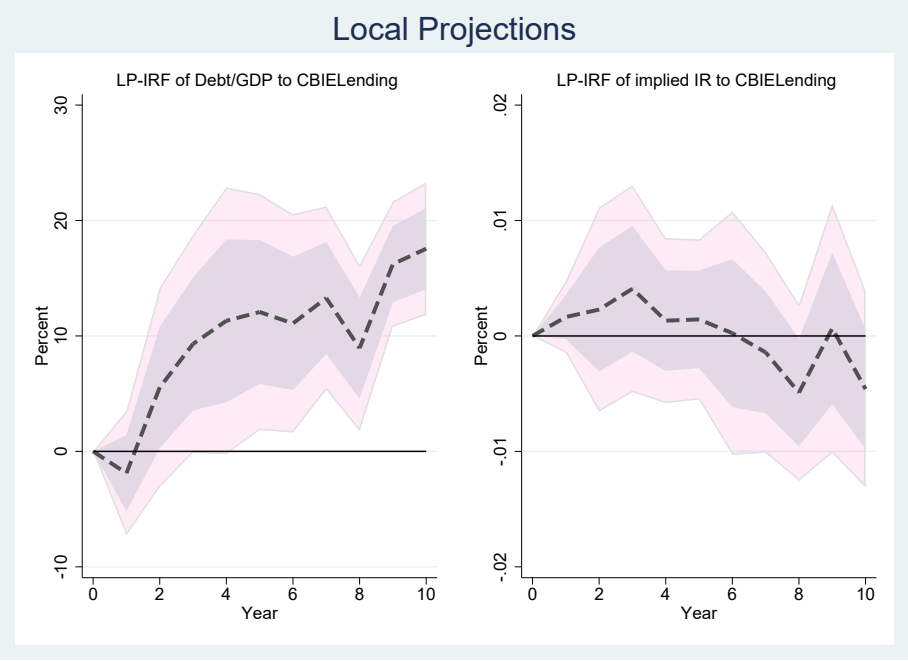
To highlight the economic significance of our results we note that the median change of the CBIE Lending index in our sample is 0.60. This implies that for the average country in our sample, an increase of that magnitude would see the debt to

[27]For this reason we focus in the rest of this paper in developing countries and we reserve results for advanced economies to Appendix 2.F.

GDP ratio of the country increase by approximately 10 percentage points, while the implied interest rate in the debt would fall by 1 percentage points. The median debt to GDP ratio in our sample is 51% (with a 41% standard deviation) , while the average interest rate is 5% (with a 3% standard deviation).

We perform a number of robustness checks. We first estimated the models using only countries that reformed their central banks, and the results are qualitatively the same (see Appendix 2.F). We also experimented with the inclusion or exclusion of different periods of interest. We alternatively started the sample in 1972 (when our CBI data start for a number of countries) and in 1980 (to avoid change in the economic environment in the immediate aftermath of the collapse of the Bretton Woods system) and we ended the sample in 2002 or in 2007 (to exclude the post Global Financial Crisis period). The results are always consistent, though for some sub periods the precision of the estimates might be impacted by the smaller sample size.[28]

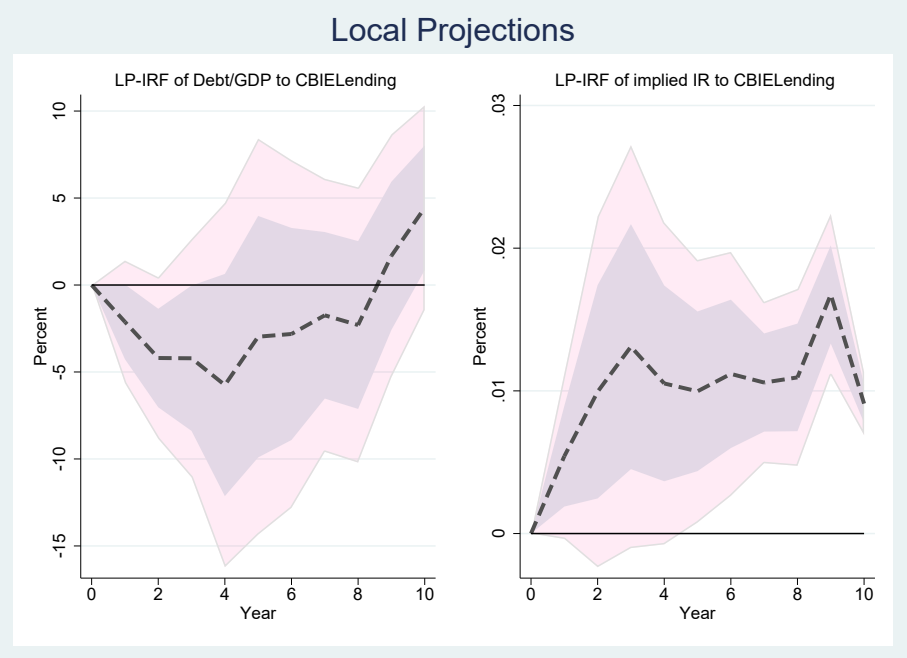
FIGURE 2.1: Local projections, CBIE Lending index, all countries, 1985-2017.



Notes: The figure shows the cumulative response of the debt to GDP ratio (left panel) and the implied interest rate (right panel) to a one point change in the CBIE Lending index at horizon h on the x axis. Shaded areas denote the 68% and 90% confidence intervals using Driscoll and Kraay (1998) standard errors.

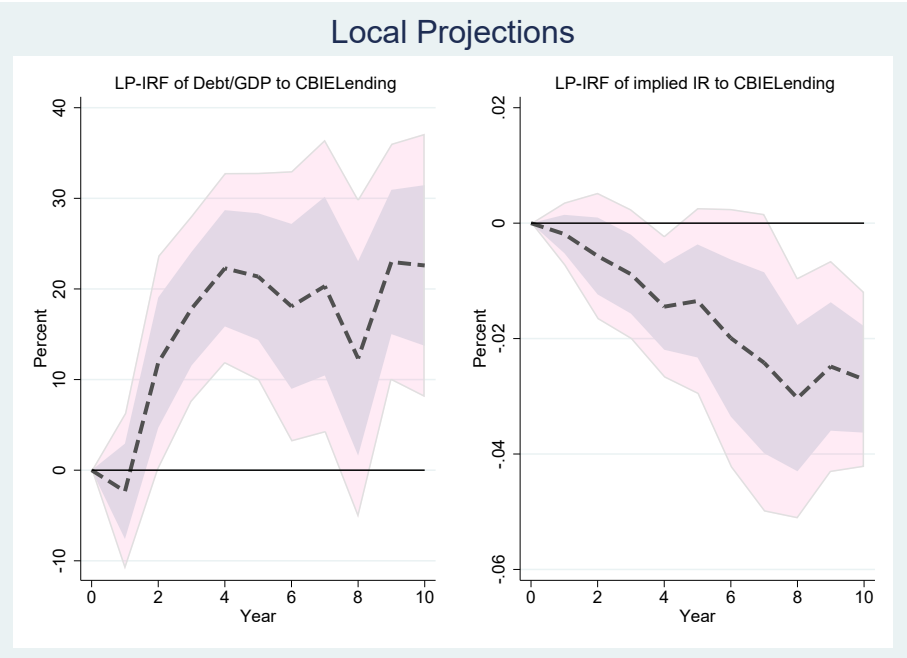
[28] All additional results are available upon request.

FIGURE 2.2: Local projections, CBIE Lending index, advanced economies, 1985-2017.



Notes: The figure shows the cumulative response of the debt to GDP ratio (left panel) and the implied interest rate (right panel) to a one point change in the CBIE Lending index at horizon h on the x axis. Shaded areas denote the 68% and 90% confidence intervals using Driscoll and Kraay (1998) standard errors.

FIGURE 2.3: Local projections, CBIE Lending index, developing countries, 1985-2017.



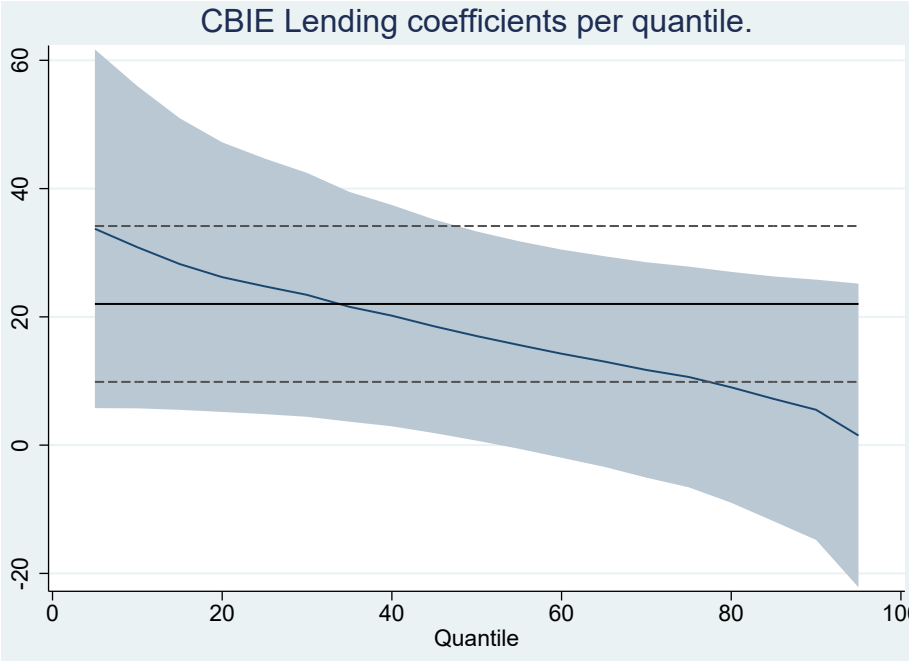
Notes: The figure shows the cumulative response of the debt to GDP ratio (left panel) and the implied interest rate (right panel) to a one point change in the CBIE Lending index at horizon h on the x axis. Shaded areas denote the 68% and 90% confidence intervals using Driscoll and Kraay (1998) standard errors.

Evidence from the distribution of effects.

In this section we provide evidence on the effects of tighter lending standards across the distribution of changes in the debt to GDP ratio. We estimate quantile regression estimates for the baseline local projections model in equation (2.1).[29] We focus in three horizons, the three, five, and ten year growth of the debt to GDP ratio. Figures 2.4,2.5, and 2.6 present the coefficients across the deciles of the distribution of each of the three horizon growth rates of the debt ratio. Across the three graphs a consistent insight emerges. The effects of lending restrictions on the growth of debt are strongest at the low deciles of the debt ratio growth distribution. We interpret this as evidence that central bank independence is supportive of expansion of the debt carrying capacity of a country, but not associated with very large increases of the debt ratio, which might also have other sources. The evidence we present here from the quatile regressions alleviate possible concerns that our analysis is confounding the effects of central bank independence with large exogenous increases in debt due to crises or other events.

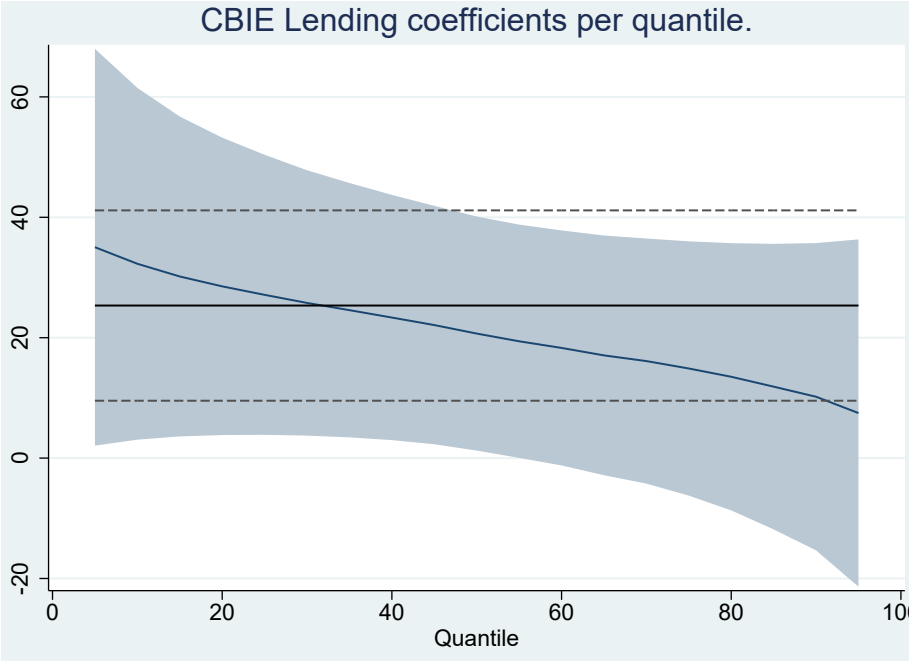
[29]Quantile regressions have recently been employed in applied macroeconomics research. The Growth-at-Risk methodology used by central banks and international bodies to calibrate macroprudential policies applies panel quantile regressions, see Adrian et al. (2019).

FIGURE 2.4: Quantile regression coefficients, CBIE Lending, 3-year Debt to GDP ratio growth, developing countries, 1985-2017.



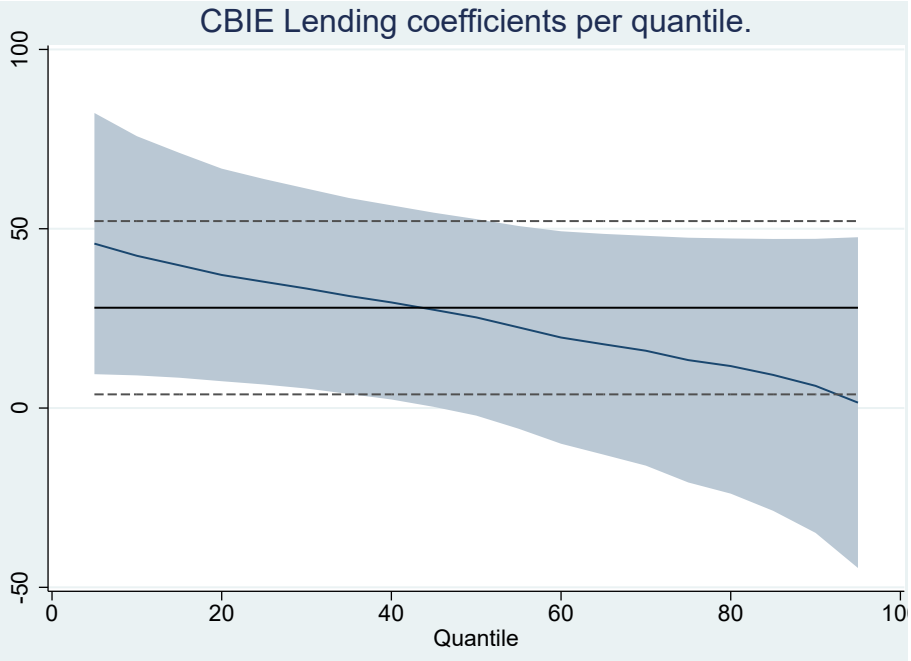
Notes: Figure shows the coefficient estimates for Λ^h in equation (2.1) for the h=3 three year debt to GDP ratio growth from different quantile regressions in the horizontal axis.

FIGURE 2.5: Quantile regression coefficients, CBIE Lending, 5-year Debt to GDP ratio growth, developing countries, 1985-2017.



Notes: Figure shows the coefficient estimates for Λ^h in equation (2.1) for the h=5 five year debt to GDP ratio growth from different quantile regressions in the horizontal axis.

FIGURE 2.6: Quantile regression coefficients, CBIE Lending, 10-year Debt to GDP ratio growth, developing countries, 1985-2017.

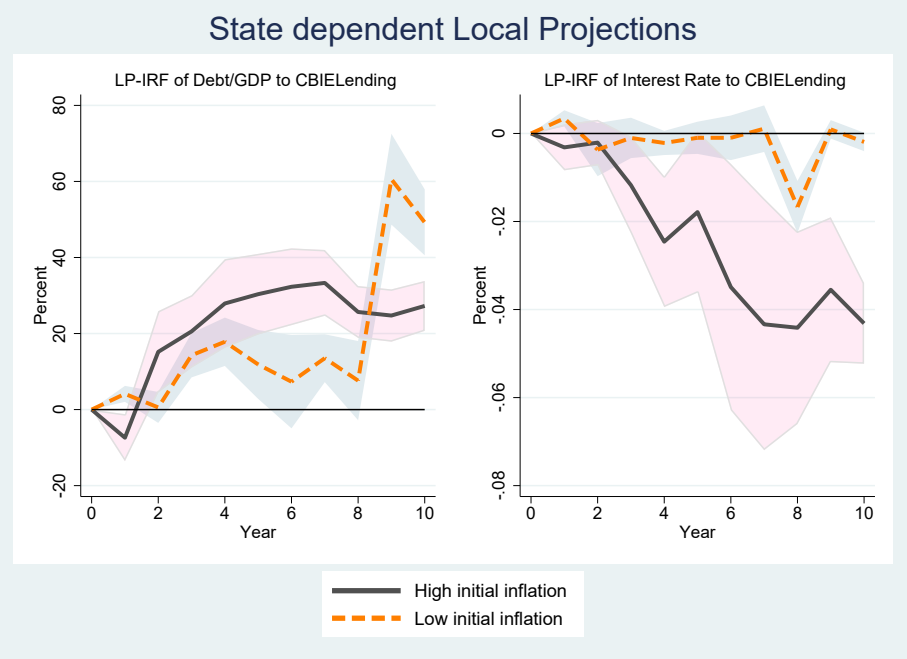


Notes: Figure shows the coefficient estimates for Λ^h in equation (2.1) for the h=10 ten year debt to GDP ratio growth from different quantile regressions in the horizontal axis.

State dependent models

In this section we present the results for the non-linear (state dependent) estimations. We focus the analysis on developing economies given the results in the previous section. We present evidence on two state variables, the level of inflation and the presence of an IMF program in the last two years. Figure 2.7 shows that tighter restrictions on lending to the government affects fiscal variables (debt and the interest rate on the debt) more when the level of inflation is high. We interpret this result as indicating that the gains in credibility due to a more independent central bank are proportionate to the initial level of macroeconomic instabilities.

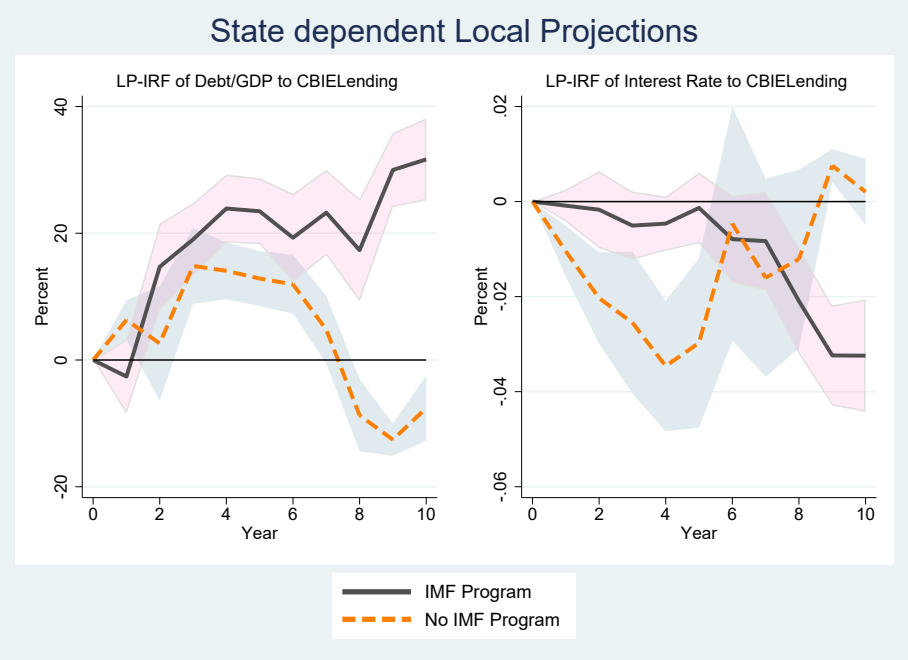
FIGURE 2.7: State dependent local projections, by level of inflation, developing countries, 1985-2017.



Notes: The figure shows the cumulative response of the debt to GDP ratio (left panel) and the implied interest rate (right panel) to a one point change in the CBIE Lending index at horizon h on the x axis. Shaded areas denote the 68% and 90% confidence intervals using Driscoll and Kraay (1998) standard errors.

Figure 2.8 shows that there does not seem to be a difference in the relationship between central bank independence and our outcome variables of interest when we condition the estimation on the presence of an IMF program in a country in the two years previous to the CBI reform. This finding partially addresses concerns about the endogeneity of central bank reforms, as countries would not choose to reform their central bank in the wake of an IMF program if there are no additional benefits of doing so at that point in time.

FIGURE 2.8: State dependent local projections, IMF program.



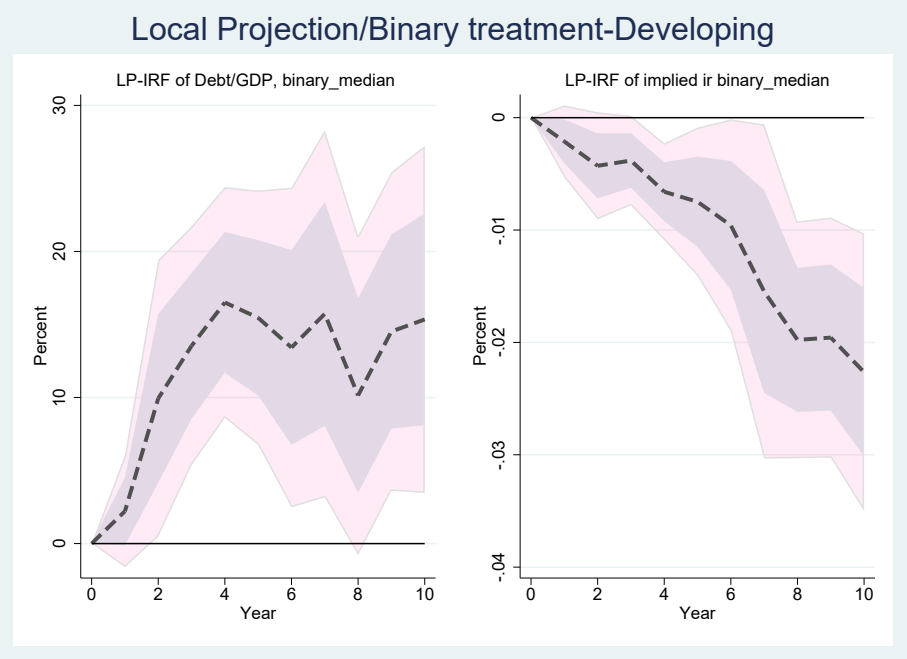
Notes: The figure shows the cumulative response of the debt to GDP ratio (left panel) and the implied interest rate (right panel) to a one point change in the CBIE Lending index at horizon h on the x axis. Shaded areas denote the 68% and 90% confidence intervals using Driscoll and Kraay (1998) standard errors.

2.4.2 Binary treatment variable

In this section we focus the analysis on central bank reform. We estimate the baseline local projections model with a binary indicator that takes the value of one from the year a major change in the central bank legislation tightening the conditions for lending to the government. Figure 2.9 presents the results for developing countries. The results closely replicate our baseline analysis. A reform of the central bank and a reduction of monetary financing to the government actually increases the amount of debt a government can carry in the medium term, while the interest rate on the debt actually falls.[30]

[30]Recall that in both the debt to GDP model and the interest rate model we account for secular trends. The effects shown are additional to the global changes in debt and interest rates over the period, and represent the difference between "treated" and "untreated" counties in the treatment effects terminology.

FIGURE 2.9: Local projections,central bank reform dummy, developing countries,1985-2017.

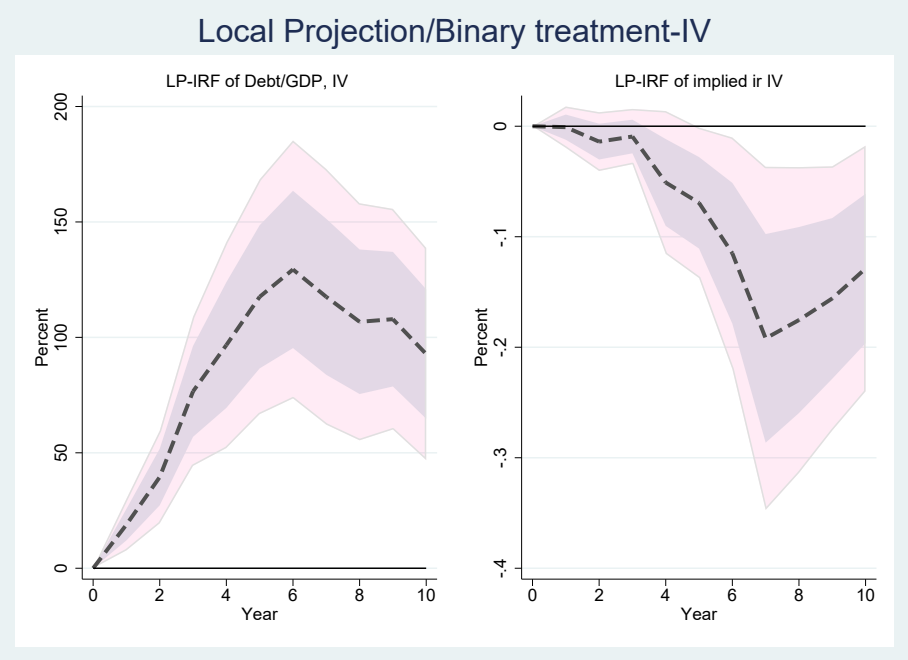


Notes: The figure shows the cumulative response of the debt to GDP ratio (left panel) and the implied interest rate (right panel) to central bank reform at horizon h on the x axis. CBI reform is proxied by a dummy variable that takes the value of one when the CBIE Lending index in a country increases by more that the median increase in our sample. Shaded areas denote the 68% and 90% confidence intervals using Driscoll and Kraay (1998) standard errors.

2.4.3 Instrumental variables local projections

In this section we present the results for the LP-IV estimation, where we use regional peer pressure to instrument for the reform of the central bank. In Figure 2.10 the IV results are considerably stronger than the OLS estimates. These results alleviate concerns about the endogeneity of central bank reforms, as well as the possibility of omitted variables that attenuate the estimated effects.

FIGURE 2.10: Local projections,IV, Developing countries,1985-2017.



Notes: The figure shows the cumulative response of the debt to GDP ratio (left panel) and the implied interest rate (right panel) to central bank reform at horizon h on the x axis. CBI reform is proxied by a dummy variable that takes the value of one when the CBIE Lending index in a country increases by more that the median increase in our sample. The reform dummy is instrumented by the 75-percentile of the distribution of the CBIE Lending index in regional peer countries. We use the Acemoglu et al. (2019) classification of regions. Shaded areas denote the 68% and 90% confidence intervals using Driscoll and Kraay (1998) standard errors.

2.4.4 Mechanism

In this section we examine one potential mechanism that connects central bank independence and higher debt to GDP ratios. As already discussed, more developed countries have been able to pursue optimally counter-cyclical fiscal policies, while developing countries are mostly deprived of this policy lever (see Frankel et al. (2013) and the references therein for this stylized fact). Better institutions are linked to the ability of countries to "graduate" from developing to advanced status, using the terminology of Frankel et al. (2013).

In our empirical analysis we use the following model to study the relationship between higher CBI and the cyclicality of a country's fiscal policy:

$$GovSpend_gap_{i,t} = Output_gap_{i,t} + \text{CBIndex}_{i,t} + Output_gap_{i,t} * \text{CBIndex}_{i,t} + \alpha_{i,t} + u_{i,t} \tag{2.3}$$

where the dependent variable is the cyclical component of government real spending, the output gap is the deviation of GDP from it's trend, and $\alpha_{i,t}$ are country fixed effects. Both the government spending gap and the output gap are estimated using the HP filter with a smoothing parameter of $\lambda = 100$.

Table 2.1 presents the results. In columns (1) and (2) we estimate the model for developing countries and in column (3) for advanced countries using the CBIE Lending to the government index. Columns (4)-(6) instead use the CBIE index of overall central bank independence.

Turning to the results we first note that the estimated coefficients for the output gap replicate the literature findings and have the expected sign for both the advanced and the developing countries. In advanced countries a high output gap is related to lower spending gap, but developing countries cannot implement counter-cyclical spending policies when their output gap is high. Second, while the standalone coefficient for the CBI indexes (both in columns (1)-(3) for the lending index, and (4)-(6) for the overall index) are not significant, the interaction with the output gap show improvements for the counter-cyclicality of the spending policy for developing countries, as we hypothesised. Of course, we only consider this evidence as suggestive at this stage.

TABLE 2.1: Cyclicality regressions

Variables *Depvar* *Government spending gap*	(1) Developing all countries	(2) Developing only reform countries	(3) Advanced	(4) Developing all countries	(5) Developing only reform countries	(6) Advanced
Output gap	0.138***	0.167	-0.00719***	0.270***	0.277***	-0.0417***
	(0.0127)	(0.145)	(0.000724)	(0.0272)	(0.0464)	(0.0107)
Output gap # CBIE Lending	-0.168***	-0.202*	0.119***			
	(0.0343)	(0.119)	(0.00266)			
Output gap # CBIE				-0.390***	-0.402***	0.123***
				(0.0986)	(0.0484)	(0.0183)
Observations	2,754	1,717	837	2,754	1,717	837
Number of Countries	101	60	31	101	60	31
Country FE	Yes	Yes	Yes	Yes	Yes	Yes

Notes: The dependent variable *Government spending gap* is the cyclical component of government spending, estimated with the HP filter. CBIE Lending is the restrictions to lending sub-index of the Central Bank Independence - Extended index introduced in Romelli (2022). *Output gap* is the deviation of real GDP from the HP filter. All models include country fixed effect. Driscoll and Kraay (1998) standard errors in parentheses. CBIE Lending, CBIE, and Polity coefficients not reported. ***/**/* denote significance at 1, 5 and 10 percent levels, respectively.

2.5 Conclusion

In this paper we have shown that the increased fiscal space that countries benefited from in the last two decades is linked to the independence of the central bank, and

to the credible commitment not to lend excessively to the government. Our results showed that tighter restrictions on lending to the central bank allow a country to carry a larger public debt without raising the required interest rate on the debt. We have argued that central bank independence is a "fiscal asset" in the term of Willems and Zettelmeyer (2022), effectively increasing fiscal space.

Any arguments that central banks should provide support to fiscal policies of the government should keep in mind that any such policies should not put in question the independence of the central bank. As we have shown in this paper it is the credibility of the central bank that allows more fiscal space. But the credibility of a central bank acquired due to its independence is probably not permanent nor unlimited. Of course we do not know how fast would central bank credibility erode if monetary financing policies were adopted. Neither would we want to.

Appendix

2.A Countries

Table 2.A.1: Analyzed countries

Countries, year of first analyzed legislation and development clusters					
Afghanistan	2003	Dev	Dominica	1983	Dev
Albania	1992	Dev	Dominican Republic	1959	Dev
Algeria	1962	Dev	Ecuador	1957	Dev
Angola	1997	Dev	Egypt	1957	Dev
Anguilla	1987	Dev	Equatorial Guinea	1972	Dev
Antigua and Barbuda	1983	Dev	Estonia	1993	Adv
Argentina	1935	Dev	Ethiopia	1994	Dev
Australia	1959	Adv	Finland	1966	Adv
Austria	1955	Adv	France	1936	Adv
Azerbaijan	1996	Dev	Gabon	1972	Dev
Bahrain	1973	Dev	Gambia	1971	Dev
Bangladesh	2003	Dev	Georgia	1995	Dev
Belarus	1990	Dev	Germany	1957	Adv
Belgium	1948	Adv	Ghana	1975	Dev
Benin	1956	Dev	Greece	1959	Adv
Bolivia	1945	Dev	Grenada	1983	Dev
Bosnia and Herzegovina	1997	Dev	Guatemala	1959	Dev
Botswana	1975	Dev	Guinea-Bissau	1956	Dev
Brazil	1964	Dev	Guinea	1994	Dev
Brunei	1984	Dev	Haiti	1979	Dev
Bulgaria	1991	Dev	Hungary	1991	Dev
Burkina Faso	1956	Dev	Iceland	1966	Adv
Burundi	1965	Dev	India	1934	Dev
Cambodia	1954	Dev	Indonesia	1953	Dev
Cameroon	1972	Dev	Iran	1972	Dev
Canada	1954	Adv	Iraq	1964	Dev
Central African Republic	1972	Dev	Ireland	1942	Adv
Chad	1972	Dev	Italy	1948	Adv
Chile	1953	Dev	Ivory Coast	1956	Dev
China	1995	Dev	Jamaica	1992	Dev
Colombia	1923	Dev	Japan	1957	Adv
Comoros	1987	Dev	Jordan	1971	Dev
Costa Rica	1953	Dev	Kazakhstan	1993	Dev
Croatia	1991	Dev	Kenya	1984	Dev
Cuba	1959	Dev	Kuwait	1968	Dev
Cyprus	1963	Adv	Kyrgyzstan	1992	Dev
Czech Republic	1991	Adv	Laos	1995	Dev
Democratic Rep. of the Congo	1993	Dev	Latvia	1992	Adv
Denmark	1942	Adv	Lebanon	1969	Dev

Notes: The table reports information on the list of analysed countries, the first year of availability of the CBI index and their developmental cluster, i.e. Adv for advanced economics and Dev for developing countries.

Table 2.A.1 Continued: Analyzed countries

Countries, year of first analyzed legislation and region group					
Liberia	1974	Dev	Saint Kitts and Nevis	1983	Dev
Libya	1996	Dev	Saint Lucia	1983	Dev
Lithuania	1994	Adv	St. Vincent and the Grenadines	1983	Dev
Luxembourg	1983	Adv	Saudi Arabia	1957	Dev
Macao S.A.R	2000	Dev	Senegal	1956	Dev
Macedonia	1992	Dev	Seychelles	1986	Dev
Malawi	1989	Dev	Sierra Leone	1963	Dev
Malaysia	1982	Dev	Singapore	1991	Adv
Maldives	1982	Dev	Slovakia	1992	Adv
Mali	1984	Dev	Slovenia	1991	Adv
Malta	1994	Adv	Somalia	1960	Dev
Mauritania	1956	Dev	South AFR	1956	Dev
Mauritius	1966	Dev	South Korea	1950	Adv
Mexico	1960	Dev	Spain	1962	Adv
Moldova	1992	Dev	Sri Lanka	1953	Dev
Mongolia	1996	Dev	Sweden	1966	Adv
Montenegro	2005	Dev	Switzerland	1953	Adv
Morocco	1959	Dev	Taiwan	1979	Adv
Myanmar	1952	Dev	Thailand	1942	Dev
Namibia	1990	Dev	The Bahamas	1974	Dev
Nepal	1955	Dev	Togo	1956	Dev
Netherlands	1948	Adv	Trinidad and Tobago	1964	Dev
New Zealand	1933	Adv	Tunisia	1958	Dev
Niger	1956	Dev	Turkey	1970	Dev
Nigeria	1969	Dev	Turkmenistan	1994	Dev
Norway	1966	Adv	Uganda	1966	Dev
Oman	2000	Dev	Ukraine	1991	Dev
Pakistan	1972	Dev	United Arab Emirates	1980	Dev
Panama	1941	Dev	United Kingdom	1946	Adv
Paraguay	1952	Dev	United Republic of Tanzania	1966	Dev
Peru	1962	Dev	United States of America	1951	Adv
Philippines	1948	Dev	Uruguay	1938	Dev
Poland	1997	Dev	Uzbekistan	2000	Dev
Portugal	1962	Adv	Venezuela	1939	Dev
Qatar	1993	Dev	Vietnam	1990	Dev
Republic of Congo	1972	Dev	Yemen	1971	Dev
Romania	1991	Dev	Zambia	1971	Dev
Russia	1992	Dev	Zimbabwe	1956	Dev
Rwanda	1997	Dev			

Note: The table reports information on the list of analysed countries, the year of the first analysed legislation and the regional clusters. AFR: Africa, EAP: East Asia and the Pacific, EECA Eastern Europe and Central Asia, LAC: Latin America and the Caribbean, MENA: Middle East and the North of Africa, SA: South Asia and WEOD: Western Europe and other developed countries.

2.B Coding rules for the CBIE Lending index

This section summarizes the guiding principles used for the construction of the sub-index on Limitations on lending to the government (CBIE Lending index).

1)	Limitations on advances	
	Advances to government prohibited	1.00
	Advances permitted, but with strict limits (e.g., up to 15 percent of government revenue)	0.67
	Advances permitted, and the limits are loose (e.g., over 15 percent of government revenue)	0.33
	No legal limits on lending	0.00
2)	Lending to government	
	Not allowed	1.00
	In the secondary market with restricted limits	0.75
	In the secondary market with lax or without limits	0.50
	In the primary market with limits or approved by central bank board with a qualified majority	0.25
	In the primary market without limits	0.00
3)	Who decides financing conditions to government (maturity, interest, amount)?	
	Central bank defines terms and conditions	1.00
	Specified by the bank charter	0.67
	Agreed between the central bank and executive	0.33
	Decided by the executive branch alone	0.00
4)	Potential borrowers from the central bank	
	Only the government	1.00
	Government plus local governments	0.67
	All of the above plus public enterprises	0.33
	All of the above and to the private sector, also if it is not mentioned otherwise	0.00
5)	Limits on central bank lending defined	
	As an absolute cash amount	1.00
	As a percentage of central bank capital or other liabilities	0.67
	As a percentage of government revenues	0.33
	As a percentage of government expenditure	0.00
6)	Maturity of advances	
	Within 6 months	1.00
	Within 1 year	0.67
	More than 1 year	0.33
	No mention of maturity in the law	0.00
7)	Interest rates on advances	
	At market rates	1.00
	Interest rates not specified in law	0.50
	At below market rates	0.00
8)	Central bank prohibited from buying or selling government securities in the primary market	
	Yes	1.00
	No	0.00

2.C Data

TABLE 2.C.1: Data and data sources

Variable	Definition	Data sources
	Dependent variable	
Debt to GDP	Gross Public Debt,% of nominal GDP	IMF:Public Finances in Modern History
Interest rate	Implied interest rate on public debt (in %) calculated using the formula: $InterestRate_{c,t} = \frac{\frac{InterestExpenseToGDP_{c,t}}{DebtToGDP_{c,t}+DebtToGDP_{c,t-1}}}{2}$	IMF:Public Finances in Modern History
	Explanatory variables	
CBIE Lending	Index on restrictions to lending to the government, Central Bank Independence - Extended (CBIE) index	Romelli (2022)
RGDP growth	Annual growth rate of real GDP	World Bank: NY.GDP.MKTP.KD
Output gap	Deviations of real GDP from HP trend.	World Bank: NY.GDP.MKTP.KD
Log of GDP per capita	Log of Per capita GDP	World Bank: NY.GDP.MKTP.KD
Inflation	Annual growth rate of CPI	World Bank: FP.CPI.TOTL.ZG
FCE	Final Consumption Expenditure, (% of GDP)	World Bank: NE.CON.TOTL.ZS
GFCF	Gross Fixed Capital Formation, (% of GDP)	World Bank: NE.GDI.FTOT.ZS
FDI	Foreign direct investment, net inflows (% of GDP)	World Bank: BX.KLT.DINV.WD.GD.ZS
Government Expenditure	Government expenditure (% of GDP)	IMF:Public Finances in Modern History
Population Growth	Population growth	World Bank: SP.POP.TOTL
Exchange rate regime	Dummy variable that takes the value of one in countries adopting a fixed exchange rate regime.	Authors following Ilzetzki et al. (2019)
Openness to trade	Degree of openness to trade of a country. $Opnness_{c,t} = \frac{Imports_{c,t}+Exports_{c,t}}{GDP_{c,t}}$.	World Bank
Polity	Index that measures the difference between the democratic and the autocratic score of a country, ranging from +10 (strongly democratic) to -10 (strongly autocratic).	PolityIV (2014)
Polity-Executive constraints	Constraints on the executive	PolityIV (2014)
Banking crisis	Dummy variable that takes the value of one in the two years following a systemic banking crisis.	Authors following Laeven and Valencia (2012)
Currency crisis	Dummy variable that takes the value of one in the two years following a systemic sovereign debt crisis.	Authors following Laeven and Valencia (2012)

Table 2.C.1 Continued: Data sources

Variable	Definition	Data sources
Sovereign debt crisis	Dummy variable that takes the value of one in the two years following a systemic sovereign debt crisis.	Authors following Laeven and Valencia (2012)

TABLE 2.C.2: Summary statistics

Variable	Obs	Mean	Std. Dev.	Min	Max
Real GDP growth rate, percent	4610	3.596	6.104	-56.994	147.973
OutputGap	5535	0	.049	-.652	.474
LnGDPpc	5570	8.465	1.531	5.086	11.663
Inflation, consumer prices (annual %)	5091	27.29	406.575	-17.64	23773.13
Final consumption expenditure (% of GDP)	5144	79.059	15.94	11.611	241.974
Gross fixed capital formation (% of GDP)	4965	22.526	7.265	-2.424	89.386
Foreign direct investment, net inflows (% of GDP)	5513	3.961	13.652	-58.323	451.639
Government expenditure, percent of GDP	3951	30.774	19.251	3.635	594.77
Population Growth	5717	.017	.022	-.1	.167
Fixed Exchange Rate Regime	5637	.355	.478	0	1
Openness to Trade	5418	76.628	46.584	.021	437.327
Polity index	5313	2.493	7.17	-10	10
Executive Constraints (Polity)	5379	1.051	17.028	-88	7

Notes: Table presents descriptive statistics for control variables included in the analysis.

2.D Evolution of CBIE Lending index

FIGURE 2.D.1: CBIE Lending index, advanced economies, 1985-2017

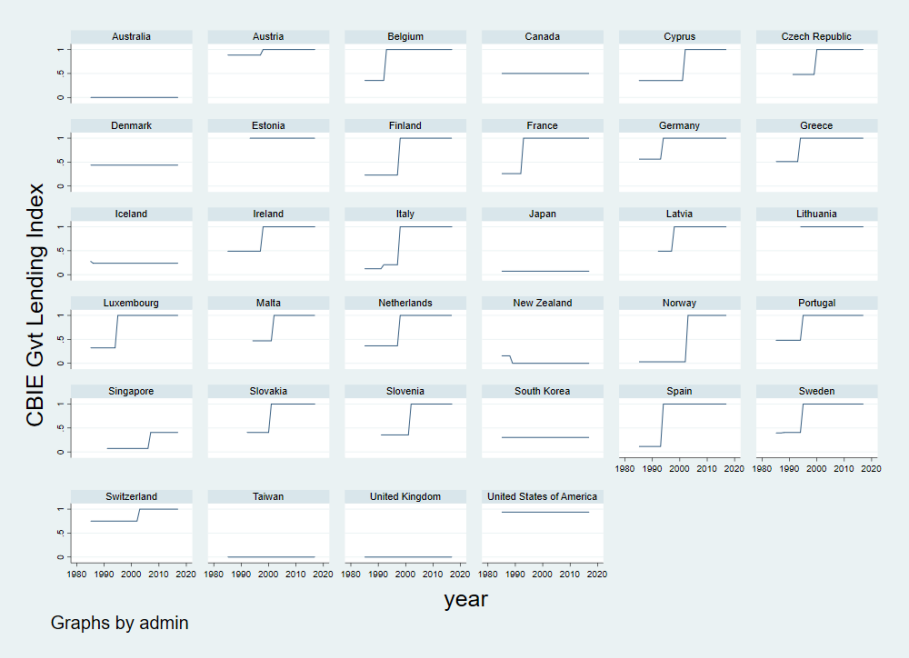


FIGURE 2.D.2: CBIE Lending index, developing countries (Part I), 1985-2017

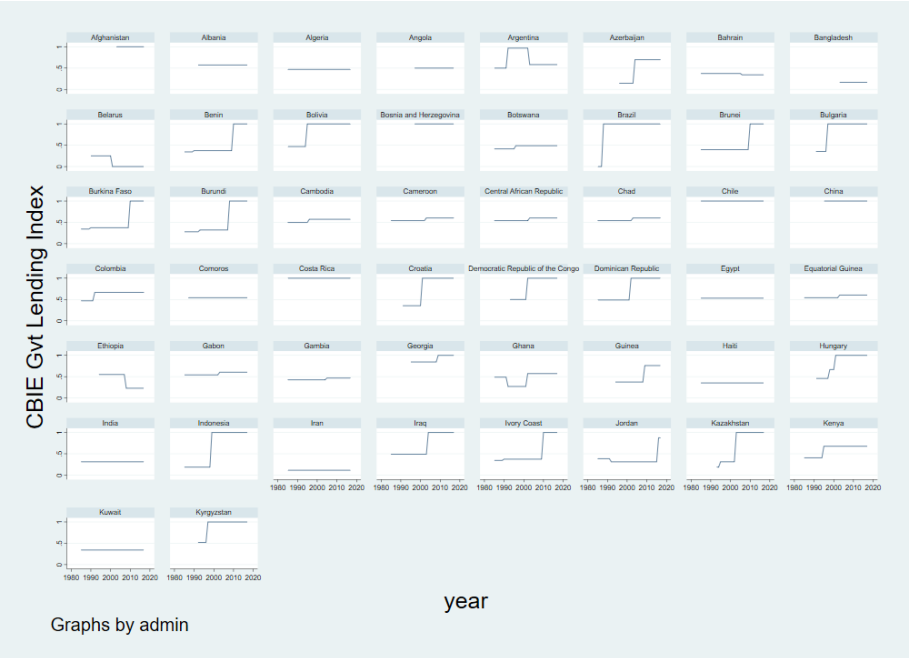


FIGURE 2.D.3: CBIE Lending index, developing countries (Part II), 1985-2017

2.E IV Local projection estimation

Table 2.E.1 presents the first stage of our IV estimation. We construct the instrument from the 75th percentile of the regional distribution of CBIE Lending index. We use the regional classification from Acemoglu et al. (2019) to identify peer countries.

TABLE 2.E.1: IV First stage estimates

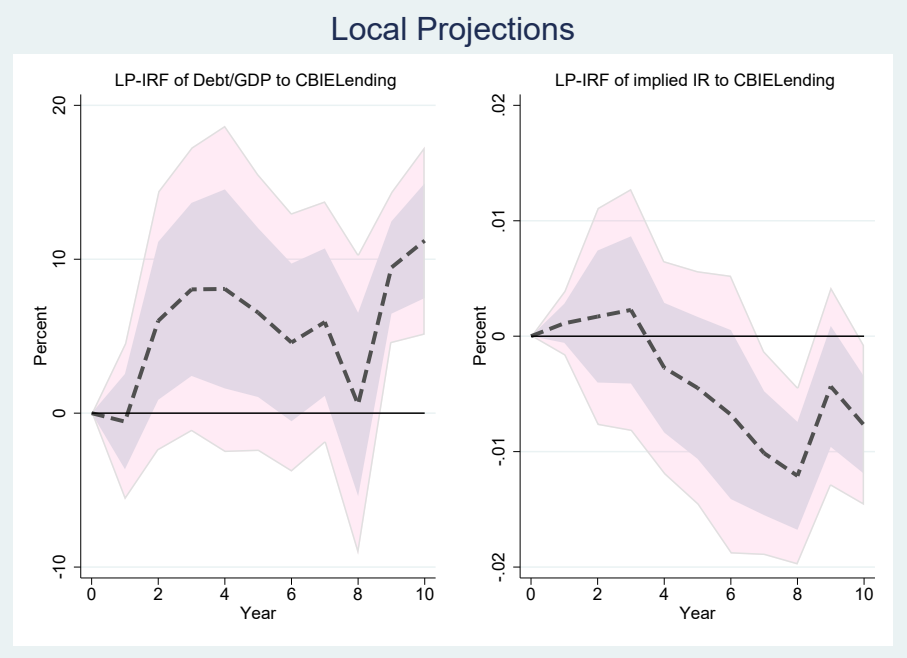
	1
Regional peer pressure t-1	0.629**
	(0.119)
KP weak IV	28.06
Observations	2030
Countries in sample	99
Controls	Yes

Notes: The table shows the first stage results of the IV estimation. We instrument the CBIE Lending index of restriction on central bank lending to the government from Romelli (2022) with a measure of regional peer pressure (see text for details). KP weak IV refers to the Kleibergen and Paap (2006) rk Wald F-statistic.

2.F Additional results

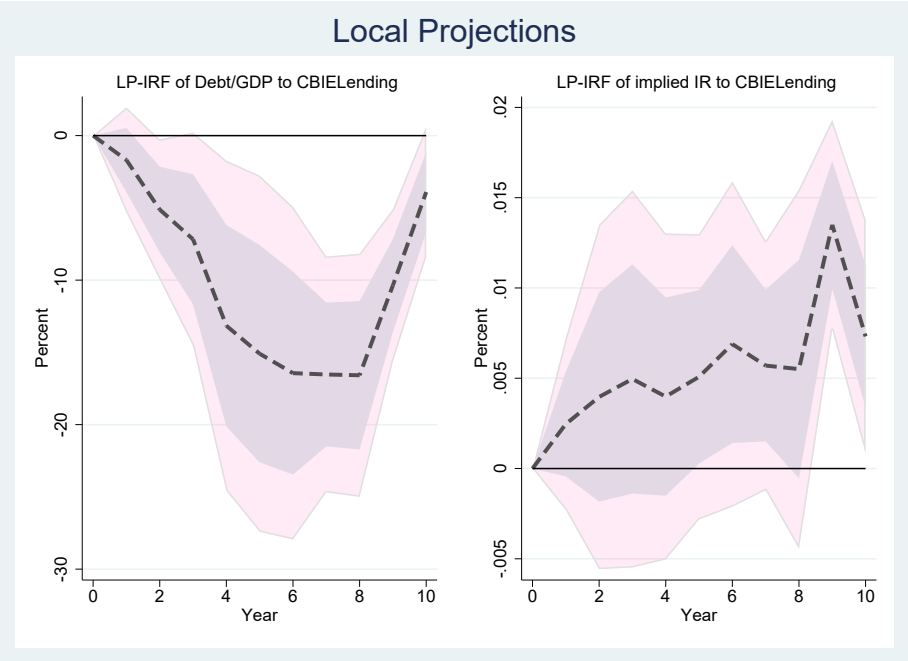
Appendix figures 2.F.1, 2.F.2, and 2.F.3 shows the local projection results when we only included countries that reformed their lending to the government legislation for the whole sample, advanced countries, and developing countries.

FIGURE 2.F.1: Local projections, CBIE Lending continuous index, whole sample, only reform countries, 1985-2017.



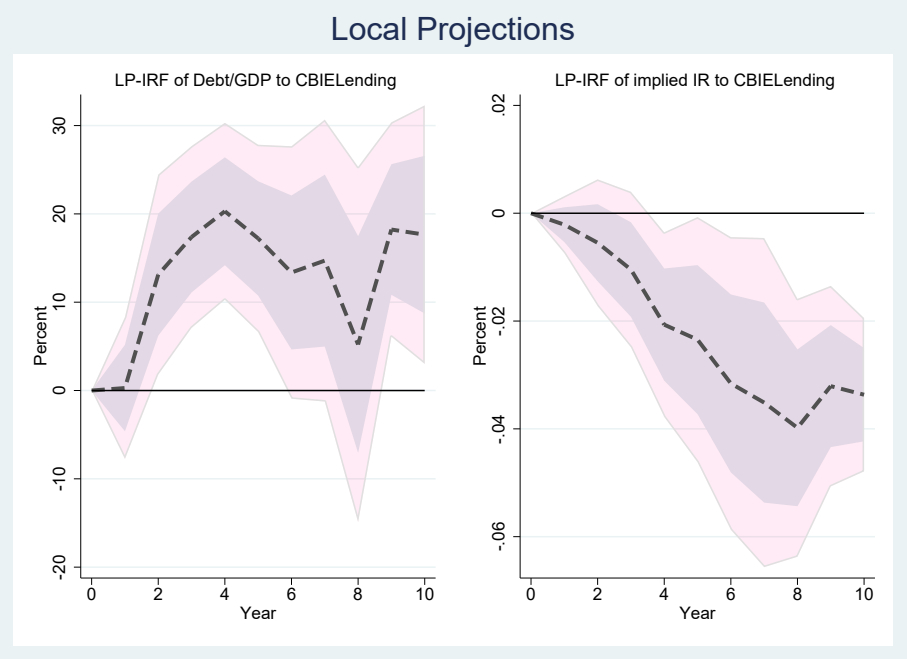
Notes: The figure shows the cumulative response of the debt to GDP ratio (left panel) and the implied interest rate (right panel) to a one point change in the CBIE Lending index at horizon h on the x axis. Shaded areas denote the 68% and 90% confidence intervals using Driscoll and Kraay (1998) standard errors.

FIGURE 2.F.2: Local projections, CBIE Lending continuous index, Advanced countries with reforms, 1985-2017.



Notes: The figure shows the cumulative response of the debt to GDP ratio (left panel) and the implied interest rate (right panel) to a one point change in the CBIE Lending index at horizon h on the x axis. Shaded areas denote the 68% and 90% confidence intervals using Driscoll and Kraay (1998) standard errors.

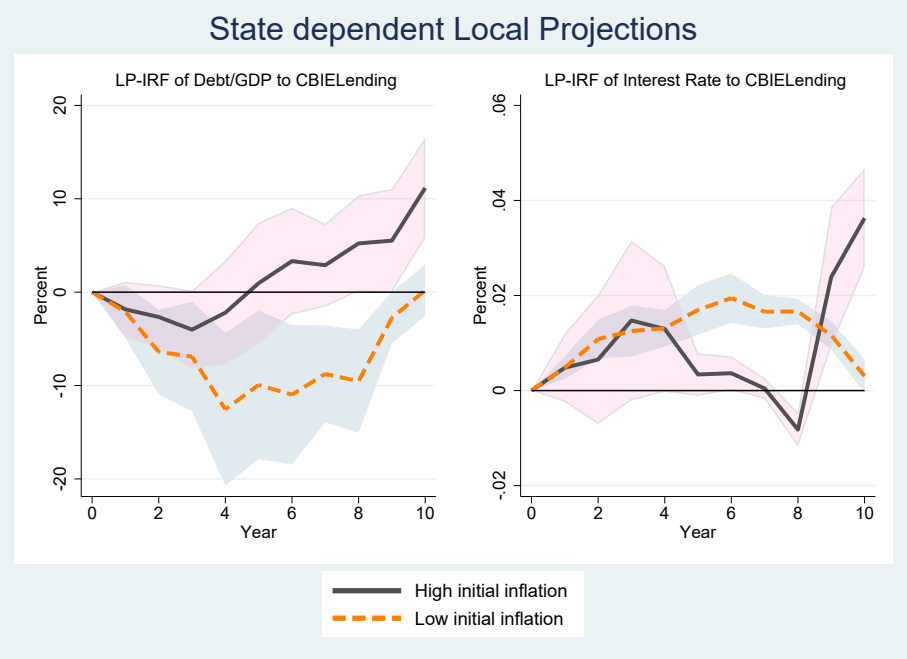
FIGURE 2.F.3: Local projections, CBIE Lending continuous index, Developing countries with reforms, 1985-2017.



Notes: The figure shows the cumulative response of the debt to GDP ratio (left panel) and the implied interest rate (right panel) to a one point change in the CBIE Lending index at horizon h on the x axis. Shaded areas denote the 68% and 90% confidence intervals using Driscoll and Kraay (1998) standard errors.

Appendix figures 2.F.4 presents the estimates for advanced economies for the state dependent models when inflation is the state variable.

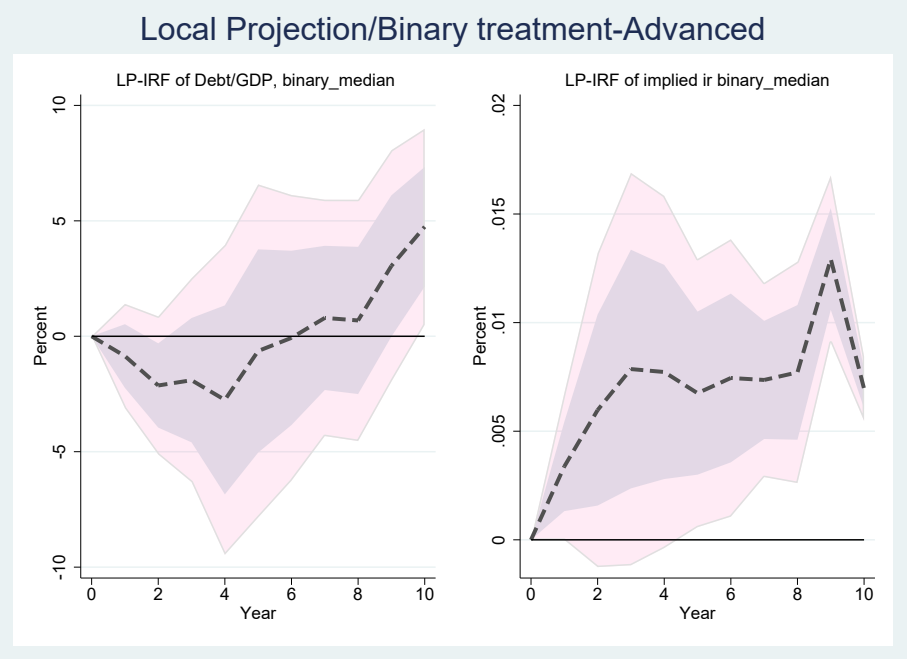
FIGURE 2.F.4: State dependent local projections, by level of inflation, advanced economies, 1985-2017



Notes: The figure shows the cumulative response of the debt to GDP ratio (left panel) and the implied interest rate (right panel) to a one point change in the CBIE Lending index at horizon h on the x axis. Shaded areas denote the 68% and 90% confidence intervals using Driscoll and Kraay (1998) standard errors.

Appendix figures 2.F.5 presents the estimates for advanced economies for CBIE Lending reform.

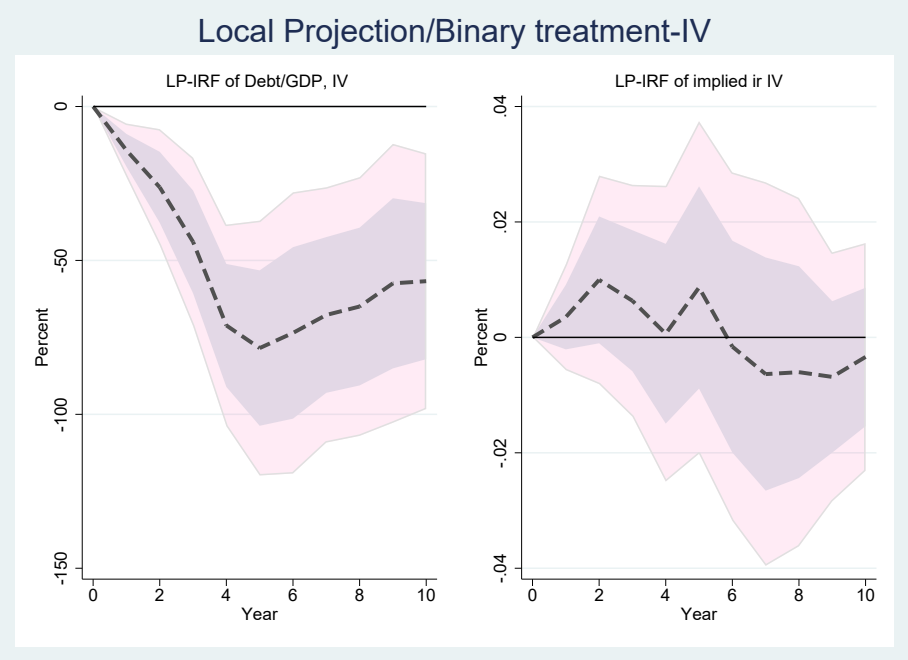
FIGURE 2.F.5: Local projections, dichotomous index, Advanced countries,1985-2017.



Notes: The figure shows the cumulative response of the debt to GDP ratio (left panel) and the implied interest rate (right panel) to central bank reform at horizon h on the x axis. CBI reform is proxied by a dummy variable that takes the value of one when the CBIE Lending index in a country increases by more that the median increase in our sample. Shaded areas denote the 68% and 90% confidence intervals using Driscoll and Kraay (1998) standard errors.

Appendix figures 2.F.6 presents the estimates for advanced economies for the IV estimation.

FIGURE 2.F.6: Local projections,IV, Advanced economies,1985-2017.



Notes: The figure shows the cumulative response of the debt to GDP ratio (left panel) and the implied interest rate (right panel) to central bank reform at horizon h on the x axis. CBI reform is proxied by a dummy variable that takes the value of one when the CBIE Lending index in a country increases by more that the median increase in our sample. The reform dummy is instrumented by the 75-percentile of the distribution of the CBIE Lending index in regional peer countries. We use the Acemoglu et al. (2019) classification of regions. Shaded areas denote the 68% and 90% confidence intervals using Driscoll and Kraay (1998) standard errors.

Chapter 3

Zombie firms and financial constraints

3.1 Introduction

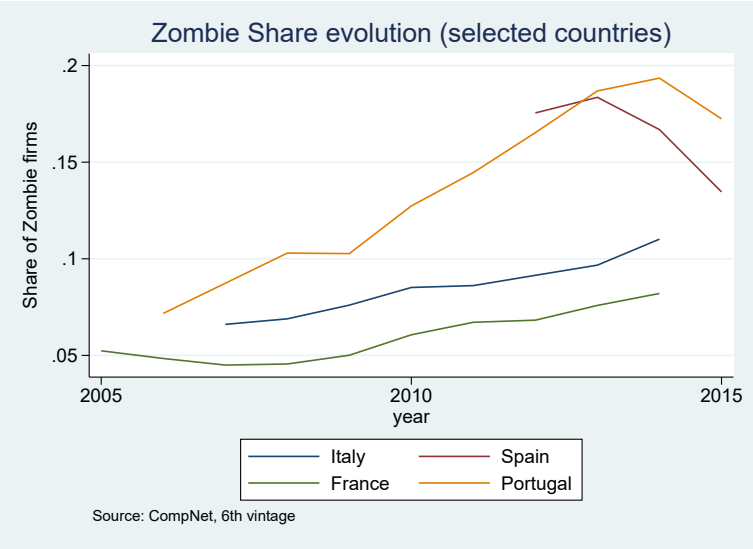
Pessimism over the slow economic recovery and falling productivity growth in Europe in the aftermath of the twin financial and sovereign debt crises in the last decade has brought to the fore the importance of the allocative efficiency in an economy. The perceived inability of monetary policy to stimulate demand and spur growth has turned the attention to the supply side of the economy and has renewed fears of possible perverse effects of excessively low interest rates, and of misallocation of resources. For example, Crosignani et al. (2020) demonstrate how unconventional monetary policy measures of long-term liquidity provision by the European Central Bank at the outset of the sovereign debt crisis incentivised banks to direct purchases towards eligible government bonds in order to generate trading profits. Acharya et al. (2019) show that such windfall gains at under-capitalised European banks were disproportionately redeployed in loans to weaker firms with which banks had previously established lending relationships, a phenomenon that has come to be called "zombie" lending.[1] Figure 3.1 shows the increase in the proportion of such zombie firms in four European economies.[2]

[1] The term "zombie firm" first appears in the 1980s in the US during the Saving and Loans crisis. The term was introduced in the economics literature by Caballero et al. (2008). It broadly refers to insolvent firms that are kept "alive" through the forbearance of their creditors, usually banks that are under-capitalised themselves.

[2] As it will be made clear later in this paper, there can be many different methods to identify zombie firms, based on operational or financial characteristics. However, all these methods paint a broadly similar picture of a considerable increase in "zombie infestation" particularly in countries mostly exposed to the euro debt crisis.

Bank lending misdirected to poorly performing unproductive incumbent firms can be an important mechanism contributing to resources misallocation. For example, Peek and Rosengren (2005) argue that credit misallocation "hinder[ed] the economic recovery and prolonged the malaise" in one of the most severe examples of prolonged stagnation, the Japanese economy since the 1990s. Systematic bank forbearance towards firms with poor prospects ultimately can have negative spill-over effects on healthy firms and the aggregate economy (Caballero et al., 2008). Recently, the idea of the "Japanification" of the European economy has renewed interest in these so called "zombie" firms, recipients of continued and unjustified funding from their lending banks. While the context might vary across cases, recent studies show that the higher the percentage of zombie firms in an industry, the lower the growth rate of capital investment and employment is for healthy firms in that industry.

FIGURE 3.1: Zombie shares



In explaining the extension of credit to zombie firms the recent literature typically focus on the health of the lending banks. When weakly capitalised banks are threatened with forced recapitalisation by the banking regulator perverse incentives operate and banks engage in risk shifting (Jensen and Meckling, 1976). In order to avoid recapitalisation and the certain wiping-out of existing shareholders, banks delay recognition of doubtful loans, "gamble for resurrection", and continue lending to weak borrowers that they are already exposed to.[3]

[3]Though theoretically appealing, this view implicitly assumes low or zero costs of entrepreneurial failure. Kirti (2017) provides evidence that hard-hit insurance companies in the US during the

The normative implication of the zombie lending theory is that a swift bank recapitalisation needs to be sufficiently large in size so that banks do not need to engage in "evergreening"[4] of doubtful loans, and a process of cleaning up of lending portfolios and deleveraging of banks can start.

The underlying behavioural assumption is that in normal times banks evaluate the repayment capability of potential borrowers and only underwrite loans that have a positive net present value. Lending to potentially insolvent firms would clearly be irrational, the central argument of the zombie lending theory. Yet, it is well understood that in the presence of financial frictions (in the sense of uncertainty about the prospects of a project) banks demand collateral as a means of resolving the informational asymmetry in a lending relationship.

In this paper I investigate the role played by such financial frictions in the creation of zombies. Specifically, I explore a different but related channel to complement our understanding of the zombie firm phenomenon, the collateral channel of corporate leverage. As Acharya et al. (2019) perceptively point out, the documented lending to poorly performing firms in the aftermath of the crisis in Europe is consistent with both a zombie lending/perverse incentives channel as in Caballero et al. (2008) and a balance sheet/collateral channel as in Bernanke and Gertler (1989).

The theoretical merits of collateral are well understood. Collateral is a screening mechanism that helps resolve the informational asymmetry in a lending relationship. The decision of a lender to provide funding to a firm is related not only to the business prospects of the borrower but also to the quality and liquidity of the collateral that the borrower might be able to provide. More available collateral raises the liquidation value that the lender will be able to recover thus facilitating the provision of credit.

Less attention has been played however to the costs that collateralised lending imposes on both the borrowers and the lenders. On the borrower side, loss of operational and financial flexibility[5] means that firm financing and risk management are

recent Global Financial Crisis reduced risk-taking more than less troubled ones. This implies that at some point preservation of the long-term franchise value dominates, and gambling for resurrection is eschewed.

[4]Evergreening refers to possible fraudulent accounting practices by banks that allow delinquent loans to continue to appear as being normally serviced. Typically, they include rescheduling of payments due, interest "roll up", or extension of new credit at lower rates.

[5]Unpledged collateral is a form of "financial slack" like in Myers and Majluf (1984), unused resources that can mobilised when needed.

linked, and firms trade-off these two objectives (Rampini and Viswanathan, 2010). The counter-cyclical behaviour of collateralised debt (Benmelech et al., 2020) points to potential inefficiencies in corporate investment. On the lenders side, collateralisation is an imperfect screening mechanism, inducing higher lending volumes, but also exposing banks to borrowers of inherently lower productivity[6](adverse selection).

Given these costs, it is natural to ask if collateralised lending can also be a source of misallocation of resources. Theoretical concepts as the "soft budget problem of lenders" of Dewatripont and Maskin (1995), or the "ratchet effect of corporate borrowing" of Admati et al. (2018) point to adverse selection due to collateral.[7]

The paradox of pledgeability of Donaldson et al. (2020) shows how collateral can lead to inefficiently low investment ex ante, while Bernhardt et al. (2021) describe a model where zombie lending rises endogenously.

This study focuses therefore on the lending technology, and more specifically on the most common commitment mechanism in lending, pledgeable collateral. In the paper I ask the question: is the zombie lending problem a problem of zombies or a problem of lending? In other words, is the zombie lending phenomenon related to misallocations due to collateralised lending?

To examine this, I first show that zombies have more collateral. Using an instrumental variable design, I show that the independent variation in leverage caused by the change in collateral can predict the zombie status of a firm. To empirically test the importance of collateral on the probability that a firm is a zombie I exploit a rich dataset maintained by the Competitiveness Research Network (CompNet)[8], analysing non-financial firms in 14 European countries in the period 2003-2015. Compared to the literature, the dataset I use provides unparalleled cross-country scope and almost comprehensive coverage of all firm size-classes.

In the second part of the paper, I turn to the question of the spill-over effects of zombies on non-zombie firms. The link between collateral and zombies will be exploited in studying the misallocation effects of zombies. In an augmented zombie

[6]Less creditworthy borrowers are required to pledge more collateral than more creditworthy ones. Less productive credit-constrained firms are heavier users of collateralised borrowing.

[7]Gan (2007) shows that firms that experience larger collateral value falls are less able to sustain their banking relationships and tend to obtain a smaller amount of bank credit. In other words, collateral values help firms maintain their banking relationships and therefore are a factor in the zombie survival.

[8]For more information see CompNet - The Competitiveness Research Network

regression framework, I show that the inclusion of collateral in the analysis reduces by half the zombie congestion coefficient. These results can be interpreted as an indication of a direct effect of the collateral channel on resources misallocation, in the presence of zombies.

The misallocation argument in this paper is similar to the arguments in Gopinath et al. (2017). When external funding is granted based not directly on the productivity and the prospects of a firm but on the basis of pledgeable collateral then credit is misallocated. The misallocation takes the form of both adverse selection ex ante and zombie lending ex post. The observed negative spill-over effects of zombie firms documented in the literature are therefore the consequences partially of the type of funding technology used (collateralised lending).

The rest of the paper is organised as follows. Section 3.2 reviews the related literature. Section 3.3 describes the data while section 3.4 present the empirical strategy and the results. Section 3.5 concludes.

3.2 Literature review

3.2.1 What are Zombies?

Zombies are poorly performing firms that are only allowed to remain in operation by receiving cheap credit mainly from under-capitalised banks in the aftermath of a prolonged economic and financial crisis. The main insight of the zombie lending literature is that perverse incentives for banks, often coupled with institutional weaknesses, and amplified by macroeconomic policies, can distort the creative destruction process. This can hinder resource reallocation between firms, dampen business dynamics, and ultimately lead to a fall in aggregate productivity growth.

Zombie lending misallocation of credit has been seen as one of the main causes of slow growth in Japan in the "lost decade" of the 1990s, after the joint burst of the stock market and real estate bubbles. Starting with Hoshi (2006) the zombie literature examined the role of low interest rates, of perverse incentives for banks, and of convoluted ownership structures in the zombie lending phenomenon. Peek and Rosengren (2005) using firm-bank level data first document the zombie lending channel of bank forbearance through the"evergreening" of old loans. Peek and

Rosengren show that weakly capitalised banks tended to continue lending to poorly performing and possibly insolvent firms that they had previously lent to, particularly so if both the bank and the borrower belonged to the same "keiretsu" network of affiliated firms then prevalent in Japan. In their seminal contribution to the literature Caballero et al. (2008) describe the effects of credit misallocation in a simple model of firm dynamics. In their model some firms receive a subsidy that allows them to remain in business despite negative operating profits. The presence of these zombies distorts the firm entry and exit mechanisms, and spill-over effects of zombies lower non-zombie growth. In the terms of Caballero et al. zombie firms "congest" input and output markets, keeping labour costs high and depriving healthy firms of credit, while keeping output prices low and depressing sector profitability. To test the empirical implications of their model, Caballero et al. study a sample of 2500 publicly listed firms for the period 1981-2001. They run regressions of firm performance (in terms of investment and employment growth) on the share of sector assets held by zombie firms, using a comprehensive set of interacted time and sector fixed effects to control for aggregate shocks and unobserved firm heterogeneity. This identification strategy however prevents the estimation of a direct coefficient on the zombie share indicator (which is absorbed by the sector fixed effects) and only allows the estimation of the effect of zombie congestion on the relative performance of non-zombie firms compared to zombie firm.[9] Their results show that an increased share of zombies in an industry negatively effects the *relative* performance of healthy firms vs. zombies.

The "zombie congestion" effects documented in the case of Japan in the 1990's by Caballero et al. (2008) have served as a benchmark in the literature. The zombie lending channel has received renewed interest in Europe since the global financial crisis.[10] Studies like Adalet McGowan et al. (2018) and Storz et al. (2017) replicate the results from the Japanese experience in the European context and show that when zombie firms hold a high share of industry assets the performance of healthy firms relative to zombies is negatively affected. Event study designs have also been used to strengthen identification. Acharya et al. (2019) use the announcement of the

[9] See Schivardi et al. (2022) for a detailed evaluation of the empirical design and identification in this type of studies.

[10] Other than the initial theoretical contribution of Caballero et al. (2008), the zombie firms literature reviewed in the next section is primarily empirical in nature.

Outright Monetary Transactions (OMT) programme by the ECB[11] in the summer of 2012 to show that windfall profits for poorly capitalised banks with large portfolios of government bonds lead to increased lending to zombie firms. Blattner et al. (2019) use bank supervisory data to identify misreported non-performing loans. Taking advantage of an expected tightening of bank capital requirements the authors show that credit misallocation had important negative effects on aggregate productivity in Portugal. On the other hand Schivardi et al. (2022) question the identification strategies common in the zombie literature. While they confirm the relative underperformance of healthy firms in the presence of zombies they argue that the aggregate effects on productivity are negligible, at least for the Italian case that they study.

The zombie literature reviewed so far implicitly assumes a transaction banking model, where each loan is evaluated on its own merits. Recent theoretical and empirical contributions analyse lending to poorly performing firms in the framework of a relationship banking model like Williamson (1987) and show that forbearance lending can alleviate credit constraints particularly for small and opaque firms in stressed economies (Beck et al., 2018) or help internalise fire-sales externalities (Jaskowski, 2015). The effects of collateral specificity, in the sense of Shleifer and Vishny (1992), are also analysed by Giannetti and Saidi (2019) who show that in industries where such collateral fire-sales are more likely there is more forbearance lending. This paper provides indirect evidence to these mechanisms by analysing the role of collateral.

3.2.2 Misallocation

This paper is also linked to the financial frictions and credit misallocation literature. The standard view is that collateralisation increases the borrowing capacity of a debtor, as the collateral increases the value that can be recaptured by creditors in default states. However, the effects of collateral might not always be positive. Recent empirical evidence documents perverse aggregate and distributional effects of increased creditors rights and enlarged collateral menus. Lilienfeld-Toal et al. (2012) show that a reform that increased the ability by banks to recover non-performing loans in India led to a fall in borrowing, especially by smaller firms. Vig (2013), also in India, shows that a strengthening of securitisation creditors rights increased

[11] For more information see ECB-Outright Monetary Transactions

liquidation bias and lead borrowers to reduce their use of securitized debt. Assunçao et al. (2014) show that a reform in Brazil that allowed faster and more efficient repossessions of cars in automobile loans lead to increased borrowing by riskier borrowers buying more expensive cars. Aretz et al. (2020) study the abolition of the Napoleonic security code in France and its effects on lending, and Schmalz et al. (2017) exploit collateral value shocks to identify the effects of collateral on entrepreneurship in France. Chaney et al. (2012), analysing the US economy before the Global Financial Crisis, identify a collateral channel where variation in real estate values used as collateral impact aggregate corporate investment. Gan (2007) provides similar evidence from Japan on the effect of collateral valuations on aggregate corporate investment. Acharya et al. (2011) question the standard view on creditors rights as they show that in cross-country regressions stronger creditors rights inhibit corporate risk-taking.

Generally, theoretical models stress the possible dynamic inefficiencies of collateralised debt, leading to ex ante adverse selection and ex post misallocation of resources. Collateralised debt imposes constraints both on the borrower (loss of financial and operational flexibility, liquidation bias) and on the lender (soft budget problem and adverse selection). These costs increase the risk of inefficient lending and therefore misallocations. For example, Demarzo (2019) notes that "because ex ante optimal commitments are likely to be sub-optimal ex post, observed capital structure dynamics will exhibit hysteresis and depart significantly from standard predictions.". Admati et al. (2018) describe a "leverage ratchet" effect, where shareholders always prefer to increase leverage even if this lowers the value of debt already in place. This is related to the "soft budget" commitment problem of lenders in a collateralised loan of Kornai (1986) and Dewatripont and Maskin (1995). Collateral ties-in the creditor, who cannot credibly commit to not refinance a project. In the presence of these sunk costs ex post, i.e. debt already in place but which is at risk of defaulting, lenders refinance. This aggravates the adverse selection problem ex ante, as entrepreneurs can reasonably expect continued funding of projects when lenders do not foreclose even if the projects are not viable ex post. Borrowers therefore accept collateral encumbrance ex ante because they foresee that the lender will not liquidate ex post. Empirically, Rampini and Viswanathan (2010) show that less productive and therefore more constrained firms will accept ex ante higher asset encumbrance worsening

adverse selection. Therefore, in bad states of the world, where collateral liquidation might be particularly difficult, "soft budget" models predict that there will be re-financing of lower quality firms, i.e. zombie lending, as in Bernhardt et al. (2021). While a commitment to not refinance is the optimal screening mechanism, collateral availability softens this commitment, particularly when collateral re-deployability is not complete and some losses upon liquidation are expected.

This paper is also linked to the growing literature on firm-level financial frictions and their effects on firm selection and aggregate productivity. Gopinath et al. (2017) develop a model of size-dependent financial frictions to explain the productivity slow-down in Southern Europe. Moll (2014) studies the effects of binding collateral constraints on capital misallocation and aggregate productivity. Midrigan and Xu (2014) show that financial frictions mainly operate through the firm entry channel in their model. Gorodnichenko et al. (2018) stress the importance of firm characteristics in analysing misallocation of resources, an approach close to this paper.

Ultimately this paper is also linked to the literature on incomplete contracts and imperfect information where pledgeable collateral increases a firm's debt capacity, by resolving frictions due to moral hazard and adverse selection (Barro, 1976; Stiglitz and Weiss, 1981; Townsend, 1979; Holmstrom, 2015). Transfer of control theories of debt (Aghion and Bolton, 1992; Hart and Moore, 1998) imply that higher bargaining power for creditors to enforce contracts or seize control of assets ex post disciplines borrowers and leads to more credit at more favourable terms ex ante.

3.3 Data and descriptive statistics

To evaluate the impact of firm characteristics on zombie and non-zombie firms I exploit the rich cross-country, cross-sector CompNet dataset. Appendix 3.A gives additional information on dataset construction. This section provides definitions of the variables used, and presents some descriptive statistics.

3.3.1 Variables and definitions

The following sections provide definitions of the variables used.

Zombie firms

Zombies are defined as firms that have three consecutive years of negative profits, but do not have high growth rates (to avoid misclassifying as zombies rapidly growing young firms with negative profits during their investment ramp-up period).[12] Table 3.1 presents descriptive statistics of the share of zombie firms across two-digit sectors for the countries in the sample, for the period 2003-2015.

TABLE 3.1: Zombie Share by country

	Zombie Share			
	Mean	Count	Min	Max
Belgium	0.05	469	0.01	0.45
Croatia	0.11	630	0.03	0.45
Czechia	0.18	283	0.00	0.95
Denmark	0.03	598	0.00	0.29
Finland	0.06	713	0.01	0.30
France	0.11	448	0.02	0.60
Italy	0.07	606	0.01	0.31
Lithuania	0.17	662	0.02	0.76
Netherlands	0.10	626	0.03	0.40
Portugal	0.13	506	0.01	0.49
Romania	0.12	395	0.02	0.34
Slovenia	0.09	446	0.01	0.28
Spain	0.15	220	0.04	0.33
Sweden	0.08	476	0.01	0.45
All countries	0.10	7078	0.00	0.95
N	7078			

Notes: Zombies are defined as firms with three consecutive years of negative profits and low growth. Observations are sector/years. *Source*: CompNet.

Theoretically, zombies are defined as low productivity insolvent firms that should have exited but are kept in business because their lenders offer forbearance. The status of zombie is inherently unobservable, not only because the private valuations of existing loans to a firm or the subjective views of the bank on the prospects of that borrower are generally not available to the econometrician[13], but more fundamentally because the zombie concept is based on a counterfactual, i.e. firms that should have exited but they have not yet.

[12] Sorting firms using a priori conditions hypothesised to be associated with the phenomenon under consideration was popularised by Fazzari et al. (1987) and has become a standard approach in the corporate finance literature.

[13] Uniquely in the literature, Blattner et al. (2019) are able to exploit confidential information on supervisory misreporting of non-performing loans and obtain direct evidence of bank fraud and forbearance.

This conceptual ambiguity notwithstanding, the challenge is how to empirically identify zombies using publicly available information. Any proxy identification of zombies is faced with a trade-off between theoretical consistency on the one hand, and data availability and sample size on the other. There are, broadly speaking, two main approaches that the literature has applied to this question. The first approach, based on Caballero et al. (2008) and adopted by Acharya et al. (2019) in the European context, identifies zombies as firms that are perceived to have received credit at an unduly low interest rate. In these studies this is normally defined as firms with an estimated average interest rate on their borrowings that is below the interest rate applied to the most credit-worthy borrowers.

This approach is very data intensive, as it requires detailed information about the maturity schedule of a firm's debt, while taking into account the timing of intermediate payments, redemptions, and refinancings. Generally, there is little detailed public information about debt servicing schedules for private debt as this information is expensive to collect or often confidential in nature. The timing of the interest payments can play a significant role in the calculation of the comparator benchmarks, particularly in periods of rapidly falling interest rates, as the one characterising the recovery from the recent sovereign debt crisis. On the other hand, larger syndicated loan transactions that are traded in pubic secondary markets with better information disclosure are biased towards a much smaller sample of larger firms. Studies applying the implicit interest rate zombie identification approach tend therefore to use relatively small samples of large companies with publicly traded securities. Finally, while the implicit interest rate approach to the identification of zombie firms might be theoretically consistent it can nevertheless have counter-intuitive empirical implications. This method is akin to an asset pricing model where low interest costs predict a higher expected probability of default. There is a long literature linking interest rates to the probability of default, and in most cases lower interest rates imply lower ex ante default probability (Jarrow and Turnbull, 1995; Darrell and Singleton, 2003). The low interest rate approach pioneered by Caballero et al. (2008) identifies firms with exceptionally low interest rates but claim that these firms should have had high default and exit rates. This conclusion can only be supported with additional narrative evidence of corruption and fraud that the authors provide amply in the

case of Japan in the 1980s and 1990s, though they acknowledge the risk that this procedure might classify as zombies exceptionally well performing firms.

Given the practical difficulties of the first approach detailed above, an alternative second approach in identifying zombies uses performance outcomes as an indication of imminent exit. In a number of recent papers, researchers from the ECB and the OECD[14] use balance sheet operational characteristics in defining zombie firms. Typical metrics examined include profitability over several years, high leverage and financial distress, low interest coverage ratios, or combinations of these criteria. Generally, researchers take care to distinguish between poorly performing older firms and younger start-up firms still in the phase of investment ramp-up and the attendant negative cash-flows. One weakness of this approach conceptually, as Caballero et al. (2008) also point out, is that using profitability as the relevant criterion "hard-wires" the correlation between zombie congestion and poor industry performance. On the other hand, the profitability approach has the advantage of being more transparent and easier to estimate. This paper is using the latter type of definition but is aware of the conceptually weak ground the zombie firm phenomenon is based. Indeed, the major contribution of this paper will be to show that financial frictions operating through characteristics of firms can explain a large part of the underperformance of healthy firms in zombie infested industries without the need to assume non-economic/irrational motives on the part of the lending banks that the literature often relies on.

Collateral

The collateral variable is defined as the ratio of tangible fixed assets over total assets. This indicator is used as a proxy for tangibility, that is assets that can be relatively easily pledged as collateral. This measure of tangibility is of course quite coarse. There is a large literature studying the specificity of collateral to a particular firm or activity. Firm or activity specific assets increase the risk of collateral fire sales. Shleifer and Vishny (1992) show that if assets are specialized by industry this limits the potential number of buyers for liquidated collateral in a bankruptcy, and therefore

[14] Amongst other papers, this approach is used by Adalet McGowan et al. (2018), Storz et al. (2017), Schivardi et al. (2022), and Andrews and Petroulakis (2019).

lowers the expected recovery value of collateral in different industries. Less specific/-more generic collateral like real estate on the other hand is more easily liquidated potentially allowing for higher debt capacity.

Recovery rate indicator

I construct a country level index of loan recovery rates using information from the 2020 European Banking Authority report on national loan enforcement frameworks (European Banking Authority, 2020). The report documents loan recovery rates for defaulted loans that have completed the resolution process across all 27 European Union countries. I construct a continuous 0-100 index, but discretising the index in quintiles provided qualitatively similar results. I use this index to proxy the degree of creditor protection rights across the sample countries.

Productivity

Total factor productivity is estimated using a Cobb-Douglas specification, applying the control function approach of Olley Pakes to account for endogeneity, using the lagged values of employment as instruments (Wooldridge, 2009). Production functions are estimated using macro-sector level value added data.

3.3.2 Descriptive statistics

Table 3.2 provides descriptive statistics, split by pre- and post-crisis periods.

3.4 Analysis and Results

In this section I present the empirical analysis and results. First, section 3.4.1 presents the evidence on the relationship between collateral and leverage. Section 3.4.2 discusses zombie firms. Section 3.4.3 analyses the effects of the collateral channel on zombie congestion regressions and misallocation.

3.4.1 The dynamic relationship between collateral and leverage

In the first part of the paper, I analyse the relationship between collateral and leverage. Collateralised debt partially resolves information asymmetries and commitment

TABLE 3.2: Descriptive statistics

	Mean	25th pct	Median	75th pct	S.D.
	Panel A: Pre-crisis				
Non-zombie Firms					
Sales (,000)	9080.02	592.27	1680.35	7452.95	22005.29
Employment(Labour,fte)	36.88	4.15	11.26	30.92	79.33
Assets	2387.02	99.68	374.59	1296.09	7010.58
Labour Productivity	63.57	24.80	44.61	69.07	70.72
Total Factor Productivity	62.44	30.40	46.86	76.85	52.95
Collateral(% of assets)	0.29	0.12	0.25	0.42	0.22
Cash (% of assets)	0.15	0.03	0.09	0.21	0.17
Zombie Firms					
Sales	1995.39	188.06	1533.03	2752.42	3416.08
Employment(Labour,fte)	12.18	2.82	5.38	13.26	20.18
Assets (,000)	456.68	18.63	91.22	477.07	1034.68
Labour Productivity	19.00	7.47	17.83	27.63	27.26
Total Factor Productivity	22.21	9.99	18.13	26.51	18.75
Collateral(% of assets)	0.30	0.09	0.24	0.45	0.26
Cash (% of assets)	0.14	0.02	0.07	0.19	0.18
	Panel B: Post-crisis				
Non-zombie Firms					
Sales (,000)	9667.08	594.57	1479.97	8478.73	22465.02
Employment(Labour,fte)	30.12	2.89	8.33	23.38	70.58
Assets	2053.33	57.65	222.60	1448.08	6384.83
Labour Productivity	79.55	29.58	52.89	101.75	89.06
Total Factor Productivity	82.47	32.96	55.08	100.94	83.23
Collateral(% of assets)	0.28	0.09	0.22	0.42	0.23
Cash (% of assets)	0.15	0.03	0.09	0.21	0.17
Zombie Firms					
Sales (,000)	1704.27	476.79	735.00	1593.60	3439.10
Employment(Labour,fte)	10.54	2.05	5.06	11.50	18.61
Assets (,000)	568.32	37.86	138.06	520.47	1307.96
Labour Productivity	21.11	8.39	19.79	31.29	29.34
Total Factor Productivity	33.53	14.19	25.63	43.39	30.38
Collateral(% of assets)	0.30	0.10	0.24	0.46	0.28
Cash (% of assets)	0.14	0.02	0.06	0.19	0.18

problems. When entrepreneurs have more information than external investors about the real prospects of a project collateral mitigates the information asymmetry and facilitates funding. Collateral therefore increases debt capacity of a firm. Increased

tangibility[15] of firm assets raises the recovery value for lenders in case of restructuring or default. Empirically, a number of recent studies briefly surveyed in the literature section, use regulatory changes in the collateralisation rules to document the effects of collateral on leverage growth in many different country settings.

To demonstrate that debt and leverage growth are linked to available collateral in my setting I run the following regression, typical in the corporate finance literature:

$$\begin{aligned} LeverageGrowth_{c,s,t} = \; & \beta_1 Collateral_{c,s,t} + \beta_2 Productivity_{c,s,t} \\ & + \beta_3 Leverage_{c,s,t-1} + \gamma_{c,s} + \gamma_t + \varepsilon_{c,s,t} \end{aligned} \tag{3.1}$$

The dependent variable is the change of leverage in country c, sector s in year t. Leverage is defined as the ratio of total debt over total assets. The coefficient of interest β_1 captures the effect of balance sheet tangibility/collateral availability on the growth of firm leverage. I expect this coefficient to be positive . In the baseline specification, $\gamma_{c,s}$ and γ_t are country-sector and year fixed effects, so the identifying variation is between sectors across time. I also control for the initial levels of leverage and productivity, and cluster errors at the country-sector level.

In a second specification, I analyse the effects of stronger creditor protection. Davydenko and Franks (2008) show that in creditor-unfriendly legal systems banks require more collateral, limiting the borrowing capacity of debtors. To test this hypothesis I use an index of loan recovery rates in the countries in my sample. The index, discussed in the data section of the paper, is a proxy for the degree of creditor rights and effective creditor protection. While many studies codify legal provisions into "best practice" types of creditor rights indices, I take a more direct approach,

[15] Many studies in corporate finance and economics use net worth as the state variable that determines access to external finance. There are three reasons why using tangible assets rather than firm net worth as a measure of access to finance is preferable. First, net worth when calculated as the residual difference between assets and liabilities as is most often the case includes non-financial (operational) liabilities, that are of course not shareholders equity (see for example Welch (2011) for the bias induced by the inclusion of non-financial liabilities in the calculation of shareholder's net worth as a residual). Second, shareholders equity also reflects the value of assets that cannot be collateralised, notably intangibles like goodwill. On the other hand, tangible assets (of varying degree of specificity) can be pledged as collateral to a loan. I therefore use collateral as a more precise measure of access to credit. Third, using only asset tangibility breaks the link between productivity of a firm and debt growth. While net worth is a direct measure of expected productivity advantage of a firm, the degree of asset tangibility is not directly related to the superior performance of a firm. Rather it is productive use of these assets that is captured in a high net worth. However, debt, though of a put option on the assets of a firm, is not priced off/related to the growth prospects of the firm but rather based on the liquidation value of the collateral in bad states of the world. Therefore, a measure of available liquidity or security that a firm holds (i.e. tangible assets) is preferable to measures of its growth prospects (like shareholders net worth) when thinking of debt and leverage growth.

and use average loan recoveries for loans that have gone through liquidation. As this index is at the country level, I interact it with the collateral value. This specification therefore estimates the effect of collateral in countries with higher or lower degree of creditor protection. I therefore expect the estimated coefficient of the interaction of collateral and the recovery index to be positive and larger than the coefficient for collateral alone.

In a third specification, I run the following cross-country regression of multi-period credit growth on beginning of the period collateral and productivity values.

$$\begin{aligned} LeverageGrowth_{c,s} = \; & \beta_1 Collateral_{c,s} + \beta_2 Productivity_{2004,c,s} \\ & + \beta_3 Leverage_{2004,c,s} + \gamma_{c,s} + \varepsilon_{c,s} \end{aligned} \tag{3.2}$$

The dependent variable here is the three-year change in leverage between 2004 and 2007 which is regressed on the two year average collateral and average productivity for the 2003-2004 period. With this specification I aim to address concerns about reverse causality.

TABLE 3.1: Collateral and Leverage growth

	(1)	(2)	(3)
VARIABLES DepVar:*Leverage growth*			
Collateral	0.145**		
	(0.0652)		
Collateral*Recovery Rate		0.395***	
		(0.103)	
Collateral_2004			0.171***
			(0.0475)
Leverage	-1.251***	-1.246***	
	(0.0724)	(0.0744)	
Leverage_2004			-0.550***
			(0.0561)
TFP	0.0233***	0.0251***	
	(0.00685)	(0.00653)	
TFP_2004			0.0576***
			(0.0177)
Observations	7,930	7,591	503
R-squared	0.265	0.262	0.739
Country/Sector FE	Yes	Yes	No
Year FE	Yes	Yes	No
Country Sector FE	No	No	Yes
Cluster	sector#year	sector#year	

Notes: The dependent variable is firm leverage expressed as the ratio of total debt to total assets. *Collateral* is tangible assets as a percentage of total assets. *Recovery rate* is an index of recoveries for liquidated loans from European Banking Authority (2020). For cross-section model in column (3), beginning of the period values are marked by a 2004 subscript. ***/**/* denote significance at 1, 5 and 10 percent levels, respectively.

Results reported in Table 3.1 underline the role of asset tangibility in leverage growth. In column (1) the coefficient on the collateral variable is positive and statistically significant. This result replicates a standard finding of the optimal capital structure literature. The positive relationship between pledgeable assets and leverage is a robust stylised fact in this literature.

When collateral is interacted with the index of loan recovery rates in column (2) the effects is larger, indicating that in jurisdictions where creditor protection is higher, collateral plays a more important role in the allocation of credit and the determination of firm leverage. As will be shown in the following section, this ultimately leads to a

higher proportion of zombies, as collateral induces misallocation of leverage.

Finally, the cross-sectional model in column (3) shows that credit growth is related to the ex ante available tangible collateral. The collateral channel of leverage and misallocation can therefore have long term dynamic effects, a point that I will return in the following sections.

3.4.2 The relationship between collateral, leverage and zombies

In this section zombies are introduced to the analysis. Section 3.4.2 presents predictive regressions of zombie status, while section 3.4.2 presents regressions that predict zombie concentration at the sector level.

Zombie status prediction

Zombie firms exist as long as their debt in not called. The canonical zombie firm theory of Caballero et al. (2008) defines as zombie a non-viable firm receiving forbearance (or even additional loans) from its lenders. In the absence of long-term bankruptcy costs (like reputational costs of entrepreneurial failure), the equity owners of a firm hold the call on the firm's assets. As long as this call has a positive value the equity holders will want to prolong the life of a firm. Therefore, the survival of zombie firms depends on the willingness of external funders to provider refinancing to the firm.

As already discussed, there can be a positive causal relationship between firm debt (or more precisely leverage) and the probability of a firm being a zombie. The underlying assumption from the optimal capital structure literature is that firms optimally select their level of leverage (Auerbach, 1985; Fama and French, 2002; Flannery and Rangan, 2006), so causality goes from leverage variation to performance outcomes.[16] However, it is well understood that the relationship between leverage and economic performance is subject to reverse causality. For example, Chang and Dasgupta (2009) using simulated data show that we cannot reject the hypothesis that exogenously driven retained earnings variation (rather than firm characteristics)

[16]The two main competing capital structure theories are the pecking order theory (Donaldson, 1961; Shyam-Sunder and Myers, 1999) and the market timing theory (Baker and Wurgler, 2002).

predicts observed leverage ratios.[17] Myers (1984), formulating the modern version of the pecking order theory of corporate finance, argues that observed leverage ratios are driven by historical profitability, while the market timing view also claims that current capital structure is strongly related to historical equity market valuations. At the macro level, the main lesson from the seminal analysis of Reinhardt and Rogoff (2009) was indeed that the causality between debt and economic outcomes does not run from debt to economic crisis, but that a crisis causes debt burdens to increase.

In order to obtain independent variation in debt levels I instrument firm leverage by the tangibility of the firm's balance sheet. Collateral availability, proxied by ratio of tangible assets to firm total assets is a well-researched variable in the optimal capital structure literature. The results in the previous section justify the use of collateral as a plausible instrument for leverage in the rest of the paper. The strong positive relationship between balance sheet tangibility and leverage growth as shown in the previous section alleviates worries about weak instrument bias in this setting. On the other hand, balance sheet structure should not enter the structural equation when leverage is the variable of interest. The identifying assumption/exclusion restriction is that balance sheet tangibility is technologically determined, so pre-determined to the leverage selection.[18] Analogous to the idea of Rajan and Zingales (1998) that a firms' external financial dependence is technologically determined, Rampini and Viswanathan (2010) argue that the nature of assets required for production determines the type of financing, i.e. debt vs. equity. In other words, the causal effect of the asset tangibility on the zombie status is mediated through its impact on leverage, but not directly.

To test the relationship between zombie status of a firm and its balance sheet structure I closely follow the zombie literature (Andrews and Petroulakis, 2019; Schivardi et al., 2022). I estimate a firm-level Mincer-type model, for 14 countries and 54 2-digit sectors for the period 2003-2015 as follows:

[17]The authors show that in simulations, when earnings variation is determined by a coin toss, firm characteristics cannot predict leverage. This implies that in the actual data it is unclear if firm characteristics affect the debt ratio directly (as implied by the optimal capital structure view) or indirectly through their effect on performance, retained earnings, and financial deficits.

[18]Time fixed effects account for macroeconomic factors that affect the supply of credit given collateral, and therefore block the potential causal path between the outcome (zombie status) and the instrument.

$$Z_{i,c,s,t} = \beta_1 Leverage_{i,c,s,t} + \Theta' X_{i,c,s,t} + \gamma_{i,c,s,t} + \varepsilon_{i,c,s,t} \tag{3.3}$$

The dependent variable is a dummy that takes the value of one if firm i is identified as a zombie. Countries are indexed by c, sectors by s , and years by t. The leverage variable is defined as the ratio of total debt over total assets. In the vector of firm controls I include firm productivity and the cash reserves of the firm as a percentage of total assets. I include a comprehensive set of triple-interacted country/sector/year fixed effects to absorb any unobservable sector and country heterogeneity as well as any macro and sector shocks. Identification is therefore obtained by exploiting variation between firms within country/sector/years. Equation (3.3) is estimated with a linear probability model (OLS) given the large number of fixed effects and the well-known incidental parameters problem of non-linear (probit) estimators. Standard errors are clustered at the same country/sector/year level. The main coefficient of interest β_1 captures the effect of a firm's leverage on the probability that the firm is a zombie. I expect that this coefficient should be positive, as more levered firms are more susceptible to being a zombie.[19]

Table 3.2 presents the results of the estimation of the baseline probability model. I first present in columns (1)-(3) the OLS estimates for the whole sample, and the two sub-sample periods before and after 2008. I find that leverage positively predicts the zombie status of a firm, while the firm controls I employ (productivity and cash holdings[20]) have the expected negative coefficients. In columns (4)-(6) I present the IV estimate of the effect of leverage on the zombie status, using collateral as the

[19] While the specification above closely follows the literature econometrically it differs substantially in the explanatory variables used. Many studies in the current zombie literature answer the related question of who lends to zombies. To test the zombie lending hypothesis that weak(zombie) banks lend to zombie firms, these studies regress a zombie dummy on characteristics of the lending bank. In these types of research design the focus is mainly on the capital adequacy of the lending bank (Schivardi et al., 2022), previous lending to the firm (Peek and Rosengren, 2005), or even balance sheet structure and vulnerabilities of the bank (di Patti and Sette, 2016). These models imply that it is credit supply that is driving the effect. The empirical challenge therefore to this kind of credit regressions is to account for firm credit demand. Usually a modified Khwaja and Mian (2008) specification is employed when firms borrow from more than one lender, with firm fixed effects accounting for demand. However, this identification strategy has the unintended consequence that it not only typically reduces the available sample size but more importantly it biases the sample towards larger firms with multiple banks, further exacerbating the sampling problem in some studies.

[20] The coefficient of firm cash holdings, not reported here for visual clarity, are large, negative, and statistically significant. This is stating the obvious fact that firms with large cash holdings cannot be considered zombies, that is loss-making firms starved for cash and saved by the credit from their banks. The pecking order theory of funding suggests that firms first use internal funds before turning to outside sources.

excluded instrument. This is a proxy of asset tangibility and is assumed that these assets can be used as collateral against bank borrowing.[21]

The coefficient for the whole sample and the post 2008 period are significant and larger that the OLS. Standard tests for instrument relevance strongly reject the null of weak instrument bias. The results for the pre 2008 model however show that the zombie mechanism is not as relevant (the coefficient is only significant at the 10% level). This is not surprising, as during this period the zombies were much less prevalent.

TABLE 3.2: Firm level predictive regressions

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
VARIABLES		OLS			IV: collateral		IV: Collateral
DepVar: Zombie dummy	Full sample	Pre 2008	Post 2008	Full sample	Pre 2008	Post 2008	Pre 2007 collateral
Leverage	1.390***	1.223***	1.391***	1.822***	8.879*	1.355***	1.899***
	(0.0983)	(0.176)	(0.0961)	(0.284)	(5.275)	(0.219)	(0.228)
Observations	5,998	810	5,188	7,726	1,752	5,974	4,400
R-squared	0.780	0.768	0.783	0.762	-1.041	0.784	0.761
Country/Sector/Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Cluster: Country/Sector/Year	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Cragg-Donald F stat				232.3	8.847	252.7	241.2
Kleibergen-Paap F stat				67.38	2.969	77.82	76.43
Kleibergen-Paap LM test p-value				0	0.0814	0	0

Notes: The dependent variable is a dummy that takes the value of one if the firm is classified as a zombie. Leverage is expressed as the ratio of total debt to total assets. In IV estimates in columns (4)-(6) leverage is instrumented by collateral, expressed as tangible assets as a percentage of total assets. ***/**/* denote significance at 1, 5 and 10 percent levels, respectively.

To further address the endogeneity issue, I also present in column (7) an IV estimate when leverage is instrumented by the (average) collateral in the pre-crisis period (2003-2007 in my data). This specification tries to address concerns about reverse causality. In a static one period model it is possible to argue that factors that determine the profitability and the viability of a firm also determine the selection of the production technology, and therefore the tangibility of the balance sheet. In a dynamic setting, when the collateral variable is predetermined by several years these concerns are less valid.[22].

[21] Of course, the degree to which an asset can be pledged as collateral varies to its capacity to be swiftly liquidated, its price volatility and economic risk, and its correlation to the credit risk of the borrower pledging this asset as collateral. There are active markets in collateral establishing a pecking order of usability, characterised amongst other things by the collateral "haircut" applied to each type of asset pledged. For the purposes of the analysis here, it is assumed that all tangible collateral is equally pledgeable, while intangible assets are not.

[22] Indeed, as discussed in the following section, while collateral can resolve financial frictions in static settings, in dynamic games it can be shown that collateral also imposes costs on both borrowers and lenders.

The results in column (7) show that, the coefficient is large, statistically significant and economically meaningful. A one percentage point increase in leverage increases the probability that the firm is a zombie by 1.89 pp. At an average zombie rate of close to 10% in the sample this means that the probability increases by just short of 20%. To put this in perspective, I compare this result with similar estimates of Andrews and Petroulakis (2019) who predict the zombie probability of a firm by using the health of its lending banks as predictor, a typical design strategy in the zombie literature (see also Schivardi et al., 2022; Storz et al., 2017). They find that a one standard deviation improvement in the health of the lending bank reduces the zombie probability by around 10% in their sample.

Table 3.3 separately presents results for manufacturing, the construction sector, and services. While the estimates are positive and significant for manufacturing and services, the model is mis-specified for the construction sector (as there is a weak instrument bias, indicated by the Kleibergen-Paap LM test p-value). One potential explanation might be that in the construction sector the product of the sector is often the collateral posted, e.g., residential dwellings in the case of real estate developers. When this might be the case the collateral cannot serve any more to insulate the lender from the underlying business prospects of the borrower, and counter-intuitively it might be less important in the lending decision.[23]

Sector level predictive regressions

Zombie congestion is arguably a sector level phenomenon. While the literature has focused on the bank-firm relationships when identifying zombies, the effects of zombies on competition are at the core of the zombie firms phenomenon. In this section therefore, I analyse the relationship between financial constraints and the prevalence of zombies at the sector level. The regression specification here is as follows:

$$ZombieShare_{c,s,t} = \beta_1 Leverage_{c,s,t} + \theta_1' X_{1i,c,s,t} + \theta_2' X_{2i,c,s,t} + \gamma_{c,s,t} + \varepsilon_{c,s,t} \quad (3.4)$$

[23] In standard asset pricing models it is the correlation between the credit risk of the borrower and the collateral posted that determines the value of a collateralised loan (repo).

TABLE 3.3: Zombie predictive regressions, sector level

	(1)	(2)	(3)
VARIABLES	IV: Pre 2007 Collateral		
DepVar:*Zombie Dummy*	Manufacturing	Construction	Services
Leverage	3.073***	-6.923	1.339***
	(0.510)	(8.435)	(0.280)
Observations	1,756	284	2,360
R-squared	0.628	-0.859	0.774
Country/Sector/Year FE	Yes	Yes	Yes
Cluster: Country/Sector/Year	Yes	Yes	Yes
Cragg-Donald F stat	74.65	1.763	156.5
Kleibergen-Paap F stat	24.20	1.036	52.69
Kleibergen-Paap LM test p-value	1.67e-06	0.330	0

Notes: The dependent variable is a dummy that takes the value of one if the firm is classified as a zombie. Leverage expressed as the ratio of total debt to total assets. Leverage is instrumented by collateral, expressed as tangible assets as a percentage of total assets. ***/**/* denote significance at 1, 5 and 10 percent levels, respectively.

Subscripts c , s, and t index countries, sectors, and years. The dependent variable is the ratio of capital assets sunk in zombie firms to the total assets in the sector. I include two sets of controls for firm and sector characteristics with corresponding parameters vectors θ_1 and θ_2 . Firm controls include productivity and cash holdings. Sector controls try to capture both the macroeconomic environment, like employment growth, as well as sector level characteristics. I therefore include as controls the sector job creation and destruction rates, the sector Herfindahl-Hirschman Index (HHI) of market concentration, and the productivity dispersion in the sector measured as the difference in productivity between the firms at the 90th and the 10th percentiles. I include interacted country-year fixed effects, accounting for common macro shocks and unobserved country heterogeneity, so identification is obtained by cross-sector variation at a point in time. The coefficient of interest β_1 is expected to have a positive sign. In an IV specification I use balance sheet tangibility as the excluded instrument.

TABLE 3.4: Sector zombie share

	(1)	(2)	(3)	(4)	(5)
VARIABLES	OLS	IV	IV Predetermined	Reduced form	Mediation analysis
DepVar:*Zombie Share*					
Leverage	0.148***	0.143***	0.131***		0.157***
	(0.0123)	(0.0278)	(0.0373)		(0.0146)
Collateral				0.0518***	0.00521
				(0.00851)	(0.00957)
Instrument		Collateral	Collateral pre-crisis	Reduced form	
Observations	4,337	4,337	3,988	4,454	4,454
R-squared	0.397	0.093	0.086	0.371	0.404
Firm controls	Yes	Yes	Yes	Yes	Yes
Sector controls	Yes	Yes	Yes	Yes	Yes
Counry/Year FE	Yes	Yes	Yes	Yes	Yes
Cragg-Donald F stat		863.6	479.8		
Kleibergen-Paap F stat		589.4	339.7		
Kleibergen-Paap LM test p-value		0	0		

Notes: The dependent variable is the ratio of capital assets sunk in zombie firms to the total assets in the sector. Leverage expressed as the ratio of total debt to total assets. Parameter vector θ_1 includes firm controls: productivity and cash holdings. Parameter vector θ_2 includes sector controls: sector job creation and destruction, the HH index of sector concentration, and sector productivity dispersion measured as the difference in productivity between the firms at the 90th and the 10th percentiles. In IV estimates the excluded instrument is asset tangibility expressed as tangible assets as a percentage of total assets. ***/**/* denote significance at 1, 5 and 10 percent levels, respectively.

Table 3.4 presents the analysis at the sector level. In column (1) I start by presenting the OLS estimate. In column (2), the IV estimate is shown, which current period collateral used as instrument, while in column (3) the pre-crisis collateral is used. In both cases the model is not mis-specified and the estimates are positive and statistically significant. In the next column (4) the reduced form is presented, and collateral is strongly positively correlated to the share of zombies in a sector.[24] In column (5), I provide additional evidence that the exclusion restriction is plausible. I run a Baron and Kenny (1986) type mediation analysis, where the excluded instrument is included in the structural equation. As argued by Baron and Kenny (1986) a null coefficient of the instrument implies that the effect of collateral in the zombie share is completely mediated by leverage. This suggest that there is no direct effect of collateral on the outcome of interest, strengthening the support for the validity of the instrumental strategy I employ.

[24] Almeida and Campello (2007) also use asset tangibility in regressions predicting firm credit constraints.

3.4.3 The real effects of zombie misallocation

Zombie congestion regressions

In the two previous sections the relationship between balance sheet tangibility, leverage, and zombie firms was analysed, showing that collateral availability is strongly predictive of zombie status. In this section I analyse the real effects of zombies and collateral availability through the prism of the zombie congestion literature. As presented in other parts of this paper, the literature on zombie firms has analysed negative spill-over effects that a high prevalence of zombie firms in a sector has on non-zombie firms. The canonical zombie congestion regressions of Caballero et al. (2008) for Japan, since replicated in a number of recent papers for Europe, estimates the effects of zombies on non-zombies. The first question to ask is what are the effects of zombie congestion on healthy firms. The standard empirical framework in the literature is the specification of Caballero et al. (2008), also followed by many studies analysing the recent experience of zombie lending in Europe such as Schivardi et al. (2022) and Adalet McGowan et al. (2018).

Specifically, the baseline regression is of the form:

$$\begin{aligned} Y_{i,c,s,t} = \; & \beta_1 NonZombie_{i,c,s,t} + \beta_2 NonZombie_{i,c,s,t} \\ & * ZombieCongestion_{c,s,t} + \theta' \, X_{i,c,s,t} + \gamma_{c,s,t} + \varepsilon_{c,s,t} \end{aligned} \tag{3.5}$$

Subscripts i, s, c, and t index firms, sectors, countries, and years as before. The dependent variable is a measure of firm performance, such as capital stock growth, or employment growth. The *NonZombie* variable is a dummy taking the value of one for healthy, non-zombie firms. The *ZombieCongestion* variable is the share of sector capital that is sunk in zombie firms. The coefficient of interest is β_2. This coefficient, usually referred to in the literature as the"zombie congestion effect" captures the spill-over effects of zombies on the performance of healthy firms relative to zombie firms. The model of Caballero et al. (2008) (see also Schivardi et al., 2022) predict that β_2 will be negative.[25]

[25]Several recent studies have proposed a related empirical strategy. They estimate a modified version of the misallocation model of Foster et al. (2016). These studies index firms by their relative productivity, rather than the more common in this literature binary zombie indicator. Results of such models in my dataset, as indeed in these studies, are qualitatively similar to the results reported here.

Motivated by the results of the predictive regressions, I introduce collateral as an additional explanatory variable. To the extent that balance sheet tangibility is predictive of the zombie status as shown in the previous sections, collateral should also enter in a model of the spill-over effects of zombies. The extent to which the collateral variable can account for the zombie congestion effect can be quantified by comparing the β_2 coefficient estimate from the full model including collateral with the estimate from a model that excludes this variable.

Equation (3.5) is estimated with a full set of interacted country, sector, and year fixed effects. In this way all unobserved time-invariant heterogeneity is removed, and any unspecified time-varying macro and sector shocks are accounted for. Identification is therefore obtained from the within sector variation across firms. There are two consequences of this demanding identification design. First, the effect of the sector level zombie congestion (i.e. the share of sector capital held by zombie firms) cannot be identified as it is absorbed by the sector fixed effects, and for this reason does not appear in the specification above. Second, the β_2 coefficient can only identify the *relative* effects on non-zombies (compared to zombies) but not the absolute effects.

The vector θ of firm controls include firm size measured by employment and firm sales growth. The inclusion of the sales growth tries to capture potential growth opportunities. A major challenge to zombie congestion regressions of the type I run here is to isolate zombie firm demand for credit. Sales growth is a standard proxy in investment equations in the corporate finance literature. In the context of the zombie firms literature, Caballero et al. (2008) argue for the inclusion of sales growth in an "accelerator" type specification when estimating investment growth equations.

The sign of the β_1 coefficient for the non-zombie dummy is a priori ambiguous. While most studies yield positive and occasionally statistically significant estimates, it is not clear from a theoretical perspective what the sign should be. On the one hand, the general equilibrium effects of modest zombie forbearance might lead to better absolute performance for non-zombies and a positive coefficient. However, it has been pointed out by Caballero et al. (2008) and others, that if the zombie distortions are particularly large then the performance of non-zombies might be affected in absolute terms and therefore the coefficient might even be negative. Following the literature,

I will not attempt to interpret the non-zombie coefficient here.[26]

Table 3.5 presents the results of the zombie congestion analysis. In the first column I replicate the main result from the zombie firms literature, the negative coefficient β_2 of the zombie congestion on the growth rate of capital of non-zombies relative to zombies, and in the second column, flowing the suggestion of Caballero et al. (2008), I add firm sales growth as a proxy of firm growth opportunities. The size of the estimated effects in my regressions is larger than typical results in the literature. This might be explained by the fact that this paper is using a much larger and more diverse sample of countries and sectors than the exiting literature, possibly lowering measurement error and reducing any attenuation bias.

In columns (3) and (4) of the table introduce my variable of interest, the amount of collateral held.[27] As shown in the previous section, this variable predicts the zombie status, so its inclusion in the zombie congestion regression allows for the estimation of the part of the congestion effect potentially attributable to this variable. Column (3) shows that indeed the collateral variable is related to a lower growth rate of capital of non-zombie firms. In the specification of column (4), when both the zombie congestion and the collateral variables are included together, the coefficient of the zombie congestion falls to -0.132, a fall of almost a third compared with the estimate of -0.18 in column (2). Following the logic of Andrews and Petroulakis (2019) I attribute this to the effects of collateral. Again, the collateral variable I introduce in the canonical zombie congestion regression framework seems to have considerable explanatory power.

The following three columns (5)-(7) repeat this analysis using the average collateral in the pre-crisis years (from the beginning of my sample in 2003 to 2007).[28] This measure of collateral is plausibly uncorrelated with current investment opportunities

[26] There is a current literature on the effects of corporate debt overhang on the economy. Generally, studies like Adrian et al. (2019), Tobias et al. (2018), or Giesecke et al. (2014) find little effect of corporate debt on the long-term fragility of the economy and the probability of infrequent but large loses. This general finding in the literature is in stark contrast with the effects of household lending booms, documented in Schularick and Taylor (2012) and Mian et al. (2017). If zombie congestion is a result of excess corporate lending to these firms, the zombie literature can be informative in analysing the effects of debt overhang.

[27] I present only a specification with the interaction of collateral with the non-zombie dummy. When I include the direct effects the results are unchanged. All additional results are available upon request.

[28] A recent example in the corporate finance literature that uses an similar empirical strategy would be Gan (2007).

that can confound the estimates. As shown in the previous section, pre-crisis collateral predicts the zombie status of a firm during the crisis period. Here the inclusion of the collateral channel in the estimation of spill-over effects on non-zombies, halves the estimate of the zombie congestion effect to 0.095 in column (6) from 0.18 in the baseline estimate in column (2). When in column (7) I estimate the model only for the post 2008 period the estimate of the zombie congestion is no longer statistically significant, while the effect of negative collateral on the allocation of resources is consistently negative.

TABLE 3.5: Zombie Congestion regressions

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
VARIABLES DepVar:*Capital Stock Growth*							
NonZombie	0.0767***	0.0719***	0.0712***	0.0845***	0.0796***	0.0894***	0.0871***
	(0.00485)	(0.00538)	(0.00410)	(0.00527)	(0.00418)	(0.00617)	(0.00680)
ZombieCongestion	-0.226***	-0.180***		-0.132***		-0.0952**	-0.0625
	(0.0352)	(0.0376)		(0.0331)		(0.0424)	(0.0426)
Size	-0.0220***	-0.0252***	-0.0273***	-0.0300***	-0.0218***	-0.0258***	-0.0334***
	(0.00470)	(0.00469)	(0.00457)	(0.00448)	(0.00593)	(0.00597)	(0.00565)
SalesGrowth		0.000698***	0.000806***	0.000816***	0.00104***	0.00103***	0.00109***
		(0.000236)	(0.000262)	(0.000214)	(0.000217)	(0.000228)	(0.000147)
NZ*Collateral			-0.0892***	-0.0801***			
			(0.00944)	(0.00936)			
NZ*Collateral_PRE_2007					-0.112***	-0.106***	-0.105***
					(0.0117)	(0.0116)	(0.0123)
Constant	0.103***	0.102***	0.108***	0.106***	0.117***	0.118***	0.122***
	(0.00449)	(0.00441)	(0.00435)	(0.00428)	(0.00665)	(0.00653)	(0.00589)
Observations	4,084	3,002	3,136	2,996	2,326	2,226	1,846
R-squared	0.985	0.986	0.986	0.987	0.986	0.987	0.987
Country/Sector/Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Notes: The dependent variable is firm capital stock growth. *NonZombie* is a dummy taking the value of one for healthy, non-zombie firms. *ZombieCongestion* is the share of sector capital that is sunk in zombie firms. *Size* in measured by full time equivalent firm employment. Collateral is expressed as the ratio of tangible assets to total assets. ***/**/* denote significance at 1, 5 and 10 percent levels, respectively.

In Table 3.5, I only present results for capital growth. Specifications with employment growth as the outcome variable did not produce statistically significant estimates on my dataset, and in some case the estimates even had the wrong sign. This is not particularly surprising as generally in the literature the spill-over effect of zombies on non-zombie employment is quite often marginal. For example, in the case of Japan, Caballero et al. (2008), controlling for sales growth as a proxy of the firm's prospects, find a non-significant coefficient in the labour growth equation (column (8) of their Table 3). Gouveia and Osterhold (2018) also fail to find any zombie congestion effects in the labor market. The fact that zombie congestion does not seem to have a significant negative impact on sector employment points to positive

general equilibrium effects. As zombie survival supports employment in zombie firms, non-zombie firms do not contract their own labour force.

3.5 Conclusion

This paper analyses the zombie firms phenomenon in Europe through the lens of a collateral misallocation channel. I first replicate the well documented result in the corporate finance literature of the relationship between asset tangibility and firm financial structure and showed that zombie firms have generally more collateral than non-zombies. I then show that this collateral channel explains almost half of the zombie congestion effect in the literature. Similar to the Gopinath et al. (2017) analysis, I interpret these results as implying that credit misallocation *before* the Global Financial Crisis is an alternative and complementary view to the bank forbearance/perverse incentives view of zombie firms.

Although by no means a comprehensive answer to the causes and effects of zombie firms, the results in this paper point to a collateral channel with distinct policy implications. The zombie lending theory of Caballero et al. (2008) underlines the need for a swift and decisive re-capitalisation of weak banks, while a number of studies from OECD researchers cited in this paper point to the importance of structural reforms. The analysis in this paper highlights the effect of sub-optimal allocation of financial resources when bank debt is the dominant financing instrument and questions the possibly excessive reliance on debt rather than equity financing. As intangible assets become increasingly important, if not already predominant, in the modern economy, and to the extend that low interest rates persist and dull the tax advantage of debt, new financing instruments that are less reliant on collateralised tangible assets might provide more stable financing for new and innovative activities.

Appendix

3.A CompNet database

The main source of data in this study is the CompNet firm database developed by the Competitiveness Research Network, a research and policy analysis hub founded by the European Central Bank, other members of the European System of Central Banks (Euro-system), and other European institutions such as the European Commission and the European Bank for Reconstruction and Development . The database contains information on non-financial private sector firms from14 European countries , covering manufacturing, construction, and the service sectors.

The database is constructed following the "distributed micro-data analysis" approach of Bartelsman et al. (2004). Firm-level balance sheet, operational, and performance data are collected and maintained by national statistical agencies or central banks in relevant business registries, fiscal or other administrative databases. A common statistical code developed by CompNet is implemented by participating national authorities to consistently standardise, aggregate, and report the data at a country-sector-year level. Compared to Eurostat's Structural Business Statistics the CompNet dataset is highly representative of the underlying population of firms. Re-weighting procedures were applied to produce a distribution of employment and output that tracks well population counterparts. While some differences remain in the coverage of very large firms, compared to commercial datasets of large, listed and private companies CompNet allows for detailed analysis of all firm size-classes. The cross country, cross sector scope of the dataset makes CompNet well suited to for this study. Recent literature using confidential credit registry data has been restricted to single country cases, like Schivardi et al. (2022) for Italy and Blattner et al. (2019) for Portugal, while studies using commercial databases tend to have relatively small sample sizes of relatively large firms (around 2500 in Caballero et al. (2008) and

around 1000 in Acharya et al. (2019)). The under-representation of very large firms in CompNet notwithstanding, the dataset used in this study is to my knowledge the most comprehensive in the literature in terms of country and size-class coverage.

There are three distinguishing features of the data that make the CompNet database unique in scope and depth of information. First, for each country-sector-year "cell" information is provided not only for the aggregate values, but also for the variance, skewness and kurtosis of the distribution of the underlying firms, along with the median and other commonly used percentiles. Second, information on the joint distributions of various of the firm's characteristic is provided. For example, distributions across size-classes, or percentiles of the productivity distribution of the underlying firms are provided, where the aggregation is at the country/sector/year/size-class level (or productivity distribution percentile).

Finally, taking advantage of the very large samples sizes in the underlying data, CompNet provides estimated production functions (at various levels of aggregation and for multiple functional forms), commonly used productivity decompositions and dispersion estimates, and estimates of allocative efficiency. Importantly for this study, CompNet provides dummy indicators for zombie firms and estimates conditional distributions of firm characteristics for zombie and non-zombie firms.

3.B Descriptive statistics

TABLE 3.B.1: Descriptive statistics

	Mean	25th pct	Median	75th pct	S.D.
	Panel A: Pre-crisis				
Non-zombie Firms					
Sales (,000)	9080.02	592.27	1680.35	7452.95	22005.29
Employment(Labour,fte)	36.88	4.15	11.26	30.92	79.33
Assets	2387.02	99.68	374.59	1296.09	7010.58
Labour Productivity	63.57	24.80	44.61	69.07	70.72
Total Factor Productivity	62.44	30.40	46.86	76.85	52.95
Collateral(% of assets)	0.29	0.12	0.25	0.42	0.22
Cash (% of assets)	0.15	0.03	0.09	0.21	0.17
Zombie Firms					
Sales	1995.39	188.06	1533.03	2752.42	3416.08
Employment(Labour,fte)	12.18	2.82	5.38	13.26	20.18
Assets (,000)	456.68	18.63	91.22	477.07	1034.68
Labour Productivity	19.00	7.47	17.83	27.63	27.26
Total Factor Productivity	22.21	9.99	18.13	26.51	18.75
Collateral(% of assets)	0.30	0.09	0.24	0.45	0.26
Cash (% of assets)	0.14	0.02	0.07	0.19	0.18
	Panel B: Post-crisis				
Non-zombie Firms					
Sales (,000)	9667.08	594.57	1479.97	8478.73	22465.02
Employment(Labour,fte)	30.12	2.89	8.33	23.38	70.58
Assets	2053.33	57.65	222.60	1448.08	6384.83
Labour Productivity	79.55	29.58	52.89	101.75	89.06
Total Factor Productivity	82.47	32.96	55.08	100.94	83.23
Collateral(% of assets)	0.28	0.09	0.22	0.42	0.23
Cash (% of assets)	0.15	0.03	0.09	0.21	0.17
Zombie Firms					
Sales (,000)	1704.27	476.79	735.00	1593.60	3439.10
Employment(Labour,fte)	10.54	2.05	5.06	11.50	18.61
Assets (,000)	568.32	37.86	138.06	520.47	1307.96
Labour Productivity	21.11	8.39	19.79	31.29	29.34
Total Factor Productivity	33.53	14.19	25.63	43.39	30.38
Collateral(% of assets)	0.30	0.10	0.24	0.46	0.28
Cash (% of assets)	0.14	0.02	0.06	0.19	0.18

Bibliography

Abbas, S., N. Belhocine, A. A. ElGanainy, and M. Horton (2010). A historical public debt database. *IMF Working Papers*, 1–26.

Acemoglu, D., S. Johnson, P. Querubin, and J. A. Robinson (2008). When does policy reform work? the case of central bank independence. *Brookings Papers on Economic Activity 2008*(1), 351–418.

Acemoglu, D., S. Naidu, P. Restrepo, and J. A. Robinson (2019). Democracy does cause growth. *Journal of political economy 127*(1), 47–100.

Acharya, V. V., Y. Amihud, and L. Litov (2011). Creditor rights and corporate risk-taking. *Journal of Financial Economics 102*(1), 150–166.

Acharya, V. V., T. Eisert, C. Eufinger, and C. Hirsch (2019). Whatever it takes: The real effects of unconventional monetary policy. *The Review of Financial Studies 32*(9), 3366–3411.

Adalet McGowan, M., D. Andrews, and V. Millot (2018). The walking dead? zombie firms and productivity performance in oecd countries. *Economic Policy 33*(96), 685–736.

Admati, A. R., P. M. DeMarzo, M. F. Hellwig, and P. Pfleiderer (2018). The leverage ratchet effect. *The Journal of Finance 73*(1), 145–198.

Adrian, M. T., C. J. Erceg, M. S. T. Gray, and M. R. Sahay (2021). *Asset purchases and direct financing: Guiding principles for emerging markets and developing economies during COVID-19 and beyond*. International Monetary Fund.

Adrian, T., N. Boyarchenko, and D. Giannone (2019). Vulnerable growth. *American Economic Review 109*(4), 1263–89.

Aghion, P. and P. Bolton (1992). An incomplete contracts approach to financial contracting. *The review of economic Studies 59*(3), 473–494.

Alesina, A. and L. H. Summers (1993). Central bank independence and macroeconomic performance: Some comparative evidence. *Journal of Money, Credit and Banking 25*(2), 151–162.

Alloza, M., J. Gonzalo, and C. Sanz (2020). Dynamic effects of persistent shocks. *arXiv preprint arXiv:2006.14047*.

Almeida, H. and M. Campello (2007). Financial constraints, asset tangibility, and corporate investment. *The Review of Financial Studies 20*(5), 1429–1460.

Alpanda, S. and A. Honig (2009). The impact of central bank independence on political monetary cycles in advanced and developing nations. *Journal of Money, Credit and Banking 41*(7), 1365–1389.

Andrews, D., M. A. McGowan, and V. Millot (2017). Confronting the zombies: Policies for productivity revival.

Andrews, D. and F. Petroulakis (2019). Breaking the shackles: Zombie firms, weak banks and depressed restructuring in europe.

Aretz, K., M. Campello, and M.-T. Marchica (2020). Access to collateral and the democratization of credit: France's reform of the napoleonic security code. *The Journal of Finance 75*(1), 45–90.

Arnone, M. and D. Romelli (2013). Dynamic central bank independence indices and inflation rate: A new empirical exploration. *Journal of Financial Stability 9*(3), 385–398.

Assunçao, J. J., E. Benmelech, and F. S. Silva (2014). Repossession and the democratization of credit. *The Review of Financial Studies 27*(9), 2661–2689.

Athanasopoulos, A., D. Masciandaro, and D. Romelli (2023). Inflation: persistence and central bank independence. *mimeo*.

Auerbach, A. J. (1985). Real determinants of corporate leverage. In *Corporate capital structures in the United States*, pp. 301–324. University of Chicago Press.

Auerbach, A. J. and Y. Gorodnichenko (2012). Measuring the output responses to fiscal policy. *American Economic Journal: Economic Policy 4*(2), 1–27.

Bagehot, W. (1873). *Lombard street*. King.

Baker, M. and J. Wurgler (2002). Market timing and capital structure. *The journal of finance 57*(1), 1–32.

Ball, L. (1995). Disinflation with imperfect credibility. *Journal of Monetary economics 35*(1), 5–23.

Ball, L. M. and N. Sheridan (2004). Does inflation targeting matter? In *The inflation-targeting debate*, pp. 249–282. University of Chicago Press.

Balls, E., J. Howat, and A. Stansbury (2018). Central bank independence revisited: After the financial crisis, what should. *Harvard Kennedy School M-RCBG Associate Working Paper No. 67*.

Banks, A. S. and K. A. Wilson (2021). Cross-national time-series data archive. databanks international. *Jerusalem, Israel. see https://www.cntsdata.com/*.

Baron, R. M. and D. A. Kenny (1986). The moderator–mediator variable distinction in social psychological research: Conceptual, strategic, and statistical considerations. *Journal of personality and social psychology 51*(6), 1173.

Barro, R. J. (1976). The loan market, collateral, and rates of interest. *Journal of money, Credit and banking 8*(4), 439–456.

Barro, R. J. (1979). On the determination of the public debt. *Journal of political Economy 87*(5, Part 1), 940–971.

Barro, R. J. and D. B. Gordon (1983a). A positive theory of monetary policy in a natural-rate model. *National Bureau of Economic Research Working Paper Series 91*(4), 589–610.

Barro, R. J. and D. B. Gordon (1983b). A positive theory of monetary policy in a natural rate model. *Journal of political economy 91*(4), 589–610.

Bartelsman, E. J., J. Haltiwanger, and S. Scarpetta (2004). Microeconomic evidence of creative destruction in industrial and developing countries. *Available at SSRN 612230*.

Beck, N. and J. N. Katz (2011). Modeling dynamics in time-series–cross-section political economy data. *Annual review of political science 14*, 331–352.

Beck, T., H. Degryse, R. De Haas, and N. Van Horen (2018). When arm's length is too far: Relationship banking over the credit cycle. *Journal of Financial Economics 127*(1), 174–196.

Benati, L. (2008). Investigating inflation persistence across monetary regimes. *The Quarterly Journal of Economics 123*(3), 1005–1060.

Benati, L. and P. Surico (2008). Evolving us monetary policy and the decline of inflation predictability. *Journal of the European Economic Association 6*(2-3), 634–646.

Benmelech, E., N. Kumar, and R. Rajan (2020). The decline of secured debt. Technical report, National Bureau of Economic Research.

Bernanke, B. and M. Gertler (1989). Agency costs, collateral, and business cycle fluctuations. *American Economic Review 79*, 14–31.

Bernhardt, D., K. Koufopoulos, and G. Trigilia (2021). The pitfalls of pledgeable cash flows: soft budget constraints, zombie lending and under-investment. *Zombie Lending and Under-Investment (January 4, 2021)*.

Binder, C. C. (2021). Political pressure on central banks. *Journal of Money, Credit and Banking 53*(4), 715–744.

Blanchard, O. (2018). Should we reject the natural rate hypothesis? *Journal of Economic Perspectives 32*(1), 97–120.

Blanchard, O. (2019). Public debt and low interest rates. *American Economic Review 109*(4), 1197–1229.

Blanchard, O. and J. Pisani-Ferry (2020). Monetisation: Do not panic. *VoxEU. org 10*.

Blattner, L., L. Farinha, and F. Rebelo (2019). When losses turn into loans: The cost of undercapitalized banks.

Bodea, C. (2013). Independent central banks, regime type, and fiscal performance: the case of post-communist countries. *Public Choice 155*, 81–107.

Bodea, C. and R. Hicks (2015a). International finance and central bank independence: Institutional diffusion and the flow and cost of capital. *The Journal of Politics 77*(1), pp. 268–284.

Bodea, C. and R. Hicks (2015b). Price stability and central bank independence: Discipline, credibility, and democratic institutions. *International Organization 69*(01), 35–61.

Bodea, C. and M. Higashijima (2017). Central bank independence and fiscal policy: Can the central bank restrain deficit spending? *British Journal of Political Science 47*(1), 47–70.

Bohn, H. (1998). The behavior of us public debt and deficits. *the Quarterly Journal of economics 113*(3), 949–963.

Bordo, M. D. and P. L. Siklos (2015). Central bank credibility: An historical and quantitative exploration. Working Paper 20824, National Bureau of Economic Research.

Born, B. and J. Breitung (2016). Testing for serial correlation in fixed-effects panel data models. *Econometric Reviews 35*(7), 1290–1316.

Brunnermeier, M. K., S. A. Merkel, and Y. Sannikov (2020). Debt as safe asset: Mining the bubble. *Princeton University work in progress*.

Buiter, W. H. (1985). A guide to public sector debt and deficits. *Economic policy 1*(1), 13–61.

Caballero, R. J., T. Hoshi, and A. K. Kashyap (2008). Zombie lending and depressed restructuring in japan. *American economic review 98*(5), 1943–1977.

Calvo, G. A. (1988). Servicing the public debt: The role of expectations. *The American Economic Review*, 647–661.

Carli, G. and P. Peluffo (1993). *Cinquant'anni di vita italiana*. Laterza Rome.

Chaney, T., D. Sraer, and D. Thesmar (2012). The collateral channel: How real estate shocks affect corporate investment. *American Economic Review 102*(6), 2381–2409.

Chang, X. and S. Dasgupta (2009). Target behavior and financing: how conclusive is the evidence? *The Journal of Finance 64*(4), 1767–1796.

Cheibub, J. A., J. Gandhi, and J. R. Vreeland (2010). Democracy and dictatorship revisited. *Public choice*, 67–101.

Chinn, M. D. and H. Ito (2008). A new measure of financial openness. *Journal of Comparative Policy Analysis 10*(3), 309–322.

CNBC (2022). Boris johnson's likely successor wants to review the bank of england's mandate. and some are worried. *CNBC*.

Cottarelli, C. (1993). Limiting central bank credit to the government: theory and practice. In *Limiting Central Bank Credit to the Government*. International Monetary Fund.

Crosignani, M., M. Faria-e Castro, and L. Fonseca (2020). The (unintended?) consequences of the largest liquidity injection ever. *Journal of Monetary Economics 112*, 97–112.

Crowe, C. and E. E. Meade (2008). Central bank independence and transparency: Evolution and effectiveness. *European Journal of Political Economy 24*(4), 763–777.

Cukierman, A. (1992). *Central Bank Strategy, Credibility, and Independence: Theory and Evidence*. The MIT Press.

Cukierman, A. and A. H. Meltzer (1986). A theory of ambiguity, credibility, and inflation under discretion and asymmetric information. *Econometrica: journal of the econometric society*, 1099–1128.

Cukierman, A., S. B. Webb, and B. Neyapti (1992). Measuring the independence of central banks and its effect on policy outcomes. *The World Bank Economic Review 6*(3), 353–398.

Culver, S. E. and D. H. Papell (1997). Is there a unit root in the inflation rate? evidence from sequential break and panel data models. *Journal of Applied Econometrics 12*(4), 435–444.

Darrell, D. and K. J. Singleton (2003). *Credit risk: Pricing, measurement, and management*. Princeton University Press.

Davydenko, S. A. and J. R. Franks (2008). Do bankruptcy codes matter? a study of defaults in france, germany, and the uk. *The Journal of Finance 63*(2), 565–608.

De Boef, S. and L. Keele (2008). Taking time seriously. *American journal of political science 52*(1), 184–200.

de Haan, J. and R. Wiese (2022). The impact of product and labour market reform on growth: Evidence for oecd countries based on local projections. *Journal of Applied Econometrics*.

Demarzo, P. M. (2019). Presidential address: Collateral and commitment. *The Journal of Finance 74*(4), 1587–1619.

Dewatripont, M. and E. Maskin (1995). Credit and efficiency in centralized and decentralized economies. *The Review of Economic Studies 62*(4), 541–555.

di Patti, E. B. and E. Sette (2016). Did the securitization market freeze affect bank lending during the financial crisis? evidence from a credit register. *Journal of Financial Intermediation 25*, 54–76.

Dincer, N. N. and B. Eichengreen (2008). Central bank transparency: where, why, and with what effects. *Central Banks and Economic Institutions, Cheltenham, Elgar*, 105–30.

Dincer, N. N. and B. Eichengreen (2014). Central Bank Transparency and Independence: Updates and New Measures. *International Journal of Central Banking 10*(1), 189–259.

Donaldson, G. (1961). *Corporate debt capacity: A study of corporate debt policy and the determination of corporate debt capacity.* Harvard Graduate School of Management, Boston, MA.

Donaldson, J. R., D. Gromb, and G. Piacentino (2020). The paradox of pledgeability. *Journal of Financial Economics 137*(3), 591–605.

Driscoll, J. C. and A. C. Kraay (1998). Consistent covariance matrix estimation with spatially dependent panel data. *Review of economics and statistics 80*(4), 549–560.

Du, W., C. E. Pflueger, and J. Schreger (2020). Sovereign debt portfolios, bond risks, and the credibility of monetary policy. *The Journal of Finance 75*(6), 3097–3138.

Eijffinger, S. and J. de Haan (1996). The political economy of central-bank independence. *International Finance 19*(19), 1–92.

Erceg, C. J. and A. T. Levin (2003). Imperfect credibility and inflation persistence. *Journal of monetary economics 50*(4), 915–944.

European Banking Authority (2020). Report on benchmarking of national insolvency frameworks across the european union. *EBA*.

Fama, E. F. and K. R. French (2002). Testing trade-off and pecking order predictions about dividends and debt. *Review of financial studies*, 1–33.

Farhi, E. and M. Maggiori (2018). A model of the international monetary system. *The Quarterly Journal of Economics 133*(1), 295–355.

Fazzari, S., R. G. Hubbard, and B. C. Petersen (1987). Financing constraints and corporate investment.

Financial Times (2022). A political backlash against monetary policy is looming. *Financial Times*.

Flannery, M. J. and K. P. Rangan (2006). Partial adjustment toward target capital structures. *Journal of financial economics 79*(3), 469–506.

Foster, L., C. Grim, and J. Haltiwanger (2016). Reallocation in the great recession: cleansing or not? *Journal of Labor Economics 34*(S1), S293–S331.

Frankel, J. A., C. A. Vegh, and G. Vuletin (2013). On graduation from fiscal procyclicality. *Journal of Development Economics 100*(1), 32–47.

Fuhrer, J. C. (2010). Inflation persistence. In *Handbook of monetary economics*, Volume 3, pp. 423–486. Elsevier.

Galí, J. (2020a). The effects of a money-financed fiscal stimulus. *Journal of Monetary Economics 115*, 1–19.

Galí, J. (2020b). Helicopter money: The time is now. *Mitigating the COVID Economic Crisis: Act Fast and Do Whatever 31*, 31–39.

Gan, J. (2007). Collateral, debt capacity, and corporate investment: Evidence from a natural experiment. *Journal of Financial Economics 85*(3), 709–734.

Garriga, A. C. and C. M. Rodriguez (2020). More effective than we thought: Central bank independence and inflation in developing countries. *Economic Modelling 85*, 87–105.

Ghosh, A. R., J. I. Kim, E. G. Mendoza, J. D. Ostry, and M. S. Qureshi (2013). Fiscal fatigue, fiscal space and debt sustainability in advanced economies. *The Economic Journal 123*(566), F4–F30.

Giannetti, M. and F. Saidi (2019). Shock propagation and banking structure. *The Review of Financial Studies 32*(7), 2499–2540.

Giesecke, K., F. A. Longstaff, S. Schaefer, and I. A. Strebulaev (2014). Macroeconomic effects of corporate default crisis: A long-term perspective. *Journal of Financial Economics 111*(2), 297–310.

Gokmen, G., T. Nannicini, M. Gaetano Onorato, and C. Papageorgiou (2021). Policies in hard times: assessing the impact of financial crises on structural reforms. *The Economic Journal 131*(638), 2529–2552.

Gopinath, G., Ş. Kalemli-Özcan, L. Karabarbounis, and C. Villegas-Sanchez (2017). Capital allocation and productivity in south europe. *The Quarterly Journal of Economics 132*(4), 1915–1967.

Gorodnichenko, Y., D. Revoltella, J. Svejnar, and C. T. Weiss (2018). Resource misallocation in european firms: The role of constraints, firm characteristics and managerial decisions. Technical report, National Bureau of Economic Research.

Gouveia, A. F. and C. Osterhold (2018). Fear the walking dead: zombie firms, spillovers and exit barriers.

Greene, W. H. (2000). 000. econometric analysis.

Grilli, V., D. Masciandaro, and G. Tabellini (1991). Political and monetary institutions and public financial policies in the industrial countries. *Economic Policy 6*(13), 342–392.

Haldane, A. (2020). What has central bank independence ever done for us? In *Discurso pronunciado ante la UCL Economistsâ Society Economic Conference, Londres. Disponible en https://bit. ly/3JdBdTZ*.

Hart, O. and J. Moore (1998). Default and renegotiation: A dynamic model of debt. *The Quarterly journal of economics 113*(1), 1–41.

Hawtrey, R. G. (1970). *The art of central banking*. Psychology Press.

Hendry, D. F. and G. E. Mizon (1978). Serial correlation as a convenient simplification, not a nuisance: A comment on a study of the demand for money by the bank of england. *The Economic Journal 88*(351), 549–563.

Holmstrom, B. (2015). Understanding the role of debt in the financial system.

Hooley, J., L. Nguyen, M. Saito, and S. Nikaein Towfighian (2021). Fiscal dominance in sub-saharan africa revisited.

Hoshi, T. (2006). Economics of the living dead. *The Japanese Economic Review 57*(1), 30–49.

Ilzetzki, E., C. M. Reinhart, and K. S. Rogoff (2019). Exchange arrangements entering the twenty-first century: Which anchor will hold? *The Quarterly Journal of Economics 134*(2), 599–646.

Im, K. S., M. H. Pesaran, and Y. Shin (2003). Testing for unit roots in heterogeneous panels. *Journal of econometrics 115*(1), 53–74.

Imbens, G. W. (2004). Nonparametric estimation of average treatment effects under exogeneity: A review. *Review of Economics and statistics 86*(1), 4–29.

IMF (2013). Note for public debt sustainability analysis in market access countries.

Ioannidou, V., S. Kokas, T. Lambert, and A. Michaelides (2023). (in) dependent central banks. *CEPR Press Discussion Paper No. 17802*.

Jacome, L. and F. Vazquez (2008). Is there any link between legal central bank independence and inflation? evidence from latin america and the caribbean. *European Journal of Political Economy 24*(4), 788–801.

Jacome, L. I. and S. Pienknagura (2022a). Central bank independence and inflation in latin america – through the lens of history. IMF Working Papers 2022/186.

Jacome, L. I. and S. Pienknagura (2022b). Central bank independence and inflation in latin americaâthrough the lens of history.

Jácome, M. L. I., M. M. Matamoros-Indorf, M. M. Sharma, and M. S. Townsend (2012). *Central Bank credit to the government: what can we learn from international practices?* International Monetary Fund.

Jarrow, R. A. and S. M. Turnbull (1995). Pricing derivatives on financial securities subject to credit risk. *The journal of finance 50*(1), 53–85.

Jaskowski, M. (2015). Should zombie lending always be prevented? *International Review of Economics & Finance 40*, 191–203.

Jensen, M. C. and W. H. Meckling (1976). Theory of the firm: Managerial behavior, agency costs and ownership structure. *Journal of financial economics 3*(4), 305–360.

Jorda, O. (2005). Estimation and inference of impulse responses by local projections. *American Economic Review 95(1)*, 161–182.

Jordà, Ò. and A. M. Taylor (2016). The time for austerity: estimating the average treatment effect of fiscal policy. *The Economic Journal 126*(590), 219–255.

Jordan, T. (2022). Current challenges to central banks' independence. *Annual O John Olcay Lecture on Ethics and Economics at the Peterson Institute, Washington DC, 11 October 2022*.

Judson, R. A. and A. L. Owen (1999). Estimating dynamic panel data models: a guide for macroeconomists. *Economics letters 65*(1), 9–15.

Khwaja, A. I. and A. Mian (2008). Tracing the impact of bank liquidity shocks: Evidence from an emerging market. *American Economic Review 98*(4), 1413–1442.

King, M. (2003). Speech at the east midlands development agency/bank of england dinner.

Kirti, D. (2017). *When gambling for resurrection is too risky*. International Monetary Fund.

Kleibergen, F. and R. Paap (2006). Generalized reduced rank tests using the singular value decomposition. *Journal of econometrics 133*(1), 97–126.

Kline, P. (2011). Oaxaca-blinder as a reweighting estimator. *American Economic Review 101*(3), 532–37.

Klomp, J. and J. De Haan (2009). Central bank independence and financial instability. *Journal of Financial Stability 5*(4), 321–338.

Klomp, J. and J. De Haan (2010). Inflation and central bank independence: A meta-regression analysis. *Journal of Economic Surveys 24*(4), 593–621.

Kornai, J. (1986). The soft budget constraint. *Kyklos 39*(1), 3–30.

Kydland, F. E. and E. C. Prescott (1977). Rules rather than discretion: The inconsistency of optimal plans. *Journal of Political Economy 85*(3), 473.

Laeven, L. and F. Valencia (2012). Systemic banking crises database: An update. IMF Working Papers 12/163, International Monetary Fund.

Leeper, E. M. (1991). Equilibria under âactiveâand âpassiveâmonetary and fiscal policies. *Journal of monetary Economics 27*(1), 129–147.

Levin, A., C.-F. Lin, and C.-S. J. Chu (2002). Unit root tests in panel data: asymptotic and finite-sample properties. *Journal of econometrics 108*(1), 1–24.

Lilienfeld-Toal, U. v., D. Mookherjee, and S. Visaria (2012). The distributive impact of reforms in credit enforcement: Evidence from indian debt recovery tribunals. *Econometrica 80*(2), 497–558.

Lorenzoni, G. and I. Werning (2019). Slow moving debt crises. *American Economic Review 109*(9), 3229–3263.

Maddala, G. S. and S. Wu (1999). A comparative study of unit root tests with panel data and a new simple test. *Oxford Bulletin of Economics and statistics 61*(S1), 631–652.

Mangano, G. (1998). Measuring central bank independence: a tale of subjectivity and of its consequences. *Oxford Economic Papers 50*(3), 468–492.

Martin, F. M. (2015). Debt, inflation and central bank independence. *European Economic Review 79*, 129–150.

Masciandaro, D., J. Magurno, and R. Tarsia (2020). Central bank independence: Metrics and empirics. *BAFFI CAREFIN Centre Research Paper* (2021-151).

Masciandaro, D. and D. Romelli (2015). Ups and downs of central bank independence from the great inflation to the great recession: theory, institutions and empirics. *Financial History Review 22*(3), 259–289.

Mauro, P., R. Romeu, A. Binder, and A. Zaman (2015). A modern history of fiscal prudence and profligacy. *Journal of Monetary Economics 76*, 55–70.

Mbaye, S., M. M. M. Badia, and K. Chae (2018). *Global debt database: Methodology and sources*. International Monetary Fund.

Mian, A., A. Sufi, and E. Verner (2017). Household debt and business cycles worldwide. *The Quarterly Journal of Economics 132*(4), 1755–1817.

Midrigan, V. and D. Y. Xu (2014). Finance and misallocation: Evidence from plant-level data. *American economic review 104*(2), 422–458.

Mizon, G. E. (1984). *The encompassing approach in econometrics.* Australian National University, Faculty of Economics and Research School of Social Sciences.

Moll, B. (2014). Productivity losses from financial frictions: Can self-financing undo capital misallocation? *American Economic Review 104*(10), 3186–3221.

Montiel Olea, J. L. and M. Plagborg-Møller (2021). Local projection inference is simpler and more robust than you think. *Econometrica 89*(4), 1789–1823.

Myers, S. C. (1984). Capital structure puzzle.

Myers, S. C. and N. S. Majluf (1984). Corporate financing and investment decisions when firms have information that investors do not have. *Journal of financial economics 13*(2), 187–221.

Nickell, S. (1981). Biases in dynamic models with fixed effects. *Econometrica: Journal of the econometric society*, 1417–1426.

Nöh, L. (2019). Increasing public debt and the role of central bank independence for debt maturities. *European Economic Review 119*, 179–198.

North, D. C. and B. R. Weingast (1989). Constitutions and commitment: the evolution of institutions governing public choice in seventeenth-century england. *The journal of economic history 49*(4), 803–832.

O'Reilly, G. and K. Whelan (2005). Has euro-area inflation persistence changed over time? *Review of economics and statistics 87*(4), 709–720.

Peek, J. and E. S. Rosengren (2005). Unnatural selection: Perverse incentives and the misallocation of credit in japan. *American Economic Review 95*(4), 1144–1166.

Pesaran, M. H. (2004). General diagnostic tests for cross section dependence in panels (iza discussion paper no. 1240). *Institute for the Study of Labor (IZA)*.

Pesaran, M. H. (2007). A simple panel unit root test in the presence of cross-section dependence. *Journal of applied econometrics 22*(2), 265–312.

Pivetta, F. and R. Reis (2007). The persistence of inflation in the united states. *Journal of Economic dynamics and control 31*(4), 1326–1358.

Plosser, C. (2022). Federal reserve independence: Is it time for a new treasury-fed accord? *Essays in Honor of Marvin Goodfriend: Economist and Central Banker*.

Polillo, S. and M. F. Guillén (2005). Globalization pressures and the state: The worldwide spread of central bank independence. *American Journal of Sociology 110*(6), 1764–1802.

Politico (2022). Ecbâs lagarde tells governments to back off and keeps tightening. *Politico*.

PolityIV (2014). Polity iv project: Political regime characteristics and transitions, 1800-2014. *On-line (http://www.systemicpeace.org/inscrdata.html)*.

Rajan, R. (2016). The independence of the central bank. *Speech at St Stephen's College, Delhi*.

Ramey, V. A. and S. Zubairy (2018). Government spending multipliers in good times and in bad: evidence from us historical data. *Journal of political economy 126*(2), 850–901.

Ramon, G. (1929). *Histoire de la Banque de France: d'après les sources originales*. B. Grasset.

Rampini, A. A. and S. Viswanathan (2010). Collateral, risk management, and the distribution of debt capacity. *The Journal of Finance 65*(6), 2293–2322.

Reinhardt, C. and K. Rogoff (2009). This time is different: Six hundred years of financial folly.

Reis, R. (2019). Can the central bank alleviate fiscal burdens? In *The Oxford Handbook of the Economics of Central Banking*, pp. 131. Oxford University Press.

Reis, R. (2022). Steady prices, sustainable debt. *Finance and Development 59*(1), 16–19.

Robins, J. M., A. Rotnitzky, and L. P. Zhao (1994). Estimation of regression coefficients when some regressors are not always observed. *Journal of the American statistical Association 89*(427), 846–866.

Rogoff, K. (1985). The optimal degree of commitment to an intermediate monetary target. *Quarterly Journal of Economics 100*(4), 1169–1189.

Rogoff, K. (2021). Risks to central bank independence. In *Independence, Credibility, and Communication of Central Banking, edited by Ernesto Pasten and Ricardo Reis, Central Bank of Chile, Santiago, Chile.*

Romelli, D. (2022). The political economy of reforms in central bank design: evidence from a new dataset. *Economic Policy*.

Romer, D. (1993). Openness and inflation: theory and evidence. *The quarterly journal of economics 108*(4), 869–903.

Rudd, J. B. and K. Whelan (2003). Inflation targets, credibility, and persistence in a simple sticky-price framework. *Credibility, and Persistence in a Simple Sticky-Price Framework (July 23, 2003)*.

Sachs, J. D. (1983). Theoretical issues in international borrowing.

Sargent, T. J. and N. Wallace (1981). Some unpleasant monetarist arithmetic. *Quarterly Review, Federal Reserve Bank of Minneapolis 5*(3), 1–17.

Schivardi, F., E. Sette, and G. Tabellini (2022). Credit misallocation during the european financial crisis. *The Economic Journal 132*(641), 391–423.

Schmalz, M. C., D. A. Sraer, and D. Thesmar (2017). Housing collateral and entrepreneurship. *The Journal of Finance 72*(1), 99–132.

Schnabel, I. (2022). Monetary policy and the great volatility. Speech by Isabel Schnabel, Member of the Executive Board of the ECB, at the Jackson Hole Economic Policy Symposium organised by the Federal Reserve Bank of Kansas City, Jackson Hole, Wyoming.

Schularick, M. and A. M. Taylor (2012). Credit booms gone bust: Monetary policy, leverage cycles, and financial crises, 1870-2008. *American Economic Review 102*(2), 1029–61.

Shleifer, A. and R. W. Vishny (1992). Liquidation values and debt capacity: A market equilibrium approach. *The journal of finance 47*(4), 1343–1366.

Shyam-Sunder, L. and S. C. Myers (1999). Testing static tradeoff against pecking order models of capital structure. *Journal of financial economics 51*(2), 219–244.

Sikken, B. J. and J. d. Haan (1998). Budget deficits, monetization, and centralbank independence in developing countries. *Oxford Economic Papers 50*(3), 493–511.

Siklos, P. L. (2008). No single definition of central bank independence is right for all countries. *European Journal of Political Economy 24*(4), 802–816.

Stiglitz, J. E. and A. Weiss (1981). Credit rationing in markets with imperfect information. *The American economic review 71*(3), 393–410.

Storz, M., M. Koetter, R. Setzer, and A. Westphal (2017). Do we want these two to tango? on zombie firms and stressed banks in europe.

Teulings, C. N. and N. Zubanov (2014). Is economic recovery a myth? robust estimation of impulse responses. *Journal of Applied Econometrics 29*(3), 497–514.

Thornton, H. (1802). *An enquiry into the nature and effects of the paper credit of Great Britain*. Routledge.

Tobias, A., F. Grinberg, N. Liang, S. Malik, and J. Yu (2018). The term structure of growth-at-risk. *American Economic Journal: Macroeconomics*.

Townsend, R. M. (1979). Optimal contracts and competitive markets with costly state verification. *Journal of Economic theory 21*(2), 265–293.

Vig, V. (2013). Access to collateral and corporate debt structure: Evidence from a natural experiment. *The Journal of Finance 68*(3), 881–928.

von Bonin, K. (1979). *Zentralbanken zwischen funktioneller Unabhaengigkeit und politischer Autonomie: dargest. an d. Bank v. England, d. Bank v. Frankr. ud Dt. Bundesbank*. Ph. D. thesis, Verlag nicht ermittelbar.

Welch, I. (2011). Two common problems in capital structure research: The financial-debt-to-asset ratio and issuing activity versus leverage changes. *International review of finance 11*(1), 1–17.

Willard, L. B. (2012). Does inflation targeting matter? a reassessment. *Applied Economics 44*(17), 2231–2244.

Willems, T. and J. Zettelmeyer (2022). Sovereign debt sustainability and central bank credibility. *Annual Review of Financial Economics 14*, 75–93.

Williamson, S. D. (1987). Costly monitoring, loan contracts, and equilibrium credit rationing. *The Quarterly Journal of Economics 102*(1), 135–145.

Wooldridge, J. M. (2009). On estimating firm-level production functions using proxy variables to control for unobservables. *Economics letters 104*(3), 112–114.

Yashiv, E. (2020). 35 breaking the taboo: The political economy of covid-motivated helicopter drops. *Europe in the Time of Covid-19*, 240.

Yasuo, G. (2011). Qui a gouverné la banque de france?(1870–1980). *Lâéconomie faite homme, Hommage à Alain Plessis, Genève*, 91–111.