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Manuel Buchholz*

Abstract

This paper investigates the effect of a macroprudential policy instrument, caps on banks' leverage, on domestic credit to the private sector since the Global Financial Crisis. Applying a difference-in-differences approach to a panel of 69 advanced and emerging economies over 2002–2014, we show that real credit grew after the crisis at considerably higher rates in countries which had implemented the leverage cap prior to the crisis. This stabilising effect is more pronounced for countries in which banks had a higher pre-crisis capital ratio, which suggests that after the crisis, banks were able to draw on buffers built up prior to the crisis due to the regulation. The results are robust to different choices of subsamples as well as to competing explanations such as standard adjustment to the pre-crisis credit boom.

JEL Codes: E51, E58, G21, G28

Keywords: macroprudential policies, domestic credit, financial crisis

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Non-technical summary

In the wake of the Global Financial Crisis, many countries have updated their supervisory framework and now incorporate the use of macroprudential policy. Macroprudential policy aims at containing the build-up of systemic risk and safeguarding the financial system as a whole. Over the last few years, advanced economies in particular have acknowledged macroprudential policy as a complement to their monetary and fiscal policies and to the existing microprudential supervision of financial institutions. Historically, emerging market economies have already had much greater experience in implementing macroprudential policy instruments. In this respect, countries which have already implemented macroprudential policy instruments in the past provide valuable examples for a study of their effectiveness.

Recent empirical studies suggest that macroprudential policy is effective in dampening the credit cycle and reducing the build-up of systemic risk. This is important because excessive credit booms might lead to systemic financial crises and thus to large economic costs in terms of output losses. However, there is a second dimension to countercyclical macroprudential policy, which is that it should not only reduce the probability of a crisis occurring but also stabilise the provision of credit during financial downturns. Less is known about how macroprudential policy contributes to stabilising financial markets and the real economy during such periods. To fill this gap, this study analyses empirically whether macroprudential policy has a stabilising effect during financial downturns.

This study focuses on one particular macroprudential policy instrument: caps on banks' leverage. This instrument, which is often referred to simply as the leverage ratio, is an example of a measure which might potentially stabilise the lending of banks during financial downturns. Technically, a cap on the leverage of a bank means that it has to hold a minimum amount of equity capital relative to its total assets. Through this, the instrument can increase loss-absorbing capacity and thus make banks more resilient in the face of adverse shocks. The Basel III regulatory framework set up by the Basel Committee on Banking Supervision (BCBS) also considers a leverage cap to be a complement to the regulation of bank capital that already exists and is based on risk-weighted assets.

The empirical analysis is based on a sample of 69 advanced and emerging countries during 2002–2014, of which eight had introduced the leverage cap before the crisis. During times of financial strain, the national supervisor is likely to pay particular attention to the stabilisation of credit to the private sector of its own economy. Therefore this study analyses the effect of the leverage cap on bank credit to the *domestic* private sector. Methodologically,

the paper applies a difference-in-differences approach. Essentially, this means that the difference in real credit growth rates in the post-crisis period of 2009–2014 and the pre-crisis period of 2002–2008 is compared for those countries that implemented a leverage cap prior to the crisis and those that did not. Under the assumption that real credit growth rates would have continued to develop similarly in both groups of countries if the crisis had not occurred, this differential effect can then be attributed to the implementation of the leverage cap prior to the crisis.

The main finding of the analysis is that after the crisis, real credit growth rates in countries that had implemented the leverage cap prior to the crisis were considerably higher than the rates in those countries that had not. This suggests that macroprudential policy does indeed have a stabilising effect on real credit growth during financial downturns. Additional evidence suggests that the channel through which this stabilising effect works is that banks build up higher capital buffers before the crisis and can then draw on them afterwards to stabilise lending to the private sector.

The implication of the result is that any comprehensive cost-benefit analysis of macroprudential policy should incorporate the potentially stabilising effect of the chosen policy instruments. This is particularly important because even if macroprudential policy might not be able to prevent financial crises from happening at all, it might still be effective in stabilising the economy in their aftermath.

Contents

1. Introduction

The use of macroprudential policy is an important aspect of the regulatory response to the Global Financial Crisis, and several advanced economies have updated their regulatory and supervisory structures over the last few years in consequence.[1] Various macroprudential policy tools are available, and they are expected to prevent the build-up of systemic risk in the financial system. Using these tools sensibly is challenging however. On the upside, lower systemic risk might reduce the probability and severity of financial crises, but on the downside, there might be leakages or other unintended consequences. Against this backdrop, the topic has gained a lot of attention among policy makers and researchers alike. Besides comprehensive theories that grasp the relevant trade-offs and channels, an empirical evaluation of the effects of macroprudential policies is key to understanding their usefulness and shortcomings. In this respect, countries which have already implemented macroprudential tools in the past provide valuable examples for study of these effects.

An important intermediate goal of macroprudential policy is to smooth the credit or financial cycle (Arregui et al. (2013)). It particularly aims to prevent excessive credit booms building up, as they might ultimately lead to systemic financial crises with potentially adverse effects on the real economy. Kaminsky and Reinhart (1999) show that crises in emerging market usually follow credit-fuelled booms in economic activity.[2] Similarly, empirical evidence for advanced economies suggests that credit booms help to predict periods of financial distress (Schularick and Taylor (2012)) and that recessions were deeper if they had been preceded by a financial crisis (Jorda et al. (2013)). At the same time, macroprudential policy aims at easing the adverse effects like excessive deleveraging that are caused by binding constraints during downturns. The results of recent studies such as Cerutti et al. (2015) suggest that macroprudential policies are indeed effective in reducing excessive lending and in dampening the financial cycle during boom times. However, less is

[1] In the USA for instance, the Financial Stability Oversight Council (FSOC) was established under the Dodd-Frank Act in 2010 with a mandate to identify and respond to threats to financial stability. In Europe, countries have designated national macroprudential authorities (following the proposal by the European Systemic Risk Board (ESRB) in 2011) that conduct macroprudential policies. Within the euro area, this responsibility is shared with the supranational Single Supervisory Mechanism (SSM). The SSM, which entered into operation in November 2014, has not only microprudential but also macroprudential responsibilities and has tools at its disposal such as the countercyclical capital buffer and capital buffers for systemically important institutions (see the capital requirements regulation and directive CRR/CRD IV).

[2] For the literature on the ability of financial indicators such as the credit-to-GDP gap to predict systemic financial crises, see also Borio and Drehmann (2009), Alessi and Detken (2011), and Duca and Peltonen (2013).

known about the stabilising role of macroprudential policy during financial downturns. This point deserves attention because it is especially the years after a financial crisis, which can be defined as an extreme financial downturn, that are more likely to see financial markets not working properly in their function of channelling funds to productive investments in the real economy. It is during precisely these periods that macroprudential policy might contribute to reducing these financial strains.

This paper addresses the question of whether there is a stabilising role for macroprudential policy in the aftermath of a financial crisis. To answer this question, we focus on the implementation of a cap on the leverage of banks (often referred to simply as the leverage ratio), which obliges banks to hold a minimum amount of equity capital relative to their total assets. Evidence of the relevance of this for the current regulatory debate is that the Basel Committee on Banking Supervision (BCBS) is currently testing the implementation of a 3% leverage ratio until the end of 2017 as part of the Basel III framework (BCBS (2014)). The stated goal of the leverage ratio is to prevent excessive leverage building up in the financial system and to function as a backstop for the risk-weighted regulatory capital ratios (BCBS (2014)). If there is an unforeseen increase in asset risk, it is this backstop function in particular which makes such a leverage cap a useful buffer against excessive deleveraging by banks in their attempt to meet regulatory requirements for risk-weighted equity capital ratios.[3] In addition, a leverage cap can mitigate the externalities generated by a potential run on banks' short-term funding liabilities such as repos during a liquidity crisis (Morris and Shin (2008)). For this reason, the cap on banks' leverage can be classified as a macroprudential policy instrument which increases the resilience of the financial system (Claessens (2014)), and so it is worthwhile to assess its role in the provision of real credit after the crisis more carefully.

To answer this question empirically, we apply a difference-in-differences approach in order to compare real credit growth before and after the crisis across countries that implemented a cap on leverage before the crisis and those that did not. The sample we draw on is a panel of 69 advanced and emerging countries of which eight countries introduced a leverage cap prior to the crisis.[4] The data on the use of macroprudential policy, which includes the implementation of the leverage cap, are taken from the dataset by Cerutti

[3] The findings by Behn et al. (2015) provide empirical support for this line of reasoning. They show that in response to a credit risk shock, German banks using the internal ratings-based (IRB) approach of Basel II to determine risk weights reduced lending by more than banks applying the standard approach with fixed risk weights did.

[4] Clearly, the small number of "treated" countries makes it important to check how far the results are driven by individual countries in the treatment group and how sensitive the results are to the different choices of the control group. These checks are provided in the robustness section.

et al. (2015). This dataset in turn is based on the Global Macroprudential Policy Instruments (GMPI) survey conducted by the IMF.

The results show, first that real credit growth in countries that introduced a leverage cap before the crisis was significantly higher in economic and statistical terms in 2009–2014, after the crisis, than it was in 2002–2008 before the crisis. In the baseline regression, the effect amounts to a real credit growth rate that is about six percentage points higher on average. This indicates that macroprudential policy can indeed have a stabilising effect during financial downturns. Second, the stabilising effect is stronger for those countries in which banks entered the crisis with a higher equity capital ratio. This suggests that banks can draw on the capital buffers built up before the crisis to stabilise lending to the private sector afterwards.

This paper relates to several empirical studies dealing with the impact of macroprudential policy on financial markets and real outcomes. Several papers analyse the impact of one or more macroprudential policy instruments on bank behaviour in single countries. Bruno and Shin (2014) find that the macroprudential policies that Korea introduced in 2010 and that were targeted at banks' short-term liabilities effectively reduced the vulnerability to capital inflow reversals. For the UK banks, Aiyar et al. (2014b) document that there is a significant amount of leakage around macroprudential policy, as branches of foreign banks which are not under the regulation of the national supervisor counteract the reduction in lending by UK-owned banks and foreign subsidiaries that is induced by higher time-varying bank-specific capital requirements. Jiménez et al. (2014) use detailed Spanish credit register data to analyse the effect of dynamic provisioning on the credit supply cycle and the real economy. The authors find that the regulation effectively smoothes the credit supply cycle and supports firm performance in bad times. Buch et al. (2014) show that banks which were affected by the German bank levy introduced in 2011 reduced lending and increased their deposit rates. Danisewicz et al. (2015) find a significant differential effect on lending to other banks between UK branches and subsidiaries of global banks after the introduction of macroprudential regulation in the home countries of the banks. Like three of these papers, this study also uses a difference-in-differences approach to identify the effect of macroprudential regulation on the outcome variable. We deviate in so far as we focus on the effect of one instrument in several countries. We also focus on the aggregate growth rate of credit to the private sector and do not look at lending by individual banks.

There are other studies which investigate the effect of macroprudential policy across different countries. The finding by Aiyar et al. (2014a) is that higher capital requirements in the UK led to a slowdown in cross-border credit provided by UK banks. Claessens et al. (2013) analyse bank-level data from 48 countries over 2000-10 and show that macroprudential policies such

as caps on debt-to-income and loan-to-value ratios are effective in reducing leverage and asset growth during boom times. They find only limited evidence that countercyclical measures have a stabilising effect in downturns though. These results are confirmed for a panel of 119 countries over 2000–2013 by Cerutti et al. (2015), who assess the impact of a combined index of several macroprudential policy instruments and find that macroprudential policy is effective in dampening credit growth but works less well in busts. Complementing these existing studies, we take a closer look at the years after the Global Financial Crisis and focus on one instrument to analyse the stabilising role of macroprudential policy during financial downturns more deeply.

The rest of the paper is organised as follows. Section 2 describes the data and provides descriptive statistics. Section 3 presents the empirical specification and identifying assumptions. Section 4 shows the estimation results. Section 5 provides several robustness checks. Section 6 concludes.

2. Data and descriptive statistics

2.1. Caps on banks' leverage

A regulatory cap on the leverage of banks requires banks to hold a minimum amount of equity capital relative to their total assets. The data on the caps on leverage are taken from the dataset on macroprudential policy measures by Cerutti et al. (2015). This is in turn based on the Global Macroprudential Policy Instruments (GMPI) survey by the IMF. In this paper we consider the sample of emerging and advanced economies that is defined in the IMF World Economic Outlook 2014 (IMF (2014), Cerutti et al. (2015)). There are 69 countries in the final estimation sample, and they are shown in Table 1. Eight countries actually introduced a cap on the leverage of banks prior to the crisis, and these were Canada, Chile, Ecuador, Jordan, Paraguay, Saudi Arabia, St. Kitts and Nevis, and the United States. Most of them brought in the leverage cap in the year 2000 or earlier. The exceptions are Ecuador, which introduced the cap in 2001, and Jordan, which introduced one in 2003. It is mostly emerging market economies that have had experience with macroprudential policy in the past, and this is reflected in the presence of only two advanced countries in this sample, Canada and the USA. Information is only available on the year of implementation and not on the actual size of the cap.

Table 1: List of countries included in estimation sample

	Advanced	**Emerging**	
Leverage cap: yes	Canada	Chile	Paraguay
	United States	Ecuador	Saudi Arabia
		Jordan	St. Kitts and Nevis
Leverage cap: no	Australia	Albania	Malaysia
	Austria	Algeria	Mauritius
	Belgium	Angola	Mexico
	Cyprus	Armenia	Morocco
	Czech Republic	Belize	Pakistan
	Estonia	Botswana	Philippines
	Finland	Brazil	Poland
	France	Bulgaria	Romania
	Germany	Cape Verde	Russia
	Iceland	Colombia	Serbia
	Ireland	Costa Rica	South Africa
	Israel	Croatia	Thailand
	Italy	Dominican Republic	Trinidad and Tobago
	Japan	El Salvador	Turkey
	Korea	Fiji	Ukraine
	Latvia	Georgia	
	Malta	Guyana	
	Netherlands	Hungary	
	Portugal	Indonesia	
	Slovakia	Kazakhstan	
	Slovenia	Kuwait	
	Spain	Lithuania	
	Sweden	Macedonia	
Total number	25	44	

Note: The table shows the 69 countries included in the estimation sample. The upper panel shows the countries which implemented a cap on banks' leverage prior to the crisis of 2008 and the lower panel shows those that did not. The countries are grouped into advanced and emerging countries using the definition by the IMF (IMF (2014), Cerutti et al. (2015)).

To gain a first impression of the data, we compare the countries which implemented the leverage cap with those that did not in terms of the descriptive statistics of their key macroeconomic variables. The descriptive statistics shown in Table 2 illustrate that countries which introduced the cap had higher GDP growth rates on average but lower interest rates and inflation. The private credit-to-GDP ratio was more than 11 percentage points lower at about 53.4 rather than 65.1 in these countries. The ratio of equity capital to total assets held by banks was also smaller, by about 1.5 percentage points. While not all of these observable differences are very large, it is important to account for country-specific differences when evaluating the effect of the

macroprudential policy tool. Clearly the implementation of the leverage cap was not random but was based on several country characteristics. These might be observed variables such as GDP growth, the level of the interest rate, or the credit-to-GDP ratio. It is, however, more likely that implementation was based on unobservable characteristics such as the preference for leverage or financial stability in general or the overall quality of institutions. This line of argumentation supports the application of a difference-in-differences approach, which directly incorporates the idea that the selection through the decision to implement the regulation is based on unobservable characteristics.

Table 2: Summary statistics

Variable	Country group	Observations	Mean	Standard deviation	Min	Max
Real credit to the private sector (growth rate, in %)	Leverage cap: yes	89	11.62	11.44	−14.10	60.74
	Leverage cap: no	730	13.81	16.86	−14.10	78.34
	Total	819	13.57	16.37	−14.10	78.34
Real GDP growth rate (in %)	Leverage cap: yes	89	3.87	3.35	−5.60	14.22
	Leverage cap: no	730	3.30	3.76	−11.77	18.23
	Total	819	3.36	3.72	−11.77	18.23
Monetary policy rate (in %)	Leverage cap: yes	89	4.56	3.40	0.13	15.36
	Leverage cap: no	730	5.95	9.97	0.08	150.00
	Total	819	5.80	9.49	0.08	150.00
CPI inflation rate (in %)	Leverage cap: yes	89	3.99	3.04	−0.73	14.99
	Leverage cap: no	730	4.77	7.01	−1.09	109.59
	Total	819	4.68	6.70	−1.09	109.59
Private credit-to-GDP ratio (in %)	Leverage cap: yes	89	53.39	28.57	14.62	134.99
	Leverage cap: no	725	65.06	40.55	4.20	172.41
	Total	814	63.78	39.57	4.20	172.41
GDP per capita (thous. international USD)	Leverage cap: yes	89	23.09	15.98	4.78	54.63
	Leverage cap: no	730	20.29	14.02	2.86	76.89
	Total	819	20.60	14.27	2.86	76.89
Financial institutions-targeted macroprudential index (0-10)	Leverage cap: yes	82	3.01	1.31	1.00	5.00
	Leverage cap: no	677	1.38	1.27	0.00	6.00
	Total	759	1.55	1.37	0.00	6.00
Borrower-targeted macroprudential index (0-2)	Leverage cap: yes	82	0.34	0.57	0.00	2.00
	Leverage cap: no	677	0.34	0.63	0.00	2.00
	Total	759	0.34	0.62	0.00	2.00
Regulatory quality (-2.5-2.5)	Leverage cap: yes	89	0.30	0.88	−1.28	1.65
	Leverage cap: no	717	0.52	0.76	−1.49	1.92
	Total	806	0.50	0.78	−1.49	1.92
Banking crisis (0/1)	Leverage cap: yes	43	0.12	0.32	0.00	1.00
	Leverage cap: no	487	0.10	0.30	0.00	1.00
	Total	530	0.10	0.31	0.00	1.00

Variable	Country group	Obser-vations	Mean	Standard deviation	Min	Max
Sovereign debt crisis (0/1)	Leverage cap: yes	43	0.02	0.15	0.00	1.00
	Leverage cap: no	487	0.00	0.05	0.00	1.00
	Total	530	0.00	0.06	0.00	1.00
Currency crisis (0/1)	Leverage cap: yes	43	0.02	0.15	0.00	1.00
	Leverage cap: no	487	0.01	0.08	0.00	1.00
	Total	530	0.01	0.09	0.00	1.00
Capital-to-assets ratio (in %)	Leverage cap: yes	63	8.34	3.78	0.00	14.03
	Leverage cap: no	691	9.91	4.26	0.00	22.56
	Total	754	9.77	4.24	0.00	22.56
Deposit-to-assets ratio (in %)	Leverage cap: yes	63	55.93	9.67	39.19	76.98
	Leverage cap: no	709	47.50	17.55	10.22	79.26
	Total	772	48.19	17.19	10.22	79.26

Note: The table shows summary statistics for the dependent variable (growth rate of real credit to the private sector, in %) and the explanatory variables to be used in the empirical specification. The sample is based on the estimation sample following the baseline specification in the results section (69 countries, years 2002–2014). All variables are winsorised at the 1% and 99% quantiles. See the data appendix for detailed description and data sources.

Figure 1 shows the evolution of the capital-to-assets ratios of banks over time in both groups of countries. It can be seen that capital ratios were relatively stable in countries without the cap over the whole sample but they increased steadily in the countries which introduced the cap in the pre-crisis period. By 2009 the capital ratios were on average at a very similar level of about 10 percent for both groups of countries. Capital ratios also increased in the post-crisis period while staying slightly lower in the countries with the cap. The former observation might appear surprising as it contradicts the idea that in times of crisis we expect banks to deleverage. However, given the sudden increase in the risk of certain assets, stable or even increasing capital ratios are likely to be the result of banks trying to keep their capital stable relative to *risk-weighted assets* in order to meet the regulatory minimum requirements. If this was achieved primarily through a reduction of mainly risky assets, capital relative to total unweighted assets might actually increase. The important point is that a higher capital-to-assets ratio might make the minimum regulatory capital requirement based on risk-weighted assets less binding during times of higher asset risk.

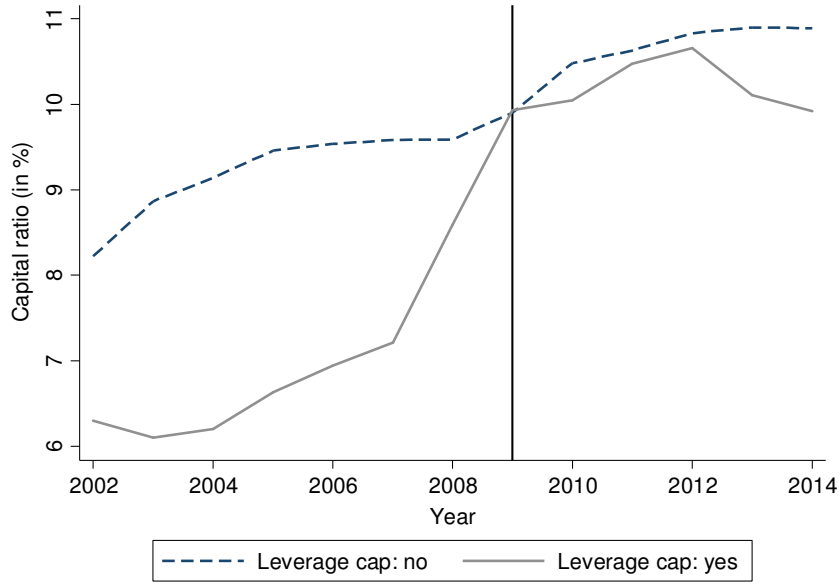

Figure 1: Capital-to-assets ratio of banks 2002–2014

Note: The graph shows the average capital-to-assets ratio (in %) of banks over 2002–2014 for countries with and without a leverage cap prior to 2008. The vertical line indicates the start of the post-crisis period (2009). The sample is based on the estimation sample (69 countries). The capital ratios are winsorised at the 1% and 99% quantiles.

To test this channel directly it would be necessary to evaluate whether the leverage caps do indeed relax the binding regulatory minimum capital requirements. However, this study does not have access to any information on regulatory capital ratios. Equally, we do not know whether the build-up of capital ratios prior to the crisis was really the result of the introduction of the leverage cap. This is because banks might choose to hold the same buffer even in the absence of the regulation. Therefore the study will take an indirect approach so as to shed some light on the buffer channel, and it relies on narrative evidence for countries such as Canada, showing that the cap might indeed have worked as described by Bordeleau et al. (2009).

2.2. Real credit growth

A key variable is the growth of credit, the rate of which can be seen as an intermediate target of macroprudential policy (Arregui et al. (2013)). Achieving this target in practice means restricting the build-up of potentially excessive credit booms and stabilising credit provision in downturns. This study follows this approach and considers the impact on the growth rate of real

credit from a multi-country perspective. It takes the period after the Global Financial Crisis as an example of a pronounced financial downturn in which the stabilising role of macroprudential policy on credit growth can be analysed. The direct crisis response was a mixture of various immediate rescue measures, but this study analyses the stabilising effect in the years after the crisis and thus takes a medium-term perspective. Some studies have evaluated the countercyclical role of macroprudential policy tools, but the countercyclical effects might not come into full effect if the financial downturn is not so large. Therefore, we explicitly analyse the period after the Global Financial Crisis, and our main focus is on how the policy increases the loss-absorbing capacity of the financial system for dealing with sizable systemic shocks.

Taking this further, this study focuses on real credit provided by resident banks to the domestic private sector.[5] The choice of this variable is guided by the notion that it is resident banks that will be affected primarily by the regulation and that regulatory authorities care most about credit provision to the private sector when they are looking to stabilise the economy as a whole. Figure 2 shows the evolution of the real credit growth rate over time. It can be seen from visual inspection that the difference in levels is considerable prior to the crisis, but the paths of real credit growth rates in both groups of countries nevertheless show a similar pattern described by an upward trend.[6] The rates declined sharply in the crisis year 2009 and remained at lower levels in both groups of countries. However, the rate fell by less in those countries which had a leverage cap in place. Interestingly, rates remain at lower levels throughout the post-crisis period.

Clearly, there are competing explanations for the effect observed. It might be that the countries which implemented the cap prior to the crisis were those countries which were affected less by the crisis. It might also be that we are only seeing a standard adjustment to a pre-crisis boom that was more pronounced in the countries which had not introduced the measure. We will check the sensitivity of our result to these alternative explanations. In sum, the descriptive analysis gives a first indication of the stabilising effect of caps on the leverage of banks on real credit growth after the crisis, and this will be analysed in detail in the following sections.

[5] Following the IMF Other Depository Corporations Survey, the private sector comprises non-financial private firms and households.

[6] The strong increase for the countries with a leverage cap from 2003 to 2004 can be explained by Paraguay going from a strongly negative growth rate of −13 percent to a strongly positive growth rate of about 24 percent. Robustness checks based on a narrower estimation window over 2005–2012 or excluding individual countries from the sample show that this does not drive the results though.

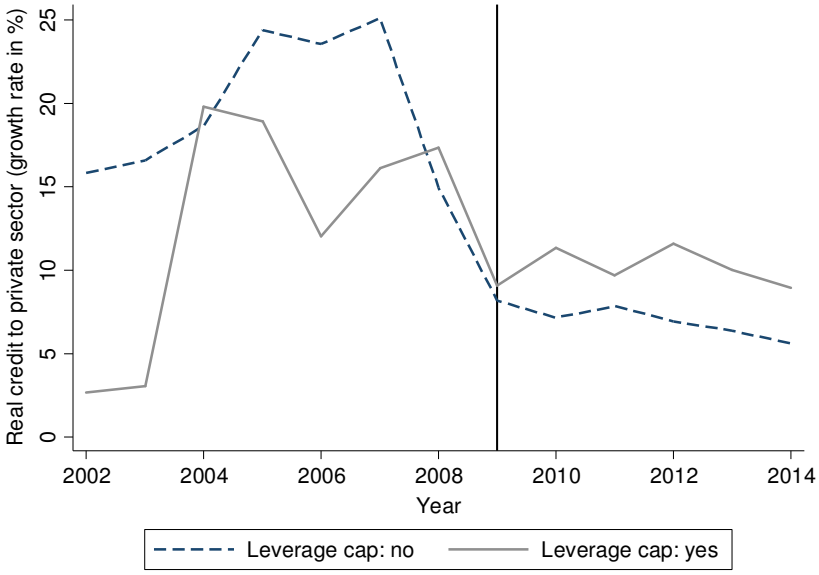

Figure 2: Real credit growth rates 2002–2014

Note: The graph shows the average growth rates of real credit (in %) over 2002–2014 for countries with and without a leverage cap prior to 2008. The vertical line indicates the start of the post-crisis period (2009). The sample is based on the estimation sample (69 countries). The growth rates are winsorised at the 1% and 99% quantiles.

3. Empirical specification

3.1. Difference-in-differences approach

We identify the effect of caps on leverage on real credit growth after the crisis using a difference-in-differences approach with two-way fixed effects:

$$\Delta \ln RealCredit_{it} = \alpha_i + \alpha_t + \beta[D_{PostCrisis} \times D_{LEV}] + x_{it}'\gamma + \varepsilon_{it} \quad (1)$$

The dependent variable is the growth rate of real credit. Index i indicates the country and t the year. $D_{PostCrisis}$ is a dummy variable indicating the post-crisis period starting from 2009. D_{LEV} is a dummy indicating whether a given country had a leverage cap prior to the crisis.[7] The time period of the baseline estimation covers the years 2002 to 2014. The parameter of interest is β as it captures the differential effect on real credit growth of the leverage cap

[7] The indicator is equal to one if the country had introduced the cap before 2008 so that it was in place before the crisis. However, all the countries with a leverage cap prior to the crisis had already introduced it by 2003.

in the post-crisis period. If it turns out to be positive we can conclude that macroprudential regulation has a stabilising effect on real credit growth. A possible channel through which this effect works is that banks can draw on pre-crisis capital buffers that they built up before the crisis because of the regulation, and this prevents them from deleveraging and cutting back lending.

Our approach differs in its terminology from the usual difference-in-differences setting for two reasons. First, the treatment is not fully defined by the introduction of the leverage cap itself, but rather it is defined as the leverage cap being already in place conditional on the crisis happening. Theoretically, the treatment would thus be absent if either i) no financial crisis hit or ii) no country had caps on leverage when the crisis hit. Second, we do not claim that the control group is not affected by the event, entirely the contrary in fact, as it will very much be affected by the crisis. The point is that the countries in the treated group, i.e. those which had a cap on leverage in place when the crisis hit, were affected differently. Despite these subtle distinctions, it is valid to use the difference-in-difference methodology to measure the intended effect as long as the identifying assumptions hold.

3.2. Identifying assumptions

Two main assumptions have to hold for the effect to be identified: both groups of countries have to exhibit a parallel trend for the real credit growth rate and the crisis has to be an exogenous event. The parallel trend assumption states that in the absence of treatment, real credit growth would have developed in a similar way in both groups of countries after the crisis. This assumption cannot be tested directly, but we can shed light on its plausibility by testing whether there is a significant differential effect for the years before the crisis. One way to do this is to allow the difference-in-differences coefficient to vary over time and to set the post-crisis period artificially equal to one already in the three years preceding the actual post-crisis period, 2006 to 2008.

$$\Delta \ln RealCredit_{it} = \alpha_i + \alpha_t + \beta_t [D_{Year \geq 2006} \times D_{LEV} \times D_t] + x_{it}'\gamma + \varepsilon_{it} \qquad (2)$$

All variables have the same definition as in Equation (1). The difference is that $D_{Year \geq 2006}$ is now equal to one starting from as early as 2006 and the interaction with D_t captures dummies indicating a specific year to get a time-varying coefficient. Our assumption is that it is only in the post-crisis period that there should be a significant differential effect on credit growth between the countries with a leverage cap and those without one. Therefore the coefficients β_t should turn out not to be significantly different from zero in the

three years before the post-crisis period. Figure 3 illustrates the results of the test for the pre-treatment effect. In all three years preceding the actual post-crisis period, there is no significant difference between the two groups of countries, and this argues in favour of parallel trends. Taking this evidence, we proceed further with the analysis.

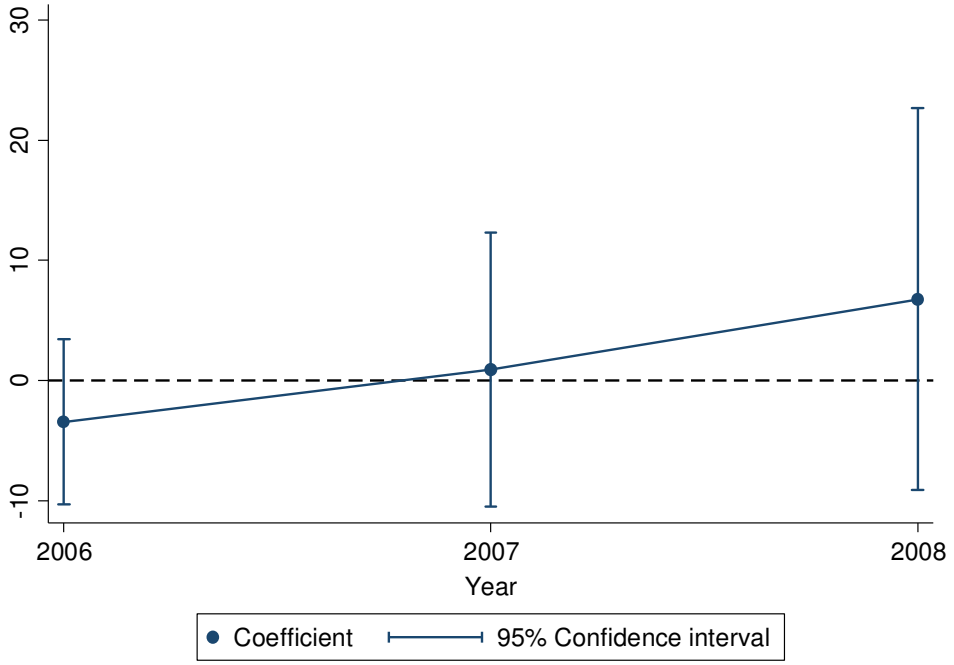

Figure 3: Pre-treatment differential effects

Note: The graph shows the differential effect of caps on leverage on real credit growth in the three years preceding the post-crisis period (2006-08). Estimation is based on Equation (2).

The assumption that the Global Financial Crisis was exogenous in the sense that it was unexpected appears plausible. Only if countries expected that they would be hit by a financial crisis and introduced the leverage cap for that reason would our results be invalidated by this assumption. We argue that this case is rather implausible as it would require first that countries implementing the measure correctly predict the date and severity of the crisis and, second, that countries introduce their caps on leverage for precisely this reason.

Regarding the anticipation of the crisis, Figure 2 shows that real credit growth rates are also lower after the crisis than before the crisis in countries which had leverage caps. This argues against the hypothesis that the impact

of the crisis was fully anticipated. In this sense our approach is similar to that of others who have used the Global Financial Crisis as an exogenous event and compared post-crisis and pre-crisis outcomes, such as Cetorelli and Goldberg (2011), who analyse lending by global banks.

Furthermore, the reasons for introducing a leverage cap are likely to differ across countries. As described above, the desire to smooth the credit cycle and prevent excessive credit booms emerging can be seen as one of the main reasons for having a macroprudential policy. Lim et al. (2011) argue that for the United States the cap on the leverage of banks was not even introduced for macroprudential purposes but rather to limit risks at the individual bank level. In Canada, the regulatory constraint on leverage has been in place since the 1980s and is mainly intended to reduce the overall leverage in the system (Bordeleau et al. (2009)). It appears that prior to the crisis, the leverage cap was generally seen not as a macroprudential tool but primarily as a microprudential tool. We thus argue that the decision to implement caps on the leverage of banks is driven not by expectations about financial crises but rather by country characteristics such as institutional quality or a preference for a more stable financial system, though not all of these characteristics are necessarily observable. The two groups of countries might well differ in this important respect, but these potentially unobservable characteristics are exactly those which are captured by the difference-in-differences approach. To show the relevance of the difference-in-differences approach, and how it is meaningful, we will show the impact on the outcome variable of some key country-specific variables which are constant over time.[8]

It might still be that countries which had caps on leverage before the crisis were hit less hard by the financial crisis and thus also experienced a less pronounced fall in their credit growth rates. For this reason it will be important to test whether the country-specific severity of the financial crisis itself can explain the differential effect in post-crisis real credit growth as a competing explanation for the stabilising effect. The results will be shown in the section on robustness.

[8] As the impact of constant country-specific variables is absorbed in the baseline specification, we will use the correlated random effects approach (Mundlak (1978), Wooldridge (2010)), which allows us to measure the impact of time-constant variables even in a fully specified fixed-effects regression.

4. Estimation results

4.1. The stabilising effect of caps on banks' leverage

The specification for identifying the stabilising effect of macroprudential regulation on domestic credit to the private sector as presented in Equation (1) in Section 3.1 is estimated via OLS. Standard errors are clustered at the country level to account for heteroscedasticity and serial correlation of the errors (Bertrand et al. (2004), Petersen (2009)).

Table 3 shows the estimation results. The results give evidence of a stabilising effect on real credit growth from caps on banks' leverage. The point estimate in column 1 for the baseline specification suggests that the real credit growth rate was about six percentage points higher after the crisis for those countries that had a leverage cap prior to the crisis than for those that did not. The effect can be considered sizeable in economic terms given that the average real credit growth rate in the sample is 13.6 percent with a standard deviation of 16.4 percent. The estimated coefficient is statistically significant at the 1 percent level. The baseline specification includes the real GDP growth rate and the monetary policy rate in order to capture the stance of the macroeconomic environment. The positive and significant coefficients of both variables indicate that a better macroeconomic stance is related to higher credit growth. Therefore it appears reasonable to include both variables in the baseline specification. For comparison, we estimate the specification without additional control variables in column 2. This leads to an estimated effect of 8.9 percentage points, which is statistically significant but considerably higher. Furthermore, the finding of a stabilising effect also holds if we lag both macroeconomic variables by one period, as shown in column 3.

Table 3: Difference-in-differences regression

Dependent variable: Real credit growth (%)	**(1)**	**(2)**	**(3)**
D_{LEV} x $D_{PostCrisis}$	6.029***	8.937***	5.889**
	(2.123)	(2.761)	(2.241)
Real GDP growth (%)	1.638***		
	(0.248)		
Monetary policy rate (%)	0.197***		
	(0.073)		
Real GDP growth (lag, %)			1.150***
			(0.207)
Monetary policy rate (lag, %)			0.284***
			(0.048)

Dependent variable: Real credit growth (%)	**(1)**	**(2)**	**(3)**
Country FE	y	y	y
Year FE	y	y	y
Countries	69	69	69
Observations	819	819	817
R^2	0.38	0.28	0.34

Note: The table shows the regression results of the main difference-in-differences regression based on Equation (1) for the period 2002–2014. The dummy variable D_{LEV} indicates countries that implemented a cap on the leverage of banks prior to the crisis of 2008. The dummy $D_{PostCrisis}$ captures the post-crisis period and is equal to one from the year 2009 on and zero otherwise. The dependent variable is the rate of growth of real credit (in %). The number of observations varies according to the availability of control variables. All specifications include country-fixed and time-fixed effects. Cluster-robust standard errors at the country-level are given in parentheses. ***,**,* denote statistical significance at the 1%, 5%, and 10% levels respectively. All variables are winsorised at the 1% and 99% quantiles.

Table 4 shows that the result remains stable – both quantitatively and in terms of statistical significance – across the inclusion of different sets of time-varying control variables. Many of the control variables turn out to be insignificant and do not add to the goodness of fit measured by the R-squared. This is particularly so for the private credit-to-GDP ratio (column 3) and the index of macroprudential regulation by Cerutti et al. (2015), which captures the range of other macroprudential measures targeted at either borrowers or financial institutions (column 5). Controlling for other macroprudential policy instruments is necessary as those instruments might interact with each other in a non-trivial way in their effect on the credit supply from banks (Kashyap et al. (2014)). The specification in column 6 additionally controls for the impact of a cap on leverage introduced after the crisis, though this does not appear to have a significant impact on real credit growth either. In addition, the occurrence of a banking or currency crisis negatively affects the real credit growth rate but does not interfere with the stabilising effect of the cap on leverage either (column 7).

Table 4: Difference-in-differences regression: time-varying controls

Dependent variable: Real credit growth (%)	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**
D_{LEV} x $D_{PostCrisis}$	6.029***	5.943***	6.178***	5.889***	5.373**	6.028**	6.276**
	(2.123)	(2.065)	(2.129)	(2.118)	(2.322)	(2.382)	(2.862)
Real GDP growth (%)	1.638***	1.629***	1.643***	1.640***	1.562***	1.566***	1.492***
	(0.248)	(0.248)	(0.253)	(0.249)	(0.242)	(0.248)	(0.286)
Monetary policy rate (%)	0.197***	0.297	0.197***	0.166**	0.153**	0.176**	0.105
	(0.073)	(0.190)	(0.073)	(0.075)	(0.076)	(0.075)	(0.084)

Dependent variable: Real credit growth (%)	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**
Inflation rate (%)		–0.148					
		(0.281)					
Private credit-to-GDP (%)			0.012				
			(0.044)				
GDP per capita (log)				–8.814			
				(14.017)			
MacroPru index (fin. sector)					–1.808		
					(1.848)		
MacroPru index (borrower)					–2.054		
					(1.605)		
Leverage cap (0/1)						–4.585	
						(12.568)	
Banking crisis (0/1)							–5.693*
							(3.042)
Sovereign debt crisis (0/1)							8.712
							(8.559)
Currency crisis (0/1)							8.379***
							(5.040)
Country FE	y	y	y	y	y	y	y
Year FE	y	y	y	y	y	y	y
Countries	69	69	69	69	69	69	62
Observations	819	819	814	819	759	759	530
R^2	0.38	0.38	0.38	0.38	0.37	0.37	0.35

Note: The table shows the regression results of the main difference-in-differences regression for different sets of time-varying control variables based on Equation (1) for the period 2002–2014. The dummy variable D_{LEV} indicates countries that implemented a cap on the leverage of banks prior to the crisis of 2008. The dummy $D_{PostCrisis}$ captures the post-crisis period and is equal to one from the year 2009 on and zero otherwise. The dependent variable is the rate of growth of real credit (in %). The number of countries and observations varies according to the availability of control variables. All specifications include country-fixed and time-fixed effects. Cluster-robust standard errors at the country-level are given in parentheses. ***,**,* denote statistical significance at the 1%, 5%, and 10% levels respectively. All variables are winsorised at the 1% and 99% quantiles.

4.2. The role of country-specific characteristics

The heterogeneity of characteristics across countries may influence both the decision to implement the leverage cap *and* the outcome variable, i.e. real credit growth. The fixed effects specification effectively controls for the impact of these variables, so it is key in identifying the desired effect of the leverage cap on real credit growth. Because it controls for both observable and unobservable country-specific characteristics, however, we cannot investigate the impact of time-constant observables any more. By using a correlated random effects model, we can still include time constant variables and detect their impact on the outcome variable.[9] The application of this approach gives an idea of those country characteristics that actually drive the results.

Table 5 shows the results. Column 1 is from a specification which includes the following time-constant country characteristics: the pre-crisis (2002–2007) average of the real GDP growth rate; the monetary policy rate; and the credit-to-GDP ratio. The coefficient of the interaction term is the same as in the baseline case (column 1 of Table 3), which it should be for the method to be correctly implemented.[10] We see that a higher private credit-to-GDP ratio before the crisis is associated with lower real credit growth rates. Column 2 further indicates that a higher equity capital ratio for banks before the crisis is on average related to higher growth of real credit. In section 4.3 it will be shown that this can be explained by the stabilising effect of pre-crisis capital on credit growth after the crisis. No significant effect is found for the pre-crisis deposit ratio. Interestingly, the dummy indicating whether a given country had a leverage cap before the crisis does not have a significant effect on real credit growth either, even though the point estimate is relatively large in absolute terms. Without over-interpreting the result, it can at least be said that it challenges the notion that the leverage cap was highly effective in reducing the build-up of a major credit boom before the crisis. The finding is in line with Cerutti et al. (2015), who do not find a significant effect on credit growth from caps on banks' leverage either when looking at the impact of individual instruments.

[9] The correlated random effects model goes back to Mundlak (1978). See Wooldridge (2010) for the case of an unbalanced panel. Technically, the correlated random effects model controls for fixed-effects by including all time-varying variables along with their group-specific mean over time. This identifies the same coefficients of time-varying variables as in the fixed-effects estimation but additionally allows time-constant variables to be included in the regression.

[10] The coefficient differs slightly in column 2 because it is based on a smaller estimation sample due to the limited availability of the control variables included.

Table 5: Correlated random effects regression

Dependent variable: Real credit growth (%)	**(1)**	**(2)**	**(3)**
D_{LEV} x $D_{PostCrisis}$	6.029***	6.147**	6.029***
	(2.140)	(2.329)	(2.142)
Real GDP growth (%)	1.638***	1.624***	1.638***
	(0.250)	(0.278)	(0.250)
Monetary policy rate (%)	0.197***	0.202***	0.197***
	(0.073)	(0.073)	(0.073)
Avg. real GDP growth 2002-07 (%)	1.101**	1.050*	1.106**
	(0.514)	(0.619)	(0.514)
Avg. monetary policy rate 2002-07 (%)	0.043	0.245	0.060
	(0.363)	(0.417)	(0.363)
Avg. credit-to-GDP ratio 2002-07 (%)	−0.076***	−0.078***	−0.076***
	(0.017)	(0.017)	(0.017)
Avg. capital ratio 2006/07 (%)		0.260*	
		(0.154)	
Avg. deposit ratio 2006/07 (%)		0.003	
		(0.039)	
D_{LEV} (0/1)			−3.991
			(7.062)
Country FE	y	y	y
Year FE	y	y	y
Countries	69	61	69
Observations	819	746	819
R^2	0.54	0.54	0.54

Note: This table displays the estimation result of the correlated random effects specification which controls for time-fixed and country-fixed effects and includes constant country-specific regressors for the period 2002–2014: the average over 2002–2007 of the real GDP growth rate, the monetary policy rate, and the credit-to-GDP ratio. The average capital and deposit-to-assets ratio in the two years before the crisis (2006/07) are added in column 2 and the dummy variable D_{LEV} indicating countries that implemented a cap on the leverage of banks prior to the crisis of 2008 in column 3. All variables are winsorised at the 1% and 99% quantiles.

If we plausibly assume that a higher credit-to-GDP ratio or a higher equity capital ratio are important in the decision being taken to introduce a cap on leverage in order to mitigate the build-up of a potentially excessive credit boom, not including them in the regression would lead to a biased estimate of the effect of the leverage cap because we see from the regression that they clearly have an effect on the real credit growth variable. In sum, the illustrative evidence for the role of country-specific variables therefore supports the use of a difference-in-differences approach in the first place. This is because the method is effective in taking into account the potentially confounding influence on key pre-crisis differences of constant country characteristics.

4.3. Does the effect work through the pre-crisis capital ratio?

One channel through which the stabilising effect of leverage caps might work is that after the crisis, banks might draw on capital buffers built up prior to the crisis. This would mean they do not have to cut lending due to deleveraging to the same extent as banks in countries that did not implement the regulation. We can investigate this channel empirically by interacting the pre-crisis capital ratio (*CapRatio*) with the interaction term of the baseline specification, and we additionally include all two-way interactions not captured by the fixed effects:

$$\begin{aligned}\Delta \ln RealCredit_{it} &= \alpha_i + \alpha_t + \beta_1[D_{PostCrisis} \times D_{LEV}\,] \\ &+ \beta_2[D_{PostCrisis} \times CapRatio_i] \\ &+ \beta_3[D_{PostCrisis} \times D_{LEV} \times CapRatio_i] + x_{it}'\gamma + \varepsilon_{it}\end{aligned} \quad (3)$$

To make sure that we capture the capital ratio with which the banks in a given country entered the crisis, we take the average of the years 2006 and 2007.

Table 6 shows the result. The coefficient of the triple interaction term tells us that the stabilising effect is significantly higher for those countries in which the pre-crisis capital ratios of the banks are higher. The size of the stabilising effect that is dependent on the pre-crisis capital ratio is plotted in Figure 4 for the range of values observed for the pre-crisis capital ratios of the countries that had implemented the regulation.[11] We see that the stabilising effect does indeed increase with a higher capital ratio and is statistically significant for capital ratios of about seven percent and above. This gives strong support to the argument that the leverage cap is effective in making banks build up buffers before the crisis that then stabilise their lending after the crisis.

[11] The total effect is given by $\beta_1 + \beta_3 \times CapRatio_i$ and depends on the value of the pre-crisis capital ratio. The standard errors of the total effect cannot be read from the regression table. They are computed as

$$SE = \sqrt{var(\hat{\beta}_1) + CapRatio^2 \times var(\hat{\beta}_3) + 2\, CapRatio \times cov(\hat{\beta}_1, \hat{\beta}_3)}$$

(see also Brambor et al. (2006)).

Table 6: The effect of the leverage cap on real credit growth conditional on the pre-crisis capital ratio

Dependent variable: Real credit growth (%)	**(1)**
D_{LEV} x $D_{PostCrisis}$	−1.059
	(3.923)
$D_{PostCrisis}$ x Capital ratio	−0.368
	(0.349)
D_{LEV} x $D_{PostCrisis}$ x Capital ratio	0.862**
	(0.416)
Real GDP growth (%)	1.562***
	(0.282)
Monetary policy rate (%)	0.195**
	(0.081)
Country FE	y
Year FE	y
Countries	61
Observations	746
R^2	0.61

Note: The table shows the regression results of the main difference-in-differences regression augmented by an additional interaction of the interaction term with the pre-crisis capital ratio (average over 2006/07) based on Equation (1) for the period 2002–2014. The dummy variable D_{LEV} indicates countries that implemented a cap on the leverage of banks prior to the crisis of 2008. The dummy $D_{PostCrisis}$ captures the post-crisis period and is equal to one from the year 2009 on and zero otherwise. The dependent variable is the rate of growth of real credit (in %). The number of countries and observations is lower than in the baseline regression due to the limited data availability for the capital ratio. The specification includes country-fixed and time-fixed effects. Cluster-robust standard errors at the country-level are given in parentheses. ***,**,* denote statistical significance at the 1%, 5%, and 10% levels respectively. All variables are winsorised at the 1% and 99% quantiles.

This finding is in line with Demirgüç-Kunt et al. (2013), who document how banks with lower leverage before the crisis showed on average a better stock market performance during the Global Financial Crisis. Similarly, Berger and Bouwman (2013) show for the US that banks with a higher capital ratio perform better during banking crises.

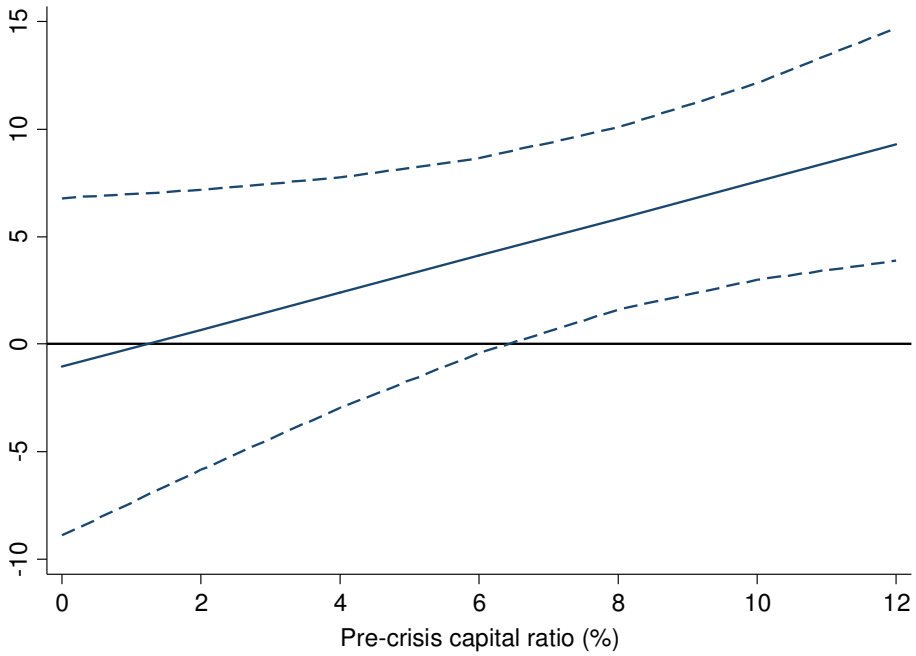

Figure 4: The effect of the leverage cap on real credit growth conditional on the pre-crisis capital ratio

Note: The graph shows the effect of the leverage cap on real credit growth (solid line, measured on horizontal axis, in percentage points) for different values of the pre-crisis capital ratio (vertical axis, in %) based on the estimation results in Table 6. The estimates are surrounded by 95% confidence bands (dashed lines).

4.4. The effect on total asset growth and the contribution of its subcomponents

The results so far suggest that the pre-crisis implementation of the leverage cap stabilised credit to the private sector after the crisis. The next question is whether lending to the private sector was achieved through a general expansion of total assets or via a reduction of claims on other sectors of the economy. To answer this, we replace the dependent variable in our baseline specification with the total asset growth rate and decompose it into the contributions by various subcomponents, which are claims on the non-financial private sector (*PrivSecClaims*, as in the previous analysis); claims on non-residents; the central bank; the public sector; and financial institutions (*FinInstClaims*). The total asset growth rate is decomposed in the following way:

$$\frac{TotalAssets_{it} - TotalAssets_{it-1}}{TotalAssets_{it-1}} = \frac{PrivSecClaims_{it} - PrivSecClaims_{it-1}}{TotalAssets_{it-1}} + \cdots + \frac{FinInstClaims_{it} - FinInstClaims_{it-1}}{TotalAssets_{it-1}} \quad (4)$$

Total asset growth and its subcomponents on the right hand side of this equation are now used as dependent variables in the baseline specification. This procedure allows the way that the subcomponents contribute to the overall effect on total asset growth of caps on leverages to be quantified. As we are still in the difference-in-differences set up, the interpretation of the results is always relative to the countries without the leverage cap.

The results are shown in Table 7. Column 1 shows the effect of the leverage cap on total asset growth to be positive. Banks in countries with the leverage cap have on aggregate expanded their balance sheet by 4.5 percentage points more than have banks in other countries. The effect is statistically significant at the 10 percent level. Column 2 shows that credit to the private sector contributed the largest part to this overall effect, giving about 3.2 percentage points of the total of 4.5. From columns 3 and 4, we see that the relative increase in claims on non-residents and the central bank after the crisis also contributed positively to the overall effect on asset growth. In contrast, there was a relative decrease in claims on the public sector and financial institutions, which therefore negatively contributed to the overall asset growth (columns 5 and 6). In terms of statistical inference, only the contribution by the claims on the private sector is significant. The results suggest that claims on the private sector were by far the most important component of the overall credit provided to the economy.

Table 7: The effect of the leverage cap on total asset growth and the contribution of subcomponents

Dependent variable: Change in claims subcomponent relative to total assets of previous period	**(1)** Total Assets	**(2)** Private Sector	**(3)** Non-residents	**(4)** Central bank	**(5)** Public sector	**(6)** Financial institutions
D_{LEV} x $D_{PostCrisis}$	4.559*	3.205**	1.367	0.565	−0.076	−0.462
	(2.476)	(1.570)	(0.854)	(0.752)	(0.507)	(0.414)
Real GDP growth (%)	1.016***	0.690***	0.118	0.111	−0.012	0.035*
	(0.272)	(0.127)	(0.074)	(0.090)	(0.009)	(0.020)
Monetary policy rate (%)	0.244***	0.075**	0.101***	0.095***	0.001	0.003
	(0.032)	(0.033)	(0.009)	(0.016)	(0.003)	(0.003)
Country FE	y	y	y	y	y	y
Year FE	y	y	y	y	y	y
Countries	66	66	66	66	65	66
Observations	761	761	761	739	748	761
R^2	0.33	0.33	0.33	0.33	0.33	0.33

Note: The table shows the effect of the leverage cap on total asset growth of banks and its subcomponents for the period 2002–2014. The dummy variable D_{LEV} indicates countries that implemented a cap on the leverage of banks prior to the crisis of 2008. The dummy $D_{PostCrisis}$ captures the post-crisis period and is equal to one from the year 2009 on and zero otherwise. The number of countries and observations might vary according to the availability of the dependent variable. The dependent variable in column 1 is total asset growth (in %). The dependent variables in columns 2–6 measure the contributions of the respective subcomponent to total asset growth and are defined as the yearly change in that subcomponent relative to the total assets of the previous period (in %). The names of the subcomponents are given in the header of each column and comprise claims on the non-financial private sector, non-residents, the central bank, the public sector (central and state/local governments), and other financial institutions. All specifications include country-fixed and time-fixed effects. Cluster-robust standard errors at the country-level are given in parentheses. ***,**,* denote statistical significance at the 1%, 5%, and 10% levels respectively. All variables are winsorised at the 1% and 99% quantiles. The decomposition effects in the first row of results do not exactly add up to the total effect in column 1 due to missing data on some components and winsorising.

5. Robustness

5.1. Competing explanations

Some of the results from above suggest that a closer look is needed at the role of the financial cycle prior to the crisis. We must therefore check whether adjustment to the pre-crisis credit boom is a competing explanation

for the effect we found. The reason for this exercise is that the pattern of real credit growth rates we observe is compatible with the story that those countries that did not implement macroprudential regulation were in the upturn of the financial cycle before the crisis and therefore saw their growth rates adjust accordingly afterwards. In this case, the observed effect would not have anything to do with macroprudential regulation but would rather reflect a standard adjustment to the pre-crisis credit boom. We can test for this alternative explanation by including the credit-to-GDP ratio from just before the crisis from the average of 2006 and 2007, and interacting it with the post-crisis indicator to check for the competing differential effect. As it turns out, however, the result is not significant and the initial stabilising effect remains strong, statistically and economically, as can be seen in column 1 of Table 8.

Table 8: Robustness: competing explanations

Dependent variable: Real credit growth (%)	**(1)**	**(2)**	**(3)**	**(4)**
D_{LEV} x $D_{PostCrisis}$	6.250***	5.256**	6.450**	5.408***
	(2.250)	(2.371)	(2.610)	(1.963)
Pre-crisis credit boom x $D_{PostCrisis}$	0.011			
	(0.032)			
Severity of crisis x $D_{PostCrisis}$		−0.461		
		(0.433)		
Regulatory quality x $D_{PostCrisis}$			2.512	
			(1.759)	
Systemic banking crisis x $D_{PostCrisis}$				−5.103
				(3.160)
Real GDP growth (%)	1.633***	1.541***	1.576***	1.632***
	(0.245)	(0.257)	(0.239)	(0.241)
Monetary policy rate (%)	0.193***	0.205***	0.150*	0.209***
	(0.070)	(0.075)	(0.089)	(0.069)
Country FE	y	y	y	y
Year FE	y	y	y	y
Countries	69	69	68	69
Observations	819	819	806	819
R^2	0.38	0.39	0.38	0.39

Note: The table reports the results of the baseline specification for the period 2002-14 augmented by the interaction term of the post-crisis indicator and i) the pre-crisis credit boom variable (measured as the average credit-to-GDP ratio over 2006/07) in column 1, ii) the severity of the crisis (measured as the drop in the 2009 GDP growth rate) in column 2, iii) regulatory quality (measured as the average of the regulatory quality indicator taken from the World Bank's Worldwide Governance Indicators database over 2002-07) in column 3, and iv) the indicator of a systemic banking crisis in 2007/08 based on the database by Laeven and Valencia (2012,2013) in column 4. The dummy variable D_{LEV} indicates countries that implemented a cap on the leverage of banks prior to the crisis of 2008. The dummy $D_{PostCrisis}$ captures the post-crisis period and is equal to one from the year 2009 on and zero otherwise. Cluster-robust standard errors at the country-level are given in parentheses. ***,**,* denote statistical significance at the 1%, 5%, and 10% levels respectively. All variables are winsorised at the 1% and 99% quantiles.

Another competing explanation might trace the development of post-crisis real credit growth back to the impact of the financial crisis and the severity with which it and the subsequent Great Recession hit those countries. As a consequence of larger losses in real output, credit might grow at lower rates in the following years. We use the drop in the GDP growth rate in the recession year 2009 to measure the severity of the crisis and check its differential effect as part of the specification. As it turns out, the stabilising effect is limited quantitatively by this exercise, so the severity of the crisis might play a role (column 2 of Table 8). However, the severity of the crisis effect is not statistically significant itself and the stabilising effect of the leverage cap remains sizable in economic terms.

A further test of competing explanations involves the effect of the pre-crisis average from 2002–2007 of the regulatory quality indicator provided by the Worldwide Governance Indicators database (World Bank) to test whether the differential effect on credit growth is driven by a higher level of regulatory quality. The results suggest that this is not the case either (column 3). The same holds true for the effect of a systemic banking crisis in 2007/08 measured as a dummy variable drawn from the database by Laeven and Valencia (2012, 2013) in column 4.

5.2. Subsample analysis

The treatment group, consisting of the countries which actually implemented the cap on leverage, is relatively small at only eight in the baseline specification. To make sure that the results are not driven by the impact of one individual country, it is reasonable to check how robust the results are to the exclusion of one of these countries from the sample. This is done in Table 9. The results show that the effect varies somewhat in size but remains statistically significant no matter which country is excluded from the sample.

Table 10 presents the results from four additional robustness checks for different subsamples. There might be other macroprudential measures which affected real credit growth after the crisis, and therefore we estimate the effect using only countries in the control group which did not introduce any macroprudential regulation before the crisis. The results are shown in column 1. Another robustness check considers the subsample of emerging market economies only (column 2).[12] Then we narrow the estimation period down to the years 2005–2012, dividing the period symmetrically into four pre-crisis and four post-crisis years (column 3). To check more carefully that our effect

[12] We do not run the corresponding subsample analysis for the advanced economies because only two of them (USA and Canada) have a leverage cap.

really captures the difference between the post-crisis and pre-crisis periods, we also exclude the explicit crisis years 2008 and 2009 from the sample (column 4). The clear picture that emerges from all of these robustness exercises is that the finding of a stabilising effect on real credit growth from caps on the leverage of banks after the crisis remains valid.

Table 9: Robustness: excluding countries from treatment group

Dependent variable: Real credit growth (%)	**(1)** Canada	**(2)** Chile	**(3)** Ecuador	**(4)** Jordan	**(5)** St. Kitts & Nevis	**(6)** Paraguay	**(7)** Saudi Arabia	**(8)** United States
D_{LEV} x $D_{PostCrisis}$	6.030***	6.026***	6.339***	5.420**	5.422**	5.012**	7.043***	6.790***
	(2.123)	(2.123)	(2.338)	(2.271)	(2.263)	(2.084)	(2.065)	(2.200)
Real GDP growth (%)	1.636***	1.640***	1.641***	1.648***	1.700***	1.627***	1.642***	1.638***
	(0.248)	(0.248)	(0.250)	(0.252)	(0.251)	(0.261)	(0.251)	(0.248)
Monetary policy rate (%)	0.198***	0.198***	0.198***	0.197***	0.198***	0.207***	0.197***	0.197***
	(0.0728)	(0.0727)	(0.0726)	(0.0733)	(0.0724)	(0.0645)	(0.0737)	(0.0731)
Country FE	y	y	y	y	y	y	y	y
Year FE	y	y	y	y	y	y	y	y
Countries	68	68	68	68	68	68	68	68
Observations	812	815	806	806	806	806	806	806
R^2	0.38	0.38	0.38	0.38	0.39	0.39	0.38	0.38

Note: The table shows the results of robustness checks based on the baseline specification over 2002–2014. The country denoted in the header of each column was excluded in that regression. The dummy variable D_{LEV} indicates countries that implemented a cap on the leverage of banks prior to the crisis of 2008. The dummy $D_{PostCrisis}$ captures the post-crisis period and is equal to one from the year 2009 on and zero otherwise. Cluster-robust standard errors at the country-level are given in parentheses. ***,**,* denote statistical significance at the 1%, 5%, and 10% levels respectively. All variables are winsorised at the 1% and 99% quantiles.

Table 10: Robustness: subsample analysis

Dependent variable: Real credit growth (%)	**(1)** No Macro-Pru	**(2)** Emerging economies	**(3)** 2005–2012	**(4)** Exclude 2008/09
D_{LEV} x $D_{PostCrisis}$	7.800*	7.759***	6.191**	7.232***
	(4.145)	(2.598)	(2.720)	(2.353)
Real GDP growth (%)	1.223***	1.664***	1.625***	1.823***
	(0.257)	(0.301)	(0.227)	(0.297)
Monetary policy rate (%)	−1.013	0.211***	−0.194	0.231***
	(0.741)	(0.066)	(0.177)	(0.070)

Dependent variable: Real credit growth (%)	**(1)**	**(2)**	**(3)**	**(4)**
Country FE	y	y	y	y
Year FE	y	y	y	y
Countries	24	44	69	69
Observations	275	529	521	689
R^2	0.41	0.39	0.43	0.40

Note: The table shows robustness checks for various subsamples following the baseline specification. Column 1 shows the results of the specification which only includes countries as part of the control groups which did not implement any macroprudential policy measure prior to the crisis. Column 2 reports results for the subsample of emerging economies only. Column 3 reports results for the estimation period 2005–2012. Column 4 reports results excluding the years 2008/09 from the estimation. The dummy variable D_{LEV} indicates countries that implemented a cap on the leverage of banks prior to the crisis of 2008. The dummy $D_{PostCrisis}$ captures the post-crisis period and is equal to one from the year 2009 on and zero otherwise. Cluster-robust standard errors at the country-level are given in parentheses. ***,**,* denote statistical significance at the 1%, 5%, and 10% levels respectively. All variables are winsorised at the 1% and 99% quantiles.

6. Conclusions

The purpose of the study is to investigate empirically the effect of a cap on banks' leverage on credit growth after a financial crisis. The results give information on how macroprudential policy works with an instrument that has recently been put in place as part of the Basel III regulatory framework on banking supervision.

We approach the question by applying a difference-in-differences approach to a panel of 69 advanced and emerging market economies over the period 2002–2014. We compare the growth rate of real credit before and after the crisis across groups of countries that had a leverage cap prior to the crisis and those that did not. The results show the leverage cap to have a stabilising effect on real credit growth. The stabilising effect is of about six percentage points. It is higher for countries with a higher aggregate bank capital ratio prior to the crisis. This finding is in line with the interpretation that the leverage cap made banks build up buffers before the crisis, which they could draw on after the crisis had hit to continue lending to the private sector. The stabilising effect on credit to the private sector was the most important part of a generally stabilising effect on the growth of banking assets after the crisis. The findings are robust to various robustness checks. In particular, the adjustment to the pre-crisis credit boom and the severity of the crisis can be ruled out as competing explanations.

A comprehensive analysis of the cost and benefits of the implementation of a cap on the leverage of banks is beyond the scope of this paper. Still, the results point towards a potentially stabilising role of such macroprudential policy instruments in financial downturns. This is a dimension of the overall effect of macroprudential policy that should be incorporated into a comprehensive cost-benefit analysis of the regulatory trade-off. In this sense, this study is complementary to existing empirical analyses because it highlights the ex-post rather than ex-ante dimension of macroprudential policy. This holds true in particular considering that even if macroprudential policy is effective in smoothing financial cycles, it might not be able to prevent future financial downturns and crises from happening after all. Therefore, the question of whether and through which channels macroprudential policy helps in stabilising the real economy during financial downturns remains an interesting area for further research.

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Appendix. Data

Domestic credit to the private sector: Data on credit to the private sector by resident banks are taken from the IMF Other Depository Corporation Survey, which is part of the International Financial Statistics (IFS). The series was complemented by the series on private credit-to-GDP ratios from the World Development Indicators (WDI) database, which was multiplied by nominal GDP. The credit series in local currency units was deflated using the yearly CPI index from the IMF IFS.

Macroprudential policy tools: The information on the implementation of the leverage cap and on other macroprudential measures (borrower and financial institutions-targeted macroprudential index) is taken from the dataset provided by Cerutti et al. (2015). The dataset is based on the Global Macroprudential Policy Instruments (GMPI) survey conducted by the IMF and can be accessed via the following link:
http://www.imf.org/external/pubs/cat/longres.aspx?sk=42791.0

Macroeconomic control variables: Data are either taken from the IMF International Financial Statistics (IFS) or the World Development Indicators (WDI) by the World Bank (both databases accessed via Datastream). In detail:

- Real GDP growth rate (in %): Based on GDP in constant 2005 USD (IMF IFS).
- Monetary policy rate (in %): Based on the central bank policy rate. When this was unavailable, the money market rate was used instead. When that was also unavailable, the discount rate was used (IMF IFS).
- CPI inflation rate (in %): Based on the consumer price index taken from the IMF IFS.
- Private credit-to-GDP ratio (in %): Series on domestic credit to private sector (in % of GDP) taken from the WDI database.
- GDP per capita: The series in current international USD is taken from the WDI database.

Regulatory quality: The indicator ranges from −2.5 (weak) to 2.5 (strong) and is taken from the Worldwide Governance Indicator (WGI) database of the World Bank. See Kaufmann et al. (2011) for details.

(Systemic) banking crisis, sovereign debt crisis, currency crisis: The indicators are taken from the database by Laeven and Valencia (2012, 2013).

Aggregate balance sheet variables: The variables total assets and claims on the subsectors of the economy (non-financial private sector, non-residents,

public sector (central plus state/local government), central bank), and the ratio of equity capital (position: Shares and Other Equity) to total assets are taken from the Other Depository Corporation Survey, which is part of the International Financial Statistics (IFS) by the IMF.

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