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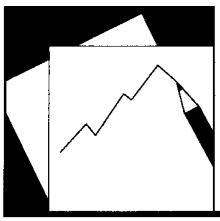

IMF Working Paper

Evaluating the Net Benefits of Macroprudential Policy: A Cookbook

Nicolas Arregui, Jaromír Beneš, Ivo Krznar, Srobona Mitra, and Andre Oliveira Santos

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Evaluating the Net Benefits of Macroprudential Policy: A Cookbook

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Abstract

The paper proposes a simple, new, analytical framework for assessing the cost and benefits of macroprudential policies. It proposes a measure of net benefits in terms of parameters that can be estimated: the probability of crisis, the loss in output given crisis, policy effectiveness in bringing down both the probability and damage during crisis, and the output-cost of a policy decision. It discusses three types of policy leakages and identifies instruments that could best minimize the leakages. Some rules of thumb for policymakers are provided.

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EVALUATING THE NET BENEFITS OF MACROPRUDENTIAL POLICY: A COOKBOOK

I. MOTIVATION

1. **The main contribution of the paper is to provide a unified framework for assessing net benefits of macroprudential policy, together with guidance on assessing policy leakages.** The paper suggests a simple conceptual framework for comparing the costs with benefits of macroprudential policy.[2] The concept of long-run cost and benefit is adopted from BCBS (2010a), albeit with differences in detail. The costs arise from an increase in the cost of intermediation and its effect on long-run output. The benefit is derived from the resilience of the economy from the policy measure—a reduction in the probability of a crisis and output losses in the event of a crisis. As a bi-product, the paper also suggests a method for analyzing feedbacks between the financial sector and real economic activity that could be useful for policy makers in general. [3]

2. **Existing literature has tackled some aspects of the net benefits to macroprudential policies.** Most studies focus on long term costs and benefits of macroprudential regulation (higher capital and liquidity requirements, most prominently) with the exception of BCBS (2010b) that also studies transitional costs. Long term quantitative studies follow similar methodologies but with different assumptions or estimation techniques (see ICFR, 2011, for a comparative summary of different studies). Benefits are generally defined as a reduction in expected crisis costs. The emphasis is more on the effect of regulation on the probability of a crisis, and less on the effect of regulation on the depth of a crisis. In terms of costs, most papers relate regulations to credit and output through the intermediate effect of regulation on lending spreads. While a few studies mention the risks posed to financial stability by regulation-induced growth in shadow banking, such side-effects/leakages are considered only qualitatively. A review of the literature on costs and benefits is provided in Annex 1.

3. **This paper takes a broader perspective on analyzing the net benefits of policy.** The starting point of the analysis rests on the notion that macroprudential policies are needed to dampen the effect of three externalities, as described in De Nicolo, Favara, and Ratnovski (2012) (DFR henceforth). The paper uses indicators to describe two of the three externalities and assumes that macroprudential policies are aimed at these indicators that serve as

[2] This paper takes the view established in IMF (2011a, 2013) that the prime objective of macroprudential policy is to limit the build-up of system-wide (*systemic*) financial risk: risks arising in the financial system and risks amplified by the financial system.

[3] For the interactions of macroprudential policies with other policies, see IMF (2013) for monetary policy and Osiński et al (2013) for microprudential policy.

intermediate targets to limit systemic risks.[4] If systemic risk is correctly identified and policy is successful in either avoiding or reducing the effects of a crisis, systemic risk is lowered, and the economy is presumed to be on a higher level of real economic activity in the long-run. However, there are costs imposed on intermediation and output associated with (1) higher price and lower volume of intermediation during normal times, and (2) mis-identification of risk or over-regulation ("type II error").

4. **The analysis contributes to new insights on a number of fronts.** So far, the cost and benefits of regulation have been discussed in the context of the Basel III rules (BCBS, 2010a and 2010b, Elliott and Santos, 2012). Even though there is some work done on analyzing the effects of macroprudential policies, there is none that uses a cross-country database of a range of macroprudential policy instruments that are currently in use by countries (except for Lim et al, 2011 and Vandenbussche et al, 2012). This paper fills the gap by using the IMF (2011c) survey (henceforth, Survey) and a new dataset compiled by Lim et al (forthcoming). Cross-country empirical evidence is essential to this analysis, because of the lack of sufficient number of crisis-episodes in individual countries. Although the structure of individual economies may vary, it is still useful to extract the common characteristics before, during and after crisis using panel data techniques. The paper also uses a time-series model for the U.S. to derive sensitivities of real GDP forecast to credit aggregates—basic macro-financial linkages—with asymmetric effects during normal and crisis times. Last, but not least, this paper analyzes leakages or unintended consequences of macroprudential policies, based on cross-country evidence and case studies.

5. **The goal is to set up the *components* of a core semi-structural model.** The model would provide real-time estimates of the medium-to-long-term trend in real economic activity, and its interactions with indicators of macrofinancial externalities (the intermediate targets). This model would bring together the various parts of the exercise—estimating probability of crisis, loss given crisis, effects of policy, forecast of real activity and intermediate targets—into one model. Although this core model is not yet ready to be discussed, all the components are introduced in this paper.

6. **The strategy will be a multi-step process, providing the key ingredients that would go towards assessing the net benefits of policy.** The paper will first present a conceptual framework to assess costs and benefits of policy in terms of parameters that can be estimated—probability of crisis, loss in output given crisis, policy effectiveness in

[4] DFR (2012) classifies three externalities that require MPP: externalities related to (1) strategic complementarities that lead banks to take excessive or *correlated risks and build up vulnerabilities during the expansionary phase* of the financial cycle; (2) *fire sales*, that causes a decline in asset prices amplifying the contractionary phase of the financial cycle; and, (3) *contagion*, caused by the propagation of shocks through financial networks. This paper will mostly deal with the first and partly with the second externality. See Scarlata et al (forthcoming) for analysis related to the third externality, interconnectedness and contagion.

bringing down both the probability of and loss during a crisis, and the cost of policy (Figure 1). Then it will provide some numbers and estimates for the building blocks in section III.

7. **The steps are as follows:**

- *When to Act.* Summarize the effectiveness of *early warning indicators*, and the role of credit aggregates in deciding when to act (Section II).

- *Concept.* Set up a simple conceptual framework for understanding the net benefits of policy expressed in terms of parameters that can be estimated (Section II). These ingredients would then be part of the *core analytical model*.

- *Policy Effectiveness.* Evaluate the effectiveness of *policy in lowering systemic risk indicators* (credit growth, loan/deposit ratios, asset price growth, foreign liabilities growth) (Section III).

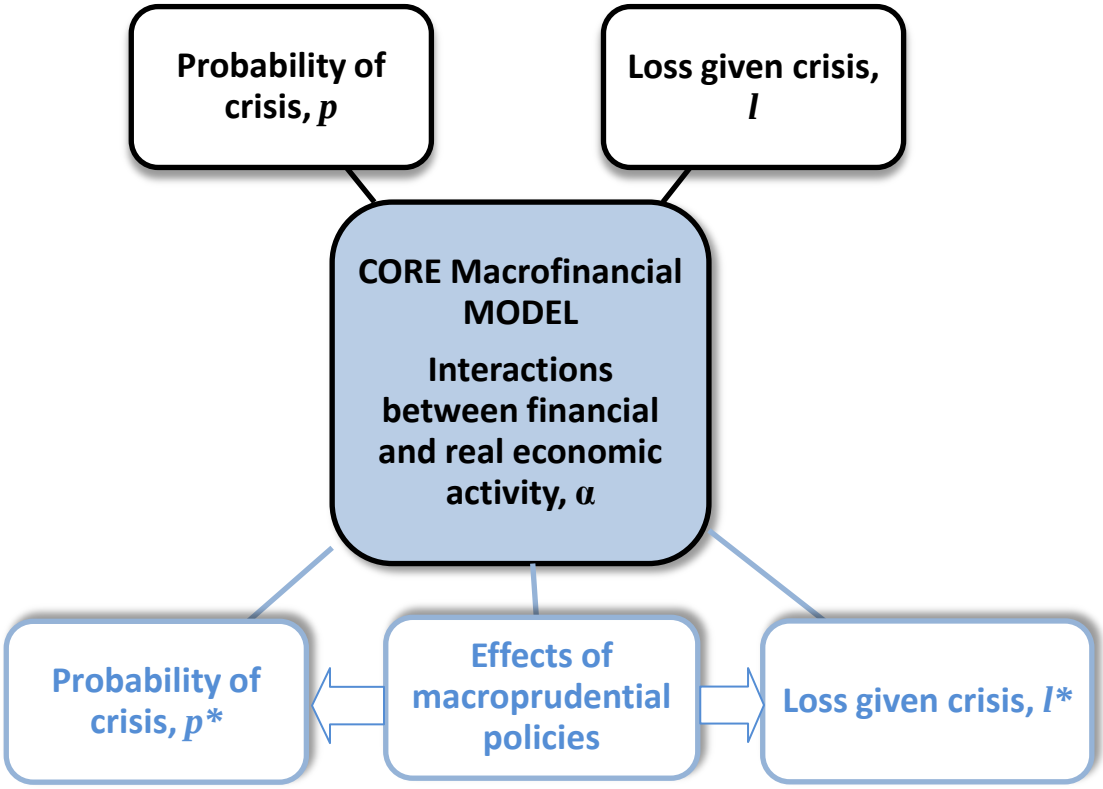
- *Benefits.* Estimate the effect of change in systemic risk indicators on the *probability of a crisis* and *depth of the output loss during a crisis* from cross-country data (Section III), by extending the analysis in IMF (2011b) to a panel-logit model.

- *Cost.* Compute the *cost of policy* by estimating the effect of change in the intermediate target (due to policies) on the forecast for GDP. This will be done with an empirical model with asymmetric macro-financial sensitivities based on whether the banking system is in a 'normal' or 'distressed' state (Section III).

- *Leakages.* While leakages from macroprudential policies are not directly included in the core analytical model, some new findings on policy side-effects will be discussed (Section IV).

Section V will conclude with takeaways and basic rules-of-thumb that would provide practical guidance for policymakers. In many cases, country circumstances and structures will require a more selective approach.

Figure 1. Structure of the Analytical Framework



II. An Analytical Recipe: The Ingredients

A. Systemic Risk Indicators: When and Whether to Act

8. **Policy instruments seek to target certain market failures or externalities.** While externalities are hard to observe, some indicators could help detect their presence or their outcomes. Thus policies would target these intermediate indicators, which are seen to be manifestations of market failures. For instance, rapid credit growth during boom times could be the result of "strategic complementarities that lead banks to take excessive or correlated risks and build up vulnerabilities during the expansionary phase of the financial cycle" (DFR, 2012). Therefore, policy would be effective if it could bring down the speed of credit growth. Similarly, indicators of funding-liquidity risk and market-liquidity risk could be used as intermediate targets for externalities related to fire sales—a generalized sell-off of financial assets causing a decline in asset prices and a deterioration of the balance sheets of intermediaries, especially during the contractionary phase of a financial cycle. Policy instruments that are able to lower a liquidity risk indicator would succeed in lowering the risk of fire sales.

9. **Having said that, early warning indicators are imperfect at measuring the risk of a financial crisis.** Previous studies have shown that rapid credit growth and credit booms signal a banking crisis (Laeven and Valencia, 2010) 2-3 years before the event (IMF, 2011b & 2012a, Lund-Jensen, 2012, Dell'Ariccia, Igan, Laeven, Tong, 2012, BCBS, 2010c, Drehmann and others, 2012). Even so, out-of-sample analysis show that credit growth (and gap measures) produced very low (but increasing) probabilities of crisis before 2007 (IMF, 2011b). Thus, while deciding on when to act, policy makers need to compare the *possible* benefits of avoiding a crisis and/or reducing the depth of a crisis, with the cost of tightening up on intermediation (and activity) now. They need to consider the imperfect nature of the signal and the possibility of over-regulation—that is, the risk that they would be acting upon a signal that could be false (a "false positive") in the first place. On the other hand, they might be eager to avoid financial crisis at any cost. Thus, *when* they act depends upon whether they prefer to mitigate risks at the earliest time a signal detects an elevated risk, or they would rather wait it out and see if the signal is durable.

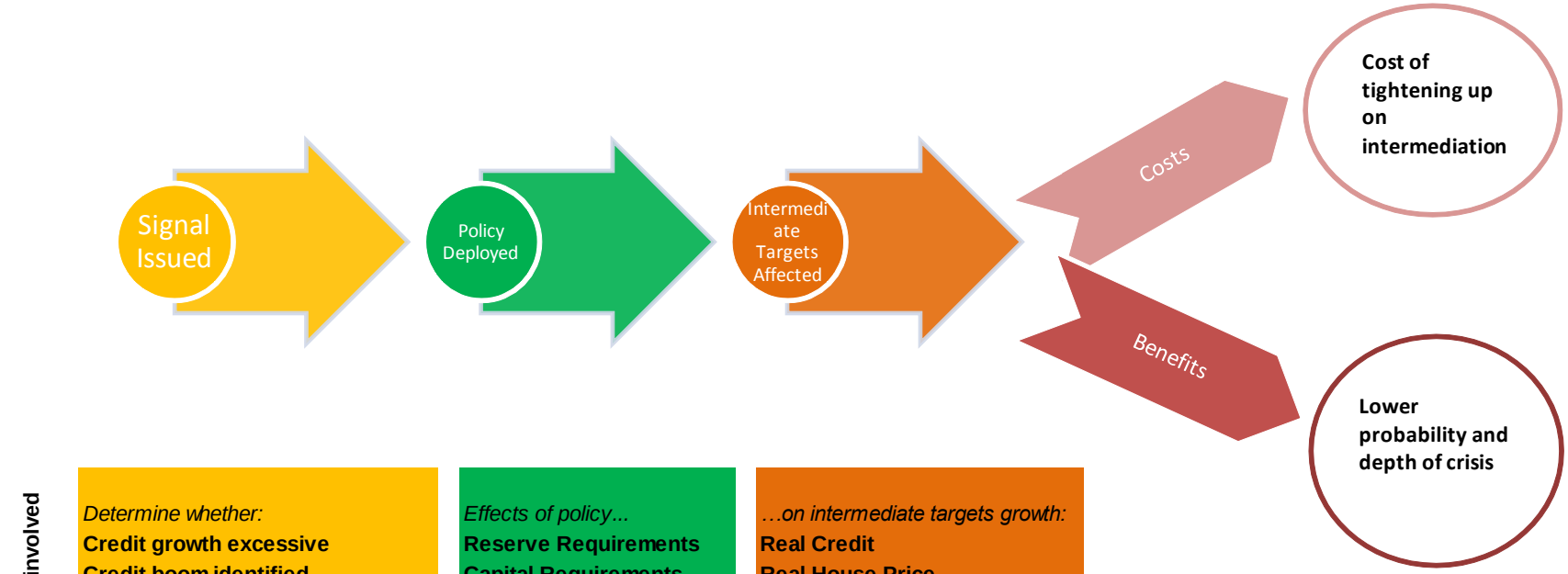
10. **Credit aggregates are useful to guide policy, especially to inform tightening of policy, by using appropriate thresholds.** Two studies that examine thresholds are IMF (2011b) in the Global Financial Stability Report (GFSR) and Dell'Ariccia et al (2012).[5] Comparing the GFSR threshold (3-5 percentage point annual change in the credit-GDP ratio) with the Dell'Ariccia et al threshold for defining credit booms (henceforth, Boom) shows that the GFSR threshold (that tries to avoid crisis at any cost) is triggered earlier and much more often than Boom (also see Annex 2).[6] If a Boom is identified, then the GFSR threshold is breached for over 70 percent of the cases (Table 1). On the other hand, if a GFSR threshold is identified, the Boom threshold is breached in about 30 percent of the cases. *Expressing concern when the GFSR threshold is breached and escalating the concern and taking policy action by the time the Boom threshold is breached provides a meaningful range for policy implementation* and could enhance transparency and market discipline.[7]

[5] Although formal techniques and models provide measures of thresholds, it is always necessary to incorporate a large amount of judgment in making a decision. What constitutes a healthy, sustainable credit expansion, and what is a risky credit bubble will always be based on a large number of formal and informal observations and considerations specific to a country. However, it is also useful to be guided by common characteristics of rapid credit expansions so that policymakers are not complacent with a "this time is different" (Reinhart and Rogoff, 2009) kind of mentality.

[6] Dell'Ariccia et al (2012) define a credit gap measure as the percentage deviation of credit-to-GDP from a backward looking, rolling, cubic trend estimated over the period t-10 and t-1. A credit boom is identified when: the deviation from trend is higher than 1.5 times its standard deviation and the annual growth of the credit-to-GDP exceeds 10 percent, *or* the annual growth of the credit-to-GDP exceeds 20 percent. The concept of gap is akin to BCBS (2011) although the methods for deriving the trends are different.

[7] Note that credit aggregates are not informative in signaling the *arrival* of crisis. See Arsov et al (2013) for a discussion of the power of "near-coincident" indicators in signaling crisis arrival.

Figure 2. Policy Time Line



Steps involved	*Determine whether:* **Credit growth excessive** **Credit boom identified** **Liquidity risks are high**	*Effects of policy...* **Reserve Requirements** **Capital Requirements** **Provisioning** **Loan-to-Value limits** **Debt-to-Income limits**	*...on intermediate targets growth:* **Real Credit** **Real House Price** **Loan-Deposit Ratio** **Foreign Liabilities/ Foreign Assets**	**Effect on (forecast of) Output**
Main References	IMF(2011b) Dell'Arriccia et al (2012) De Nicolo, et al (2012) New staff estimates	Lim et al (forthcoming) New staff estimates	New staff estimates	New staff estimates and conceptual framework BCBS (2011a)

11. **To avoid underestimating risks, policy makers should include credit from all types of lenders, not just commercial banks.** A case in point is the United States where nonbanks are significant players, especially in the consumer and mortgage lending markets (Box 1). Here, commercial bank credit alone greatly underestimates crisis risks and signals—neither the GFSR nor the Boom crosses their respective thresholds for the United States since 2000 (Annex 2). However, changes in consumer credit-GDP ratio (when measured properly) would have done so by 2003.

12. **In reality, policymakers are more likely to look at several indicators to gauge building up of systemic risk.** As explained in Blancher et al (2013)'s forthcoming "SysMo" project, different models and methods need to be combined to arrive at the decision on when and whether to act. For instance, indicators and models related to risks building up within the financial sector should be combined with asset price models to see if there is sectoral overheating. In addition, crisis prediction models are helpful in tracking the probability of crisis. Amplification channels could be explored to see if sectoral overheating is feeding into credit growth (for instance, rapidly increasing house prices lowering collateral constraints on consumption and lending behavior) and vice versa. A policy maker typically makes a decision partly based on these various combinations of models and partly on some judgment.

Table 1. Thresholds for Credit Growth
(Number of occurrences)

	GFSR	No GFSR	Probability of GFSR given Boom	Probability of Boom given GFSR
Boom	379	146	379/(379+146)	379/(379+921)
No Boom	921	4415	= 0.72	=0.29

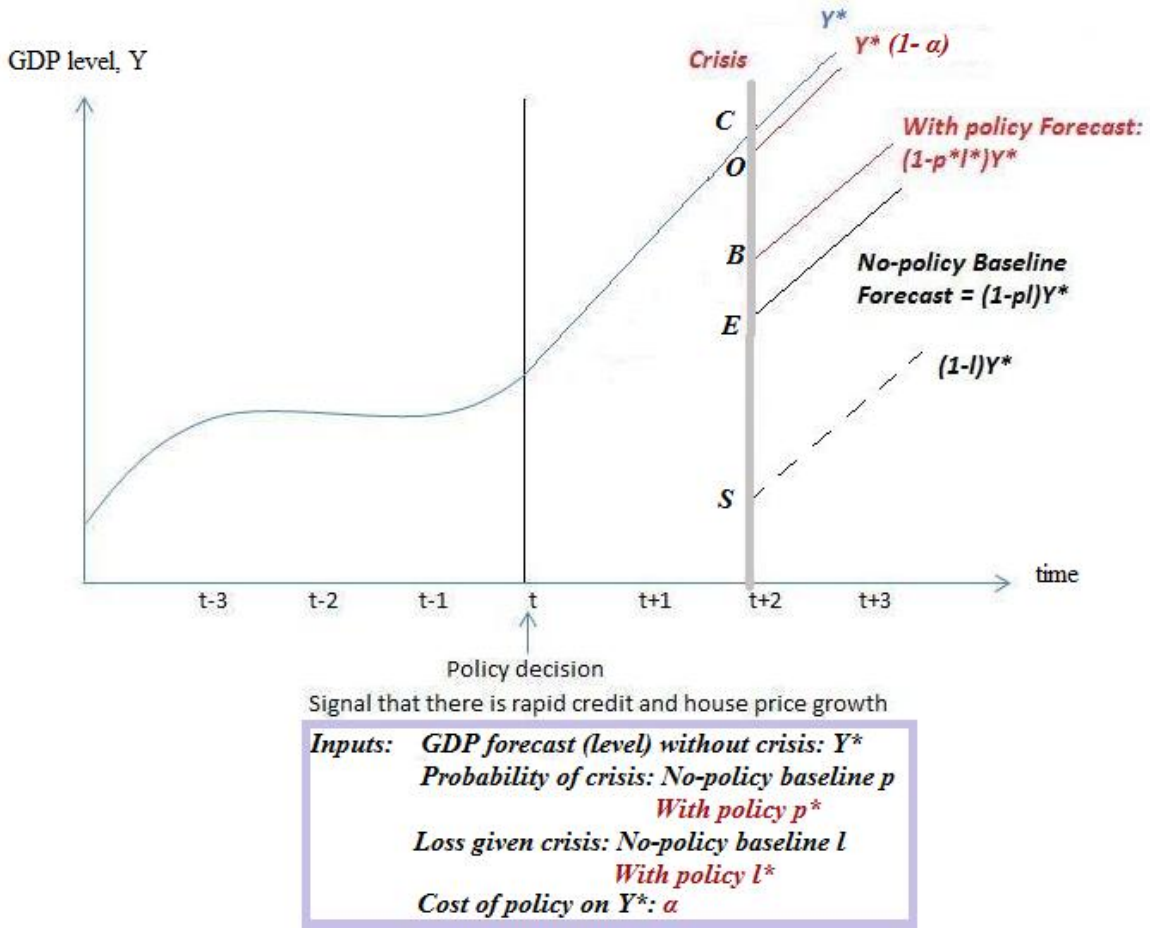
Note: The table shows the number of occurances across 183 countries from 1966 to 2010 when thresholds were breached. GFSR refers to the threshold of changes in credit/GDP ratio of 3 percentage points. "Boom" refers to the threshold in Dell'Ariccia et al (2012). See Annex 2.

B. Conceptual Framework for Assessing Net Benefits of Policy

13. **Having decided on when to act, policymakers need to assess the net benefit of any policy action on the long-term level of GDP.** The paper assumes that the ultimate objective of policy is to bolster the long-term trend in real economic activity against permanent blows arising from financial crisis. The discussion of costs and benefits is, therefore, positioned in terms of the long-term forecast for GDP. At the juncture at which policymakers are taking the decision to act, they need to know the path of future output—the expected path given the probability of a crisis and the loss in output level in the event of a crisis. In Figure 3, a policy decision is taken at time t due to a signal that systemic risk is rising, and that the probability of a crisis in the not-so-distant future (as an example, within

the next two years) has grown significantly. The blue line is the forecast of output (elaborated in the next section). If there is no crisis, the long-term level of output at t+2 will be Y*.[8] With some probability, *p*, there will be a crisis with Y dropping to Yc (shown as output dropping to S) . So the expected level of Y_{t+2}, will be somewhere between Y* and Y_C. If *p* is high, the expected level will be closer to Y_C, otherwise it will be near Y*.

Figure 3. Cost and Benefit in terms of output level—Schematic Representation



14. **Macroprudential policy that affects an intermediate target, like credit growth, has both costs and benefits.** Policy is expected to bring down the probability of crisis from *p* to *p** and the loss given crisis from *l* to *l**, recognizing that it may not eliminate crisis fully but build resilience for the financial sector. At the same time, if the probability of crisis was largely overestimated, then policy is costly by bringing down the level of intermediation and

[8] Y* can represent the sum of forecast at Y_{t+2} and the present discounted values of forecasted output growth over the medium term.

the forecast for output that would have materialized without a crisis. If there is no crisis, output will be lower than Y* by a factor α—reflecting the dampening of activity from harnessing rapid credit growth. The no-policy expected output is at E (taking into account the probability and depth of crisis) and the forecast *with* policy is at B if the probability and depth of crisis are both reduced; thus, BE is the benefit from policy. The cost of policy is the reduction in the trend from C to O in Figure 3.

15. **This paper introduces a simple analytical way of representing cost and benefit of policy.** The analysis is carried out comparing the forecast for the output level 2 years from t (in the example above), with and without policy. To present the idea conceptually, the entire future path for output (and other variables) is summarized in one data point. Expected output level at t+2 is denoted by Y_{t+2} (or Y* in Figure 3) if there is no crisis. Crisis occurs at t+2 or at a future date with probability, p, which depends upon the levels of early warning indicators. If crisis occurs, the output forecast drops by l, which can also depend upon the intermediate targets. If the probability of crisis is nearly certain, 1, then expected output level is $(1-l)Y_{t+2}$. If crisis probability is very low, say zero, then the forecast is simply Y_{t+2}. Thus, expected output is given by (1) as:

$$(1) \quad p(1-l)Y_{t+2} + (1-p)Y_{t+2} = (1-pl)Y_{t+2}$$

When policy is introduced, both *p* and *l* can be lower. At the same time, by lowering intermediation levels (for instance, credit growth), the output forecast at t+2 is also lower by some factor α, to $(1-\alpha)Y_{t+2}$. This factor depends upon the sensitivity of output to the intermediate targets and other second-round macro-financial linkages that are expected to differ during crisis and non-crisis times. Expected output *with* policy is, therefore, given by:

$$(2) \quad p^*(1-l^*)(1-\alpha)Y_{t+2} + (1-p^*)(1-\alpha)Y_{t+2} = (1-p^*l^*)(1-\alpha)Y_{t+2}$$

16. **For policy to pay off, the *ex ante* net benefit should be positive.** Expected output after policy, (2) should be higher than expected output in the absence of policy, (1). In other words, policy makers should act if

$$(3) \quad (1-p^*l^*)(1-\alpha) \geq (1-pl)$$

Another way of representing the above is:

$$(3.1) \quad \frac{1-p^*l^*}{1-pl} - \frac{1}{1-\alpha} \geq 0$$

This is a simple, static, way of understanding the concept of cost and benefit of policy, expressed in terms of things that can be estimated. As mentioned above, all the terms, p , p^* , l , and l*, are functions of the intermediate targets, including credit aggregates. Once the policymaker gathers all the ingredients, it will be relatively easy to compute the cost and the benefits of policy. The first term on the left hand side (LHS) of the expression in (3.1) is the benefits of policy; it increases with the difference between p and p^* , and that between l and l^* . That is, the benefits rise with policy effectiveness. The second term is the cost; it increases with α that depends upon the sensitivity of output to credit supply and other intermediate targets affected by policy, when the financial sector is healthy.

17. **The simple setup does not take account of two unseen 'costs'—imperfections of the early warning indicators and policy leakages.** One way to incorporate the imperfections of the signal is by including a term that represents the 'noisiness' of the signals or the noise-to-signal ratios (NSR)—the possibility that the signal is false or the crisis is missed (see IMF, 2011b, for NSR analysis and CGFS, 2012, for including NSR in cost-benefit analysis). But, given the wide range of thresholds for certain indicators (see Table 1 for credit aggregates), and the various models and judgment that policy makers are likely to use to take a decision, it is difficult to know how to assign NSRs to the term in (3). Costs of imperfections in signals could be lower when credit growth is starting to be rapid, simply because the source of the rapid growth might be better identified and appropriate policy applied.[9] As the boom progresses, there could be cross-sectoral feedback loops (for instance, going from real estate prices to credit to real estate prices again) that might make the true source of the problem difficult to identify and to pin down by policy. The sensitivity of output to intermediate targets could be higher as the amplification channels start operating at full force, resulting in higher α . Policy leakages, on the other hand, reduce the effectiveness of the policies—reducing the differences between p and p* and l and l*. The issue of leakages is explored in Section IV.

18. **The actual practical implementation of this framework will be much more complex.** This is because all interactions between output, risk and policy will be dynamic, and so will be the policy criterion (e.g., a discounted sum of output over a certain medium-to-long run horizon). Besides, in this example, a binary response variable (crisis or not) at a fixed moment of time is used to describe the occurrence of a financial crisis. In a more realistic model, this will need to be replaced with a time-varying multivariate probability distribution.[10]

[9] As was shown through a DSGE model in IMF (2011b), if policymakers mistake a healthy productivity boom for an unhealthy boom, then policies could derail the economy permanently on a lower path of real economic activity.

[10] It is assumed that crises result in net loss of the level of GDP in the medium-term as in Cerra and Saxena (2008) and IMF (2009).

19. **A few insights come out from the simple expression.** For instance:

- Net benefits do not kick in when the probability of crisis is very low, everything else constant. That is, probability is so low that even fully effective policies do not make a significant difference between *p* and *p**.
- Net benefits are extremely sensitive to how intermediate targets affect the output forecast, the sensitivity of which is given by α .
- Net benefits rise with policy effectiveness. Policies that lower both the probability and the depth of a crisis, that is both *p** and *l**, have significantly higher net benefits.

20. **Therefore, several empirical building blocks (Figures 1 and 3) are required to compare costs to benefits and these are discussed in more detail in the next section:**

a. An early warning system that alerts policymakers 2-3 years ahead of a crisis.

b. Sensitivity of a forward-looking measure of output, Y_{t+2}, to intermediate targets, α .

c. An estimate of the probability of crisis, p , and the loss in level of output in the event of a crisis, l .

d. The effectiveness of policy instruments on dampening growth in intermediate targets, and the effect of a reduction in intermediate targets on the probability of crisis, p^* , and output loss given a crisis, l^* .

III. Analytical Building Blocks: Measurements

A. Baseline—No-Policy Expected Output

21. **To examine costs and benefits of macroprudential policies, policymakers have to start from a baseline forecast for output and the intermediate target.** The baseline for expected output without policy should incorporate policymakers' best guess of the future path of economic activity and intermediation, *taking into account the risk of a crisis*. First, a method is needed for estimating the real-time forecast of activity or the forecast at time *t+h* periods ahead, taking into account information as of time *t*. Second, the probability and the cost of the crisis need to be computed. Third, the forecast for activity needs to be adjusted for the risk of a crisis (see Section II, expression 1).[11]

[11] All of these steps can be estimated in one model but the technical tools to do so need to be developed. In this paper, these are done separately.

Real-time forecasts and real-financial sensitivities (α)

22. **For the purpose of this paper, the 'trend' is defined as the long-horizon forecast of the level of a series.** In the previous section, this is the forecast of real activity in the two-year horizon (see Figure 3) as of time t. Since this forecast is based on actual observations or information at time t, it is a real-time estimate of the trend. It is important for the forecast at t+2 to be forward-looking. In this respect, the Beveridge-Nelson (BN) concept of the trend is intuitively appealing: an estimate of where the variable will be in the distant future, especially if there are unpredictable variations in the data (Beveridge and Nelson, 1981; Nelson, 2006). However, the choice of the mechanism to estimate the trend is left to the policymaker.

23. **A buildup in financial sector risk affects the forecast of GDP and this effect changes with the state of the banking sector.** A bivariate model based on U.S. data for GDP and credit-to-GDP gap is estimated in this paper (Annex 3). The model produces medium-term forecasts for output conditional on the state of the banking sector.[12,13] The role of credit for the GDP forecast changes according to the state of the banking sector, and the state is proxied by a systemic financial stress index (Arsov et al, 2013).[14]

24. **Estimates of the bivariate model point to modest direct linkages between credit and GDP forecasts during normal times, but significant linkages during distress.** Results show that a 1 percent increase in the credit-to-GDP gap amount to *improvements* in the GDP forecasts by about 0.2 percent on a 4-6 quarter-ahead horizon if there is no banking sector distress. However, the same 1 percent increase in credit-to-GDP gap will *reduce* the GDP forecast by about 1 percent (based on the same forecast horizon) in times of large banking distress (Figure 4 and Annex 2). This also means that if policymakers reduce credit growth by 1 percentage point through macroprudential policies, the GDP forecast in the medium term would dip by only about 0.2 percent if there is no crisis, but will *improve* by 1

[12] The methodology combines two approaches: (1) local linear projection method to make the results robust to misspecification and (2) smooth-transition technique to describe how the transmission between real economic activity (real GDP) and macrofinancial developments (credit-to-GDP gap) change when the economy switches from normal to distress episodes.

[13] Another model is the Systemic Risk Monitoring System (De Nicolo and Lucchetta, 2010) that forecasts in real time systemic real and financial risks, using indicators of financial and real activity and quantile regression techniques. This model is more useful as an early warning indicator than for real time forecasts for the level of the series.

[14] The index is the fraction of big banks (17 in the US) that are experiencing negative equity returns (excess of the S&P500 returns) below the 5th percentile left-tail of the joint distribution of such excess returns of all banks across time. To qualify for it to be a stress episode, the bank should have, in addition to excessively negative returns, cumulative negative excess returns over the following two weeks.

percentage point (that is, the output loss will be reduced) if there is indeed a crisis.[15] The former is an estimate for the size of α (=0.002 for every percentage point of credit growth), introduced in the last section, for the U.S. economy.[16] This finding is consistent with other papers such as Schularick and Taylor (2012) who find that excessive leverage and build-up in credit prior to the crisis results in more severe and prolonged downturn in real economic activity. This is also in line with cross-section estimates of the sensitivity of output cost during a crisis, *l*, to past credit developments (Annex 4).[17]

Probability of a financial crisis (p)

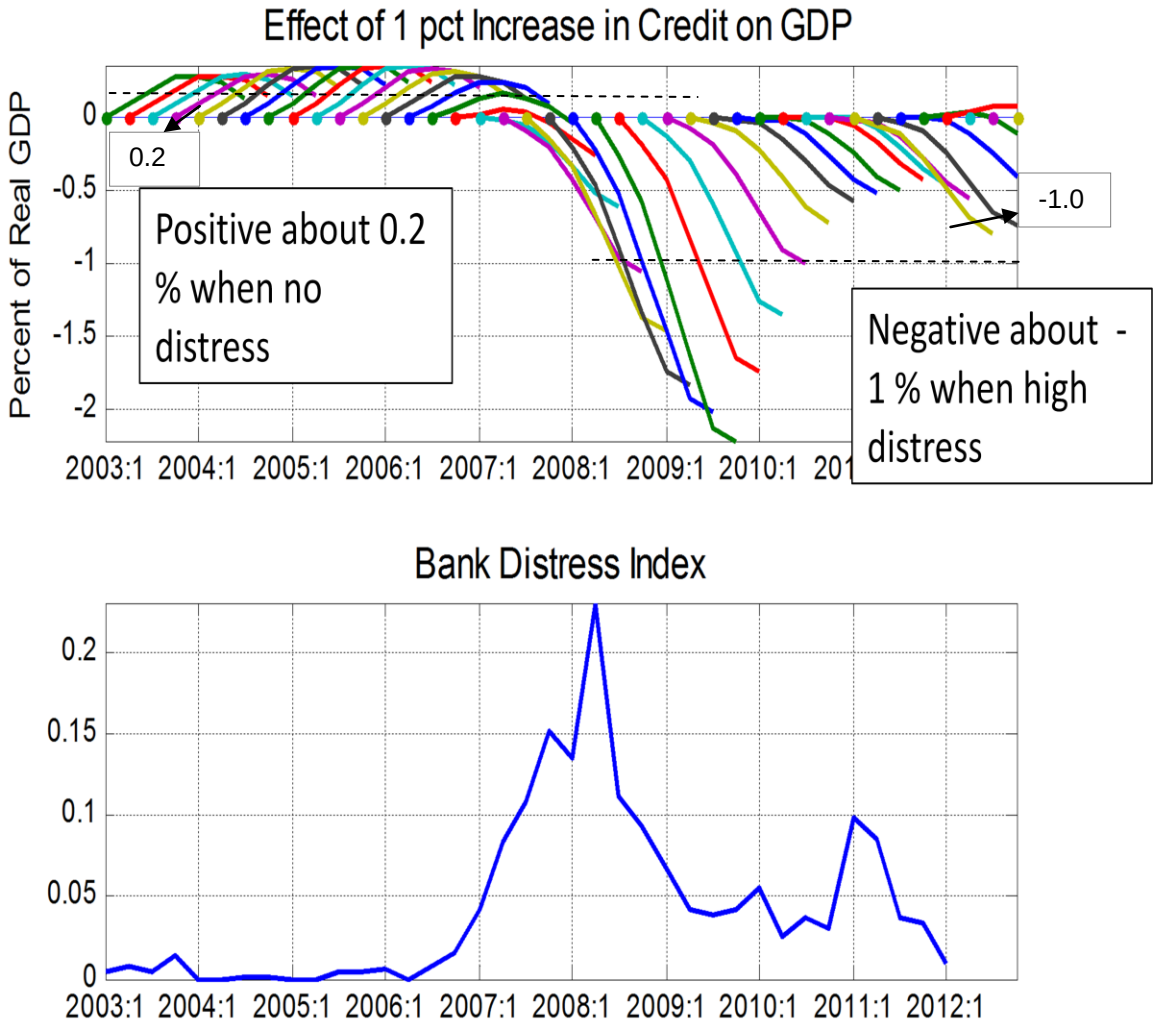
25. **Early warning indicators are used to estimate the probability of a financial crisis.** Following up on work done in IMF (2011b) and Lund-Jensen (2012), a panel logit model is used to estimate a crisis-probability 2-years ahead using credit growth and asset price growth. While equity price growth was used in IMF (2011b), real house price growth is used in this paper, together with changes in the credit-to-GDP ratio to estimate the probability of banking crisis. The analysis uses the insights that there are "good" and "bad" episodes of credit growth and that policymakers pay particular attention to fast house price growth if credit growth is also high. What started the rapid credit growth might be hard to detect but it is more likely that rapid house price growth together with rapid credit growth could end up badly. A threshold of credit-to-GDP growth of 3 percentage points is used to detect rapid credit growth. This model can itself be used as a benchmark for all countries—given limited occurrences of financial crises in any one country's history—and is fairly robust to different sub-sample analysis (advanced versus all economies), methods and time-periods (see Annex 5 for details).

[15] See IMF (2013) that shows modest cost of policies over the credit cycle. The difference between this paper and IMF (2013) is that the cost is being estimated for the level of the output forecast, not for the cycle.

[16] Note that, for the United States, the credit data includes consumer and mortgage credit from all sources, not just banks, and is derived from the Federal Reserve Board (Box1).

[17] These effects are not exactly comparable to those reported in Elliott and Santos (2012) and BCBS (2010). While the latter measure the effects of Basel III capital and liquidity requirements on credit spreads and output directly, the empirical estimates in this paper measures the *sensitivities of past credit on GDP forecasts* during normal and distressed times. Thus, these estimates of policy on output are indirect and operate through credit aggregates.

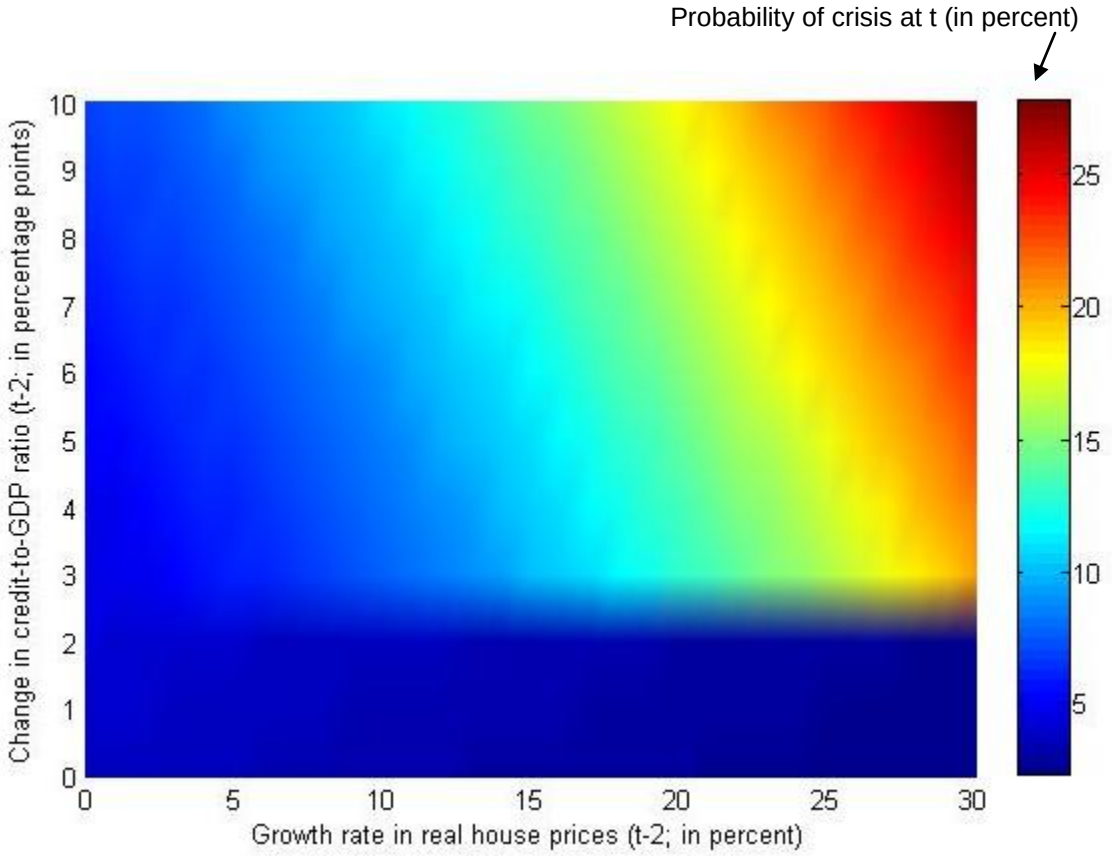
Figure 4. United States: Time-varying Sensitivities of Real GDP Forecast to Past Credit Growth *(in percent of 6-quarters-ahead level of GDP)*[1]



[1]See Annex 3.

26. **The probability of crisis can be conveniently located on a "heat map" for various combinations of credit and house price growth (Figure 5).** The heat map shows that for credit growth below the 3 percentage point mark, house price growth does not have a marginal impact on *p*. However, for higher credit growth, every 1 percentage point increase in house prices increases *p*. For instance, a combination of 5 percentage point credit growth and 20 percent real house price growth leads to *p*=14 percent; a 6 percentage point credit growth and 25 percent real house price growth pushes *p* up to 19 percent. See Annex 5 on how to compute these probabilities from the estimated logit model.

Figure 5. Probability of Crisis and Early Warning Indicators—A Heatmap



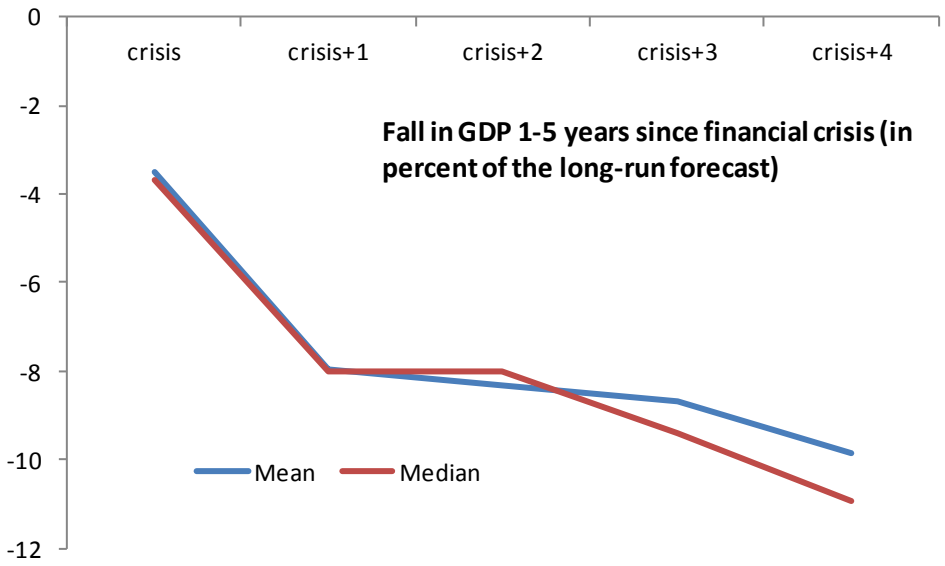
Note: See Annex 5 for details on deriving the probability.

Output loss in the event of a banking crisis (l)

27. **Experiences in various countries show that the GDP loss during crisis can be substantial.** Cross-country data for 10 countries and 12 crisis events show that GDP on average falls about 8 percent per year from the long-term forecast for five years from the beginning of the crisis (Figure 6).[18] Although, alternative cost measures (as described in Annex 1 and Annex 3) are not directly comparable, evidence shows that on average these are equivalent to 7 percent annual drop in actual output from some measure of the trend.

[18] Austria (2008), France (2008), Greece, Japan, Spain (2008), Sweden (1991, 2008), Switzerland (2008), Turkey (2000), United Kingdom (2007), and United States (1988, 2007). These countries have been chosen due to their long time series so that the BN trend can be computed. The estimates of loss of output from this sample would represent a conservative level, since emerging economies have been shown to have suffered greater losses than advanced countries.

Figure 6. Crisis cost *(in percent of trend output)*



Note: Average experience of 10 countries over 12 crisis episodes.

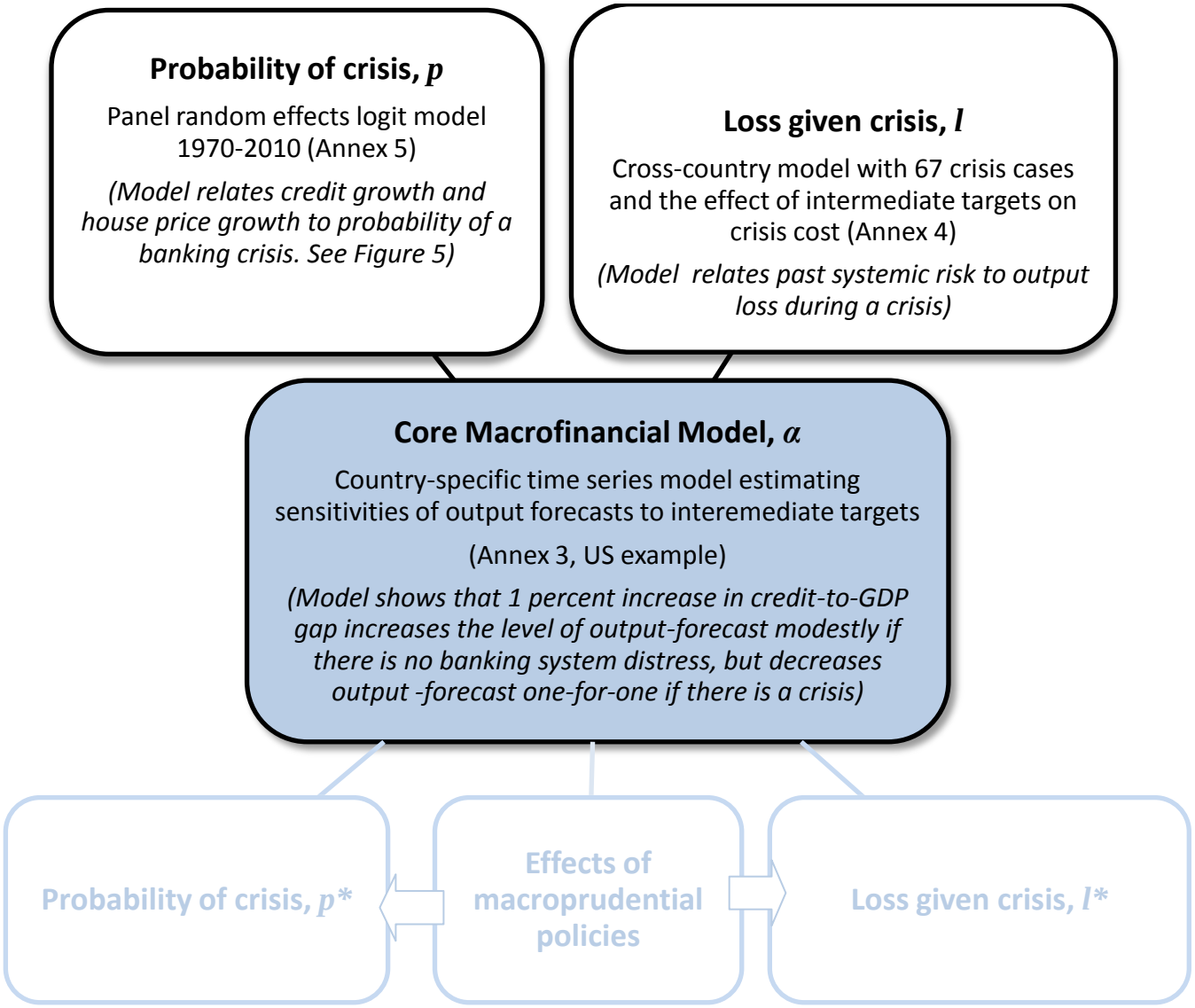
28. **The output loss during the crisis is greater the higher is systemic risk prior to the crisis.** It has been well documented that output loss following a financial crisis, such as asset price busts and banking crises, could be permanent (Cerra and Saxena, 2008, WEO, 2009) and usually deeper than other recessions (Claessens, Kose and Terrones, 2011a and 2011b) and that financial crises are typically associated with rapid growth in credit, house prices and residential investment (IMF, 2011b, Kannan et al, 2009). Credit growth, as one of the intermediate targets for policy, is therefore used in a cross-section model of 67 crises cases to get a sense of the magnitude of its effect on output cost during systemic banking crises, controlling for currency crises (Annex 4). The model shows that a 1 percentage point higher change in the credit to GDP ratio prior to the crisis is associated with a higher average yearly cost of a financial crisis of 0.6 percent. This is comparable to the estimate for the US in Annex 3 that showed that every percentage point higher gap in credit-GDP ratio results in 1 percent drop in the output forecast during a crisis.

Blending in all ingredients: Deriving a no-policy baseline

29. **Summarizing, there are several steps involved in deriving the no-policy expected output.** These steps can be illustrated by filling in the blanks in Figure 1 with the models used so far (Figure 7). Blending in all the ingredients—*p* and *l*—the baseline expected output

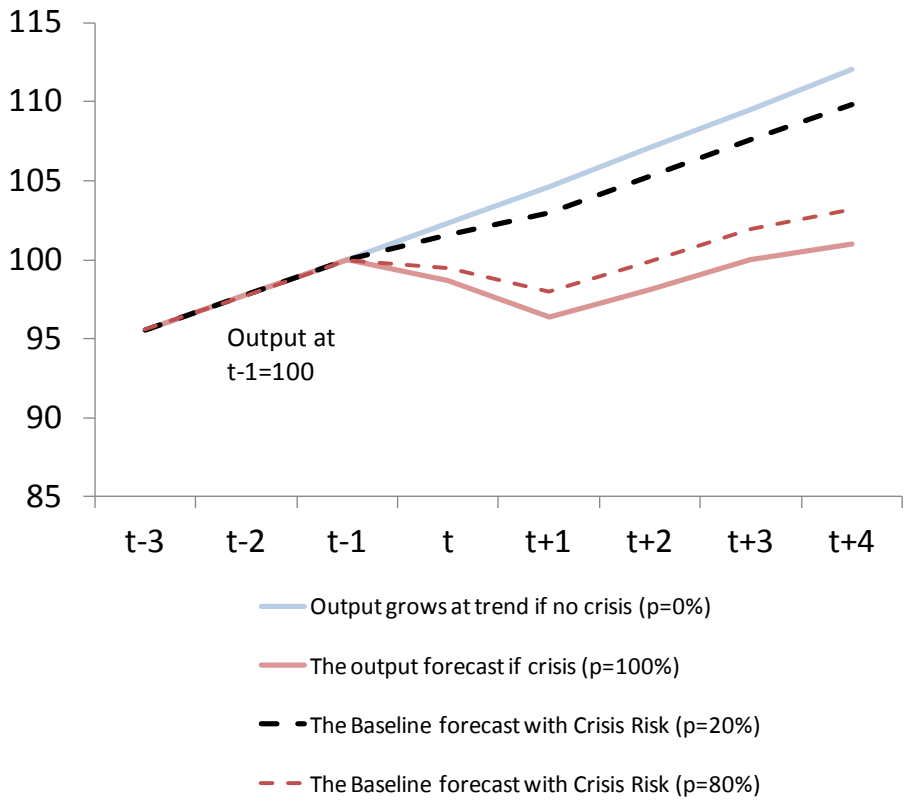
without policy can be derived by using expression (1) in Section II(B). This baseline will be conditional on credit growth, shifting down if credit/GDP growth is more rapid.[19]

Figure 7. Deriving a No-Policy Baseline: Some Measurements



[19] The sample median of credit growth 2 years before a crisis is around 3 percentage points of GDP, and the average cost of crisis is 7 percent below potential for five years. Therefore, a country with a 6 percentage point credit growth will have 7+0.6*(6-3) = 8.8 percent below potential on average for five years, where 0.6 is the marginal effect of credit growth on crisis cost.

Figure 8. Baseline Expected Output



30. **The next section looks at the effectiveness of macroprudential policies.** Expected output following a policy response would take into account (a) the policy effectiveness on intermediate targets, and relate the intermediate targets to the GDP forecast; and (b) the extent to which lowering the intermediate target lowers the probability and the cost of the crisis, that is p^* and l^*.

B. Policy Response

31. **Different policy instruments affect intermediate targets and build resilience in different ways.** This section first provides an overview of how five typically-used tools are expected to affect different parts of banks' balance sheets and lending rates, and how some tools build resilience by creating buffers in banks. Then, an empirical exercise provides evidence on the effectiveness of these tools on intermediate targets.[20]

[20] See CGFS (2012) for schematic diagrams on the policy transmission mechanisms of each tool.

Policy to Intermediate Targets: What to Expect

32. **Tools can be classified according to the portion of financial institution's balance sheets they directly affect.** For instance, risk weights, the countercyclical capital buffer (CCB) and dynamic provisions have a direct impact on the economic capital, reserve requirements on the funding structure, and Loan-to-Value (LTV) and Debt-to-Income (DTI) on assets (Table 2). In addition to building buffers and creating resilience against various risks, the tools are expected to affect intermediate targets. Some tools could have immediate effect on credit growth, for instance, either through quantitative restrictions enforced through eligibility criteria or through prices like lending rates. The pricing effects are analyzed using the loan-pricing equation introduced in Elliott and Santos (2012) and described in Box 2. The underlying assumption is that a unit of loan should provide sufficient return to cover cost of equity, debt and deposits backing the loan adjusted for expected losses on the loan and other incidental costs.

33. ***Capital based tools.*** Risk weights have typically been increased on assets such as mortgage loans fearing property price booms, loans to other overheating sectors, or foreign currency loans to unhedged borrowers. These can be flexibly imposed; for instance, risk weights can be increased on the stock of existing loans or on the flow of new loans. An increase in risk-weighted assets (RWA) makes them more expensive (raising equity is costly) if capital ratios are not allowed to decline. The negative effect on credit growth of higher RWA could be through higher lending rates, as banks recuperate the cost of raising new equity. Countercyclical capital buffers (CCB) could have similar effects except that these buffers may not be as well targeted as the RWA. Some of the loan pricing effects could be offset by investors' requiring lower return on capital due to the perception of higher resilience in the banking sector due to the higher capital buffers.

34. ***Reserve requirements (RR).*** Countries use RRs on various funding instruments to build liquidity buffers against risky sources of funds. The base for the RRs varies from certain deposits to foreign liabilities to wholesale funds, either on the stock or their flows. Since it restricts the funding available to back new loans and requires setting aside assets as reserves, there is less to lend and could have a direct effect on credit growth and loan/deposit ratio. In addition to the quantitative restriction, the increase could lead to higher lending rates as the cost of equity is higher than the cost of debt or deposits.

35. ***Loan-to-Value and Debt-to-Income Requirements.*** Both LTV and DTI tools impact the flow of new loans by tightening eligibility criteria and are quantitative tools that could limit mortgage credit growth and house price growth. Lower LTV and DTI imply that new borrowers who are not eligible are excluded from loan markets and eligible ones have to borrow less (put more down-payment). This is equivalent to a direct reduction in the flow of credit. Having more equity at stake, borrowers are discouraged from defaulting on their loan. From a risk management perspective and under the Basel II advanced approach, the reduction in borrowers' probability of default affects the loss probability distribution of loan portfolios, lowering expected and unexpected losses. The lower expected and unexpected losses then lead to a decline in loan loss provisions—if they are forward-looking—and capital, respectively. A reduction in expected losses implies lower credit spreads and, therefore, lending rates as shown in the loan pricing equation in Box 2. In turn, a reduction in

unexpected losses increases the risk-based capital ratios and would initially have no impact on lending rates. However, if banks react to the lower unexpected losses by reducing capital to keep capital ratios constant, the cost of capital funding a loan would fall, further magnifying the negative effect on lending rates arising from expected losses. It is usually expected that the negative quantitative impact on credit growth and house prices is not offset by the lowering of lending rates on eligible borrowers.

36. ***Dynamic provisioning.*** This is another tool that discourages credit growth with a pricing effect on lending rates. Dynamic provisioning rules tend to set a buffer—general provisions—against fluctuations in specific provisions for loan losses, which are currently driven by the "incurred loss" approach that recognizes loan impairment when there is objective evidence of incurred losses.[21] This leads to fluctuations in provisions and an overstatement of income during the upswings in the economic cycle.[22] To offset cyclical fluctuations in specific provisions, general provisions increase during the upswings and decline during the downswings. They are booked as either on the liability side of the balance sheet—associated with a reduction in net income—or part of shareholder's equity—associated with a reduction in distributed dividends. As a result, general provisions could lead to an increase in the cost of capital and lending rates.

[21] Even though the expected loss approach has a strong forward-looking component, it may still lead to procyclical provisions. If the probability of default (PD), the loss given default (LGD), and the exposure at default (EAD) parameters are calibrated at a point in time (PIT) but not through the cycle (TTC), expected losses will decline during upswings and increase during downswings in economic activity, also leading to cyclical movement in lending rates.

[22] The forthcoming accounting changes that focus on the expected loss approach will change the nature of provisions by recognizing upfront expected losses, which could be helpful from a macroprudential perspective.

Table 2. Comparison of Policy Tools—Expected Effects on Balance Sheets and Prices

Policy Instrument (tightening)	Banks' balance sheet directly affected			Type of effect on balance sheet items[1]		Possible decrease in intermediate targets				Possible increase in prices		Builds buffers in banks	Can be applied to other credit institutions[5]
	Assets	*Funding*	*Capital*	*Stock*	*Flow*	*Credit Growth*	*House Price growth*[2]	*Loan/ Deposit*	*Foreign liabilities/ Foreign assets*	*Eligibility criteria*	*Lending Rates*		
Risk weights on regulatory capital			X	X	X	X	X	X	?[3]		X	X	
Countercyclical capital buffer			X	X		X		X			X	X	
Reserve requirements		X		X	X	X		X	X		X	X	X
Loan-to-Value (LTV)	X				X	X	X	X		X	?[4]		X
Debt-to-Income (DTI)	X				X	X	X	X		X	?[4]		X
Dynamic Provisions			X	X		X		X			X	X	X

Notes: [1]Both 'Stock' and 'Flow' are marked if there is flexibility in applying the policy tool.

[2]House prices could be affected if capital instruments directly target mortgage loans.

[3]Foreign assets could be lower due to higher risk weights on such credit, but foreign liabilities could either go down in line with foreign assets or remain constant.

[4]With tightening LTV and DTI limits, some customers would be ineligible or face a prohibitively high interest rate. The eligible customers could face lower interest rates with the improvement in banks' loan book quality.

[5] Includes foreign bank branches and nonbank credit institutions.

Policy to Intermediate Targets: Empirical Evidence

37. **Actual experience with macroprudential policy instruments, featured in the Survey, shows that policy can be effective on intermediate targets.** The Survey (IMF, 2011c) and its extension by Lim et al (forthcoming) provides a novel dataset to understand policy effectiveness. The instruments used from the survey are *loan-to-value (LTV) limits, debt-to-income (DTI) limits, reserve requirements, provisioning and altering risk-weights* on regulatory capital. Unlike previous studies (BCBS, 2010a, Roger and Vlcek, 2011), this paper estimates both the direct and indirect impact of policy instruments on intermediate targets, rather than looking only at the effect on loan-spreads.[23, 24]

38. **The results show that certain policies could successfully bring down indicators related to two externalities.** Dynamic panel regressions of the intermediate target on its own lag, some controls and the policy variable are estimated over 2000Q1-2011Q4 for countries that used the macroprudential policy measure in place (see Annex 4 for details and Figure 9 for a summary). The effects of the macroprudential instruments are over and above the effects of the policy interest rate or the lending rate and growth in aggregate demand (proxied by GDP growth).

- During the period when *LTV limits*, *reserve requirements* and *risk weights* are applied, credit growth and house price growth—intermediate targets related to the "correlated-risk-taking" externality—slow down; provisioning policy is not significant always (probably because very few countries have used it).

- Moreover, *DTI* limits are powerful in slowing down loan/deposit growth and the share of foreign liabilities in foreign asset growth—intermediate targets related to "fire-sale" externality.

- While *RR* also works on lowering loan-deposit ratio growth, *risk weights* and *LTV* have had on average larger effects on foreign asset-liability mismatches.

These results are similar in spirit to those in Lim et al (2011) that show how policies reduce the *correlation* between credit growth and GDP growth, but go further in showing the direct

[23] This is because, loan-spread data cannot be easily comparable across countries, is very imprecise given the mix of currencies in which loans are originated in certain countries, and may not be the only channel through which policies might affect intermediate targets. There could be direct effects through tightening of lending standards and terms and conditions of lending that are not always observed in loan-spreads.

[24] The Survey data only starts in 2000, which makes it difficult to use it for relating policy instruments to the probability of crisis.

effects on banking aggregates that could be considered as intermediate targets for combating the two externalities (Figure 9).[25]

39. **Moreover, the policies have prolonged impacts.** The dynamic structure of the estimation method allows one to gauge both the short-term and the medium-term impacts of the policy measures on intermediate targets (Figure 9).

- Taking the *correlated-risk taking externality*: higher capital requirements, on average, have historically lowered credit growth by about 1 percentage point on impact and by 5 percentage points cumulatively in two years; and lowered house price growth by 1 percentage point in the short-term and by 6 percentage points in two years.

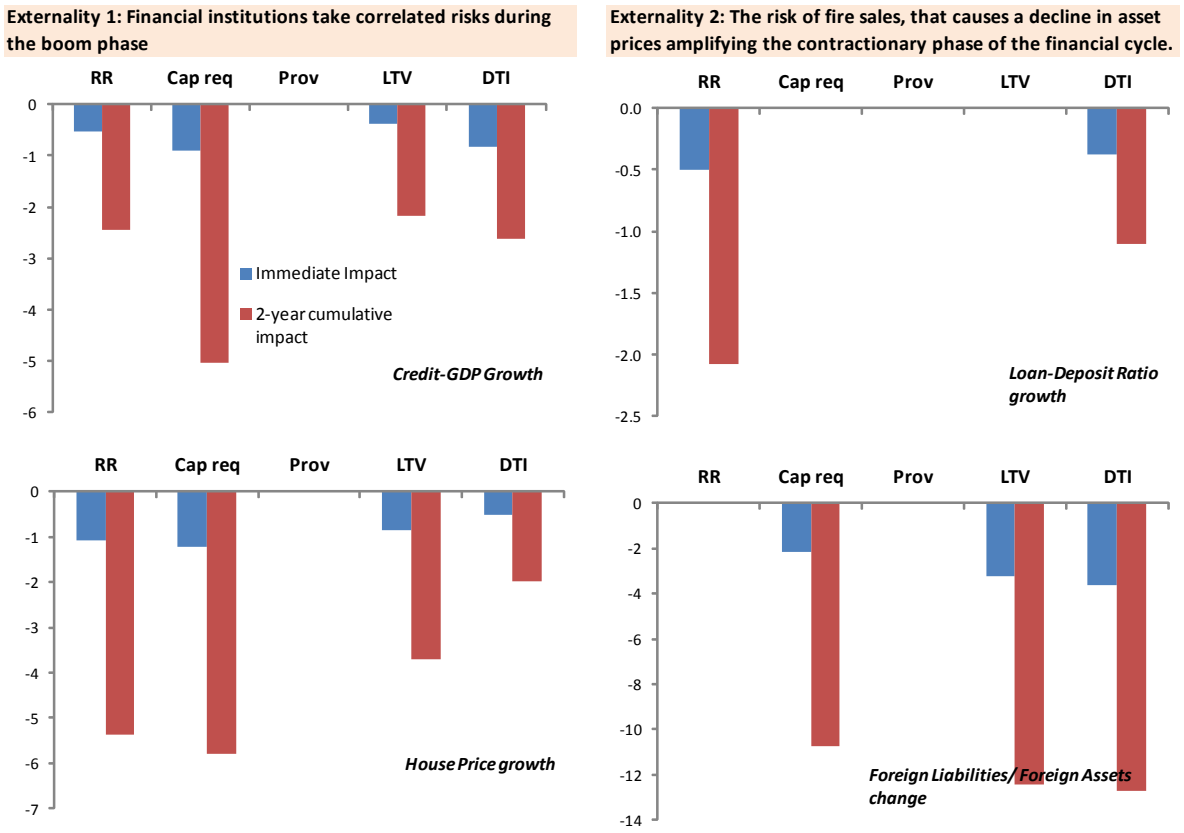
- For the *fire sales externality*, tighter DTIs seem to work towards lowering the asset-liability funding mismatches.

- Capital requirements have cut across *both the externalities*, and have been effective in three of the four intermediate targets featured here. RRs have been effective in having a prolonged impact on house price growth and loan-deposit growth.

40. **During the upswing, both capital and reserve requirements can build buffers but the quality of this buffer matters.** This is especially true for capital requirements; capital ratios are generally buoyant during booms due to high profitability (DFR, 2012) but what could be binding for banks (going forward as Basel III takes effect) is the need to raise the *quality* of the loss-absorbing buffer (IMF, 2012a, BCBS, 2011b). Ensuring higher quality (as mandated in Basel III) together with the quantity would be costlier for banks and have a larger effect on intermediate targets than is shown here, creating greater resilience in the banking system.

[25] A variation of the model for policy effectiveness is presented in IMF (2013), which also includes effects on real economic activity, differentiating the effects in busts. See Scarlata et al (forthcoming) for analysis and policies against the third externality: contagion and cross-section risks.

Figure 9. Impact of Tightening of Macroprudential Policy Instruments on Intermediate Targets *(change in percentage points)*



Note: See Annex 6. RR=Reserve Requirements; Cap req=Capital Requirements; Prov=Dynamic Provisioning; LTV=Loan-to-Value Ratio limits; DTI=Debt-to-Income limits. A step function variable is used for all policy instruments—takes +1 at the time the instrument is tightened, -1 when loosened. The immediate impact is the coefficient for the policy instrument in the regression for the intermediate target; the 2-year cumulative impact is $(1+a+a^2+a^3+a^4+a^5+a^6+a^7)$*immediate impact, where 'a' is the coefficient for the lagged dependent variable.

Table 3. Effects of Policy Tightening: An Example
(effects on credit and real house price growth, probability of crisis, loss given crisis and cost on output forecast)

Baseline: Credit-to-GDP change=5pp; Real house price growth = 20%=> *p* =0.14; *l* =0.092 [1]	**Average Effects of Tightening**			
	Reserve Requirements (RR)	**Capital Risk Weights**	**Loan-to-Value (LTV) limits**	**Debt-to-Income (DTI) limits**
Credit growth changes in two-years by (in percentage points) [2]	-2.45	-5.04	-2.18	-2.63
House price growth changes in two-years by (in percentage points) [3]	-5.36	-5.79	-3.70	-1.98
*p** [1]	0.035	0.030	0.034	0.032
*Loss given crisis, l** [4]	0.065	0.050	0.067	0.064
Cost on output forecast, α [5]	0.0049	0.0101	0.0044	0.0053
$=$				
*(1 - p*l*)/(1-pl)-(1/1-α) 0?* [6]	0.0058	0.0013	0.0064	0.0057

[1] See Figure 5 and Annex 5 for estimates of *p* and *p**, given credit growth and house price growth. See Annex 4 and Figure 8 for *l*.

[2] See Annex 6 Table 1 for the results on changes in the credit-GDP ratio. See the note under Figure 9 for the calculation of the two-year effects.

[3] See Annex 6 Table 2 for the results on real house price growth. See the note under Figure 9 for the calculation of the two-year effects.

[4] See Annex 4 and Figure 8: Average loss given crisis is 0.08. With slowing credit growth, loss is lowered.

[5] For the United States, one percentage point lower credit growth reduces the output forecast by 0.2 percent. See Annex 3.

[6] See expression 3.1 in the text for the expression on net benefits.

From intermediate targets to lowering probability and depth of crisis: p^* and l^*

41. **Tighter policy affects intermediate targets that, in turn, lower the probability and depth of output loss in case of crisis.** Tighter capital requirements, such as through higher risk weights seems to have had a higher medium term impact on credit growth historically than other policies. However, since the policy instrument is a categorical variable in the empirical work (that is, a tightening is denoted by 1, a loosening by -1, see Annex 6), the results need to be interpreted carefully. Table 3 illustrates the effects of policy tightening on credit and house price growth, and their effects on p^*, l^* and α. It is assumed that the probability of crisis is 14 percent and the loss given crisis is 9.2 percent given credit and house price growth in the baseline. Tightening of capital requirements by raising risk weights, on average across time and countries, would reduce the credit-to-GDP ratio growth by a little more than 1 percentage point on impact and 5 percentage point in two years (see Figure 9). In addition, real house price growth would be reduced by 5.8 percent over two years. The reduction in credit and house price growth would together reduce the probability of crisis to 3 percent and the loss given crisis to 5 percent.

42. **In reality, it depends upon how much risk weights usually change compared to other instruments.** Also, higher risk weights, which are applied to the whole stock of credit in a certain category, are costly for banks and are more likely to be transferred to customers through higher credit spreads or other forms of tightening of credit conditions (including DTI limits). In contrast, DTIs have an impact on credit growth only if they are binding on the flow of new customers.

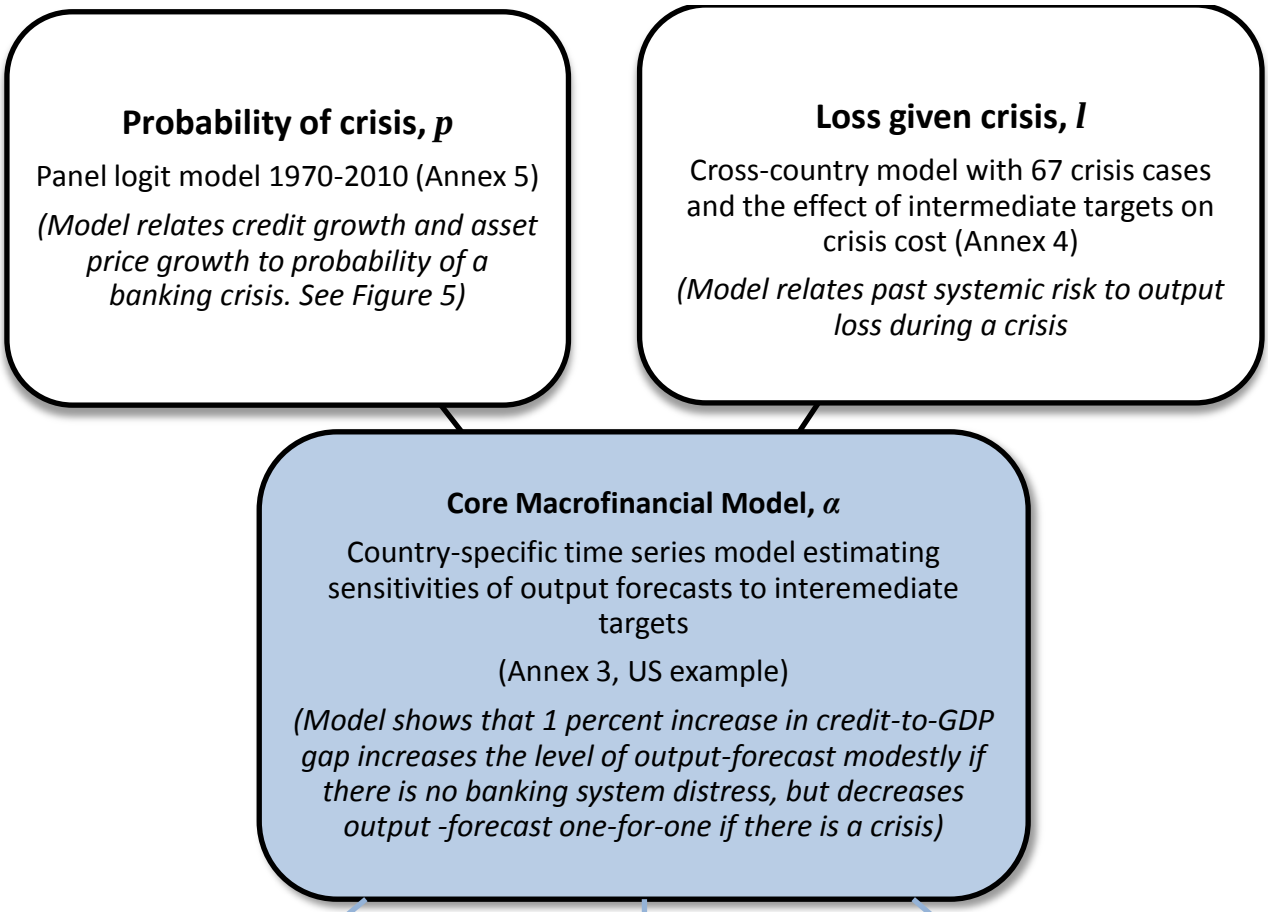
43. **These responses are likely to be higher in practice.** So far, the impacts have been discussed from the point of view of reducing credit growth and house price growth, which are two of the many intermediate targets. In reality, capital requirements and provisions build buffers that increase resilience of the system. They also affect other things like foreign liabilities growth, which together with credit, would have a multiplicative effect on p*. In addition, there could be positive confidence effects on the banking sector that would reduce crisis risk, which is difficult to capture in the same framework.

44. **Policy costs depend upon the sensitivity of the output forecast to intermediate targets, had there been no crisis.** If risks were mis-measured and crisis–risks were actually zero, then the tightened policy lowers the GDP forecast level only modestly for the United States, compared to the no-crisis, no-policy level. For instance, continuing the example in Table 3, if a crisis did not occur, the GDP forecast would be reduced by (α) 1 percent, a relatively high number since capital requirements have a large effect on intermediation.

45. **Summarizing, the various ingredients can now be mixed together to get the net benefits of policy.** The various components are summarized in Figure 10, filling in the missing pieces. These pieces can be used to evaluate the net benefits of policy using the concept in Section II as guidance. For instance, for the example in Table 3 (risk weights),

together with the other ingredients, the net benefit of policy is still positive. Of course, these estimates need to be mixed with a lot of judgment as was noted earlier. Depending on the structure of the financial sector, policy leakages are also important considerations, which are analyzed in the next section.

Figure 10. Summary of Measurements



2-year Cumulative Impacts (changes in p.p.)	Average Effects of Tightening: Reserve Requirements (RR)	Capital Risk Weights	Loan-to-Value (LTV) limits	Debt-to-Income (DTI) limits
Credit-GDP Growth	-2.45	-5.04	-2.18	-2.63
Real House Price Growth	-5.36	-5.79	-3.70	-1.98
Loan-Deposit ratio	-2.08			-1.10
Foreign Liabilities/Foreign Assets	-10.76		-12.42	-12.71

IV. LEAKAGES

46. **Macroprudential policies could have unintended side-effects, besides the intended costs and benefits, through leakages.** Where incentives for risk-taking still exists, market players other than the institutions on which policies are imposed, will attempt to make full use of it. Leakages exist when there is a disconnect between the supervision and regulation of financial *entities* and the actual *activities and the forms* of intermediation of these entities. When policies clamp down on banking activities, other institutions pick up the slack. When policies restrict local operations, either the entities spread risks elsewhere or crossborder and other nonbank intermediation substitutes for the restricted or regulated activity.

47. **There could be other unintended consequences of macroprudential policies.** First, migration of activities to the shadow banking sector make it difficult to *identify systemic risk* (see Boxes 1, 3 and 4). For instance, the extent of leverage can be hidden by shadow banking activities, or could be vulnerable to long intermediation chains. Second, application of tools can lead to *structural distortions* in the financial system that at first sight might seem innocuous but over time could have systemic implications. For example, there are some early signs of higher securitization rates and greater reliance on wholesale funding to cover the higher costs of Basel III capital rules (IMF, 2012b). Third, the policies applied in one country to address its systemic risk can have unintended consequences of *risk-shifting to other countries*.

48. **The focus here will be on new findings related to crossborder leakages and the shadow banking system.** Crossborder arbitrage through direct crossborder lending and regulatory arbitrage through the part of the domestic financial sector falling outside the banking regulatory perimeter are two core channels of leakages. The growing literature on shadow banks in advanced economies (see Claessens et al, 2012 for a survey) and opportunities of direct crossborder credit in emerging economies (Enoch and Ötker-Robe, 2007) create good starting points for analysis. There can be many other avenues for leakages (see CGFS, 2012, Santos and Elliott, 2012, BOE, 2011), but these are beyond the scope of this paper due to data limitations.

- In many countries, especially in emerging Europe, there were large *crossborder flows* into banks and nonbanks. The flows into banks were mostly from foreign parent banks into their subsidiaries, which took advantage of the growth opportunities and competed for market share with other foreign banks. Tightening of local regulatory policies often led the parent banks to lend directly to the private sector. As in Croatia (Box 3), direct crossborder lending growth accelerated with tightening of local macroprudential policies.

- The other source of leakage considered in this paper is the part of the financial sector that compete with the regulated banking sector but are subject to home country regulatory policies only, such as *foreign bank branches* in the U.K. (Box 4).

- The third kind of leakage is through *nonbank financial institutions* within the domestic financial sector that are either unregulated or not given the same regulatory treatment as banks. The latter case is illustrated by the example of the United States (Box 1).

Direct Crossborder Loans

49. **Empirical findings suggest that certain macroprudential instruments are more prone to leakages from crossborder loans than others.** Re-estimating the panel data model on policy instruments, using data on direct crossborder loans to the private sector as the dependent variable, *reserve requirements* and *provisioning policies* tend to incentivize foreign banks to directly lend to the private sector, bypassing the subsidiaries (Annex 6).[26] The evidence suggests that a tightening of reserve requirements reduces credit growth by 0.4-0.5 of a percentage point on impact but increases leakages through *higher* crossborder lending growth by 1.2 percentage points. Over two years, credit growth decreases by 2.5 percentage points, and direct crossborder loan *grows* by about 5 percentage points. Local bank provisioning policies, as was shown earlier, did not have significant impacts on credit aggregates, but does attract direct crossborder flows.

50. **There could be multiple reasons for RRs to increase leakages.** Reserve requirements are imposed on banks' liabilities. If these liabilities are foreign, coming from banks' foreign parents, *additional* requirements are easily circumvented by providing direct crossborder loans to the private sector instead of channeling funds through branches. RR would still have an effect (the 'stock effect') on credit growth from the domestic banking system, since banks are squeezed on the amount of liabilities that are available for lending. Capital requirements like higher risk weights, on the other hand, still require additional capital injections by parents or lower profit distributions that tightens the parents' belts—the foreign parents can only direct additional funds through capital injections into subsidiaries, which are not substitutable for direct crossborder lending.

51. **LTV and DTI limits, on the other hand, are part of eligibility criteria and influence loan demand.** If binding, these limits help to decrease demand for certain loans, like mortgage credit. If parent banks also perceive these limits as hard limits for their own risk management, there should be less crossborder substitution of credit due to domestic regulation. Another argument for the empirical evidence is that LTV and DTI are, in most cases, applied to mortgage loans to households. Hence, it is difficult to substitute (for households) domestic loans with a foreign loan because usually households do not have an

[26] The data used for crossborder lending comprise (changes in) two specific series from IMF's BOP statistics, Other Investment (OI) Liabilities, Net: OI Currency and Deposits Other Sectors LB—BPTSTSUB 9148784..9… and OI Loans Other Sectors LB—BPTSTSUB 9148775..9...

access to a foreign market and a foreign parent bank does not have a mechanism to take over the house in case of default.

52. **Therefore, the findings suggest that in financially open economies, capital requirements and LTV tools could be better suited to limit buildup in credit-related risks than reserve requirements.** This is especially true in economies with high foreign-ownership of the banking system and where foreign parents are willing to work with the local subsidiaries in order to get information on local clients. Having said that, there are many different kinds of RRs that the empirical work lumps into one: RRs based on the foreign currency component of liabilities, maintenance of the reserves in local versus foreign currency, marginal versus average reserve requirements, etc. Thus, some RRs might be more prone to leakages than others, but such distinction are not individually testable given current data limitations and are beyond the scope of this paper.

Foreign Branches and Nonbank Financial Institutions

53. **The other leakage is related to the presence of financial institutions that are not regulated the same way as banks but offer banking services.** As regulations on banks are tightened, other credit intermediaries like branches of foreign banks (that are regulated by the home country as in the United Kingdom), leasing and factoring companies and other finance companies, and investment banks (as in the United States in Box 1) take on commercial bank activities.

54. **The foreign bank branches in the U.K. provide a relevant case.** Empirical work shows that when capital requirements are tightened for the U.K. banks, loan supply significantly diminishes. However, about a third of the effect is offset by foreign branches in the U.K. (Box 4). Thus, any tightening in capital requirements would have to be coordinated with the home supervisor of the foreign branches, so that they tighten capital requirements for U.K. exposures as well.

55. **The significant nonbank activity in the United States provides another case.** In most countries, the bulk of consumer lending is done by banks. However, the United States stands out as having a large share of intermediation occurring in nonbanks or shadow banks (Box 1). As was shown earlier, measures of ‘excesses’ based on bank credit in the United States failed to signal a crisis when the two thresholds for credit growth (IMF, 2011b and Dell’Ariccia et al, 2012) were used. Using consumer credit growth from all sources of intermediation breaches atleast one threshold early in the 2000s and would have signaled a crisis. Like the case of bank branches in the United Kingdom, nonbanks in the United States are likely to circumvent macroprudential policies, if these policies are aimed just at banks.

56. **In such cases, LTV and DTI limits together with capital requirements could work better.** Borrower eligibility criteria can be applied to all products (rather than institutions) that are offered by any financial institution within a country. In the U.K. where there is evidence of leakage of capital requirements, LTV and DTI limits could be applied

even to foreign branches (BOE, 2011). That way, at least the 'flow' part of the credit supply is controlled. The 'stock' of credit that was supplied with high LTVs, however, remains unprotected. One way to take care of the stock problem is to have higher risk weights on high-LTV loans made in the past—but to be effective, foreign parents of the branches would also need to follow the rules set by the host supervisor and regulator. For nonbank activity, close coordination with other regulators would be needed.

57. **Summarizing, there are three sets of policy implications to counter leakages, depending upon the financial structure of the economy.**

- *Financially open economies, especially with foreign subsidiaries*: capital tools and LTV could work well for containing the "correlated risks" externality. RRs are subject to leakages through substitution of direct crossborder lending for domestic lending. Since both DTIs and RRs are usually effective at containing funding risks (loan/deposit growth)—one of the targets against the "fire sales" externality—DTI limits could be used instead or with RRs.

- *Financial systems with foreign bank branches*: A combination of LTV and DTI could work well in containing risks from both externalities as they apply to the activity not the institution. Capital tools could be problematic for universal use. In this case, RRs could also help if these can be applied to branches.

- *Financial systems with a large share of nonbanks*: As with branches, combinations of LTV and DTI tools could work, in close coordination with other regulators. For consumer credit, the macroprudential supervisor could coordinate with the consumer protection agency if one exists. Both capital tools and RRs would be difficult to impose in such financial systems.

58. **In general, a number of standard policy prescriptions apply to plug evasions and circumventions.** Regulating financial services, not sectors; strengthening (macroprudential) regulation of the (shadow) banking sector (FSB, 2013); coordinating macroprudential tools and ensuring their consistent application across borders including through reciprocity principles; monitoring arbitrage opportunities on a regular basis (CGFS, 2012) and dealing with data gaps are all potentially valuable methods of reducing systemic risks.

V. SUMMARY AND POLICY IMPLICATIONS

59. **This paper has provided a recipe for estimating cost, benefits and unintended consequences of macroprudential policies.** The idea is to provide guidance to policymakers and new findings on the various components of the decision making process. In this respect, the paper provides a conceptual framework for analyzing costs and benefits. It takes forward existing studies and uses them in order to come up with simple rules-of-thumb based on additional empirical work. It provides new evidence on the effectiveness of different policy

instruments using a database from a survey and provides new findings on the unintended consequences of macroprudential policies.

60. **The work remains under construction.** While many of the ingredients are provided in this paper, there remains work to be done on the core analytical model that blends together all the components. While the structure of the model is clear, its estimation remains complicated and subject to robustness tests. So far, the paper takes an incremental approach to integrating the various ingredients in the cost-benefit framework. The core model, which is left to another paper, would be expected to estimate the output forecast taking into account a dynamic interaction between output, risk and policy.

61. **Summarizing, for macroprudential policy to work, the ex ante benefits should be higher than the cost.** Even though this is work in progress, there are useful insights already resulting from the analysis. Net benefits would depend upon several things.

- Most important is the performance of the **early warning model**s. If a dependable set of indicators is not used, mis-use of macroprudential policies could be costly. As IMF (2012a) showed, there are adverse growth outcomes if financial buffers are too high, especially for emerging economies. What matters is the quality of the buffers.

- Given the widespread **role of credit** in early warning, policy makers could use two thresholds provided in IMF (2011b) and Dell'Ariccia et al (2012) respectively, escalating the concern and implementing corrective policies somewhere in between the two thresholds (Table 1, section II, Annex 2). That way, policymakers use judgment together with analytical results in their policy decision. This gradual approach could also influence expectations of the private sector that could mitigate the necessity of drastic and severe policy responses.

- Policymakers need proper measures of the intermediate target: not just bank credit but **all sources of credit**. The latter data would feed into the performance of the early warning models and indicators. As is shown for the U.S. case in Box 1, the out-of-sample probability of crisis in the 2000s is much higher when all sources of consumer credit are used rather than just bank credit.

- Net benefits do not kick in when the **probability of crisis is so low** that even fully effective policies do not make a significant difference between pre- and post-policy probabilities of crisis (section II). In this regard, the probability of crisis increases non-linearly when, for instance, both house prices and credit are growing rapidly, especially when credit-to-GDP ratio is growing by 3 percentage points of GDP or more (Figure 5).

- Net benefits are very **sensitive to how intermediate targets affect the output forecast**. If macro-financial linkages are high, output is highly sensitivity to

intermediation. In such cases, policy mistakes, especially when policy over-reacts to signals ("false positives"), could be very costly. However, so far, these effects have been estimated to be very modest for the Untied States (Annex 3). If policy measures are taken and there is no crisis, the output forecast drops by 0.2 percent for every 1 percentage point tightening of credit growth.

- **Net benefits rise with policy effectiveness as long as the costs are contained**. For benefits to be high, the difference between pre- and post-policy probabilities of crisis (p and p^*) and the pre- and post-policy loss given crisis (l and l^*) need to be large (Section II).

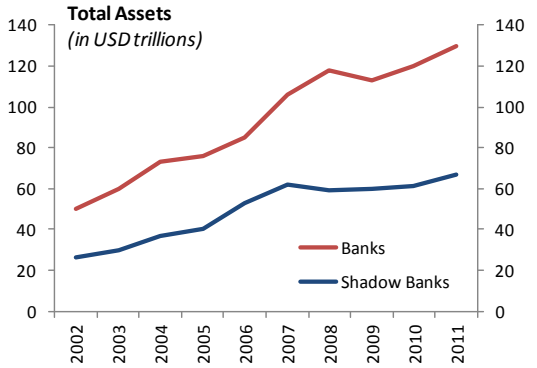
- The measures that are **most effective and have prolonged effects on credit growth and house price growth** are *reserve requirements*, higher *risk weights* on capital and *LTV limits*. Provisioning policies have not been tried in many countries, but where data is available, these did not have significant effects. By influencing both asset prices and credit growth, the three instruments could lower the probability of crisis and its depth substantially to increase the benefits of policy. Historically, the use of LTVs seems to have less bite than capital requirements and RRs (Section III, Annex 6).

- Since there is evidence of **leakages or unintended consequences of some policies**, policymakers should pay attention to the financial structure of the economy and use the most effective set of policy instruments. For instance, reserve requirements could be subject to leakages through direct crossborder credit to the private sector especially in *financially open economies*, and so capital tools, LTV and DTI could be better suited. On the other hand, in economies with an active set of *foreign bank branches*, capital requirements could be easily circumvented, and so RRs could be better suited if these can be applied to at least broad money liabilities for foreign branches. Similarly, LTV and DTI tools could be applied across banks and nonbanks to plug leakages through *nonbanks* (Section IV), since they are focused on activities, not specific types of institutions.

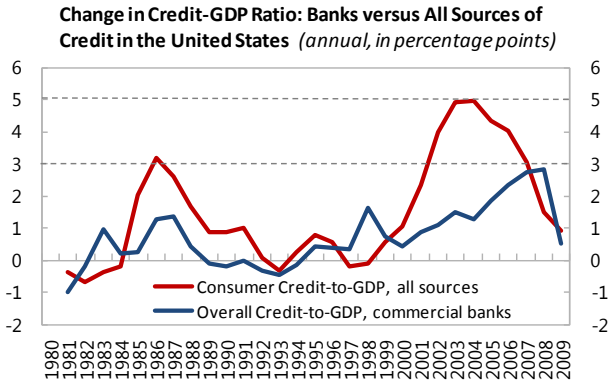
62. **A very basic recipe is provided in the paper.** Policymakers are encouraged to add flavors that are country-specific and garnishes that reflect their preferences.

Box 1. Nonbank Lenders in the United States: Possibilities for Underestimating Systemic Risk

There is a significant presence of nonbank lenders in the United States. The FSB estimates a growing contribution of shadow banks in the US financial sector assets, especially during 2005-2007, the run up to the 2008-2009 financial crisis (figure below, left). Shadow banks include nonbank lenders of consumer and mortgage credit to households that fall outside the regulatory regimes for commercial banks.



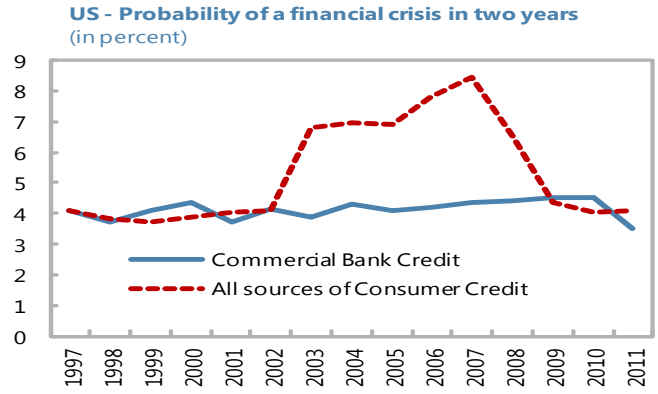
Source: Financial Stability Board



Sources: IMF International Financial Statistics; Federal Reserve Board; IMF staff calculations.
Note: The data on consumer credit is taken from the Federal Reserve Board's all sources of consumer credit (G.19) and mortgage debt held by households (Flow of Funds, Z.1).

Credit aggregates used for the analysis of systemic risk should be inclusive of these nonbank lenders. Data (figure above, right) shows that the growth in consumer credit from all sources far outpaced the growth in commercial bank credit before the advent of both the episodes of systemic banking crises in the US—1988 and 2008 (Laeven and Valencia, 2010). Moreover, credit from commercial banks could have been underestimated due to loans sold to the Government Sponsored Enterprises (conforming mortgages) and to investment banks (nonconforming mortgages). These loans, however, are captured in the flow of funds data used to estimate consumer (including mortgage) credit growth in the United States.

Crisis signals are underestimated if credit aggregates are not inclusive of all lenders. When policy makers rely on credit aggregates for a crisis signal (see Section II), credit growth from commercial banks alone do not breach either of the two thresholds used here—GFSR and Boom (Annex 2). However, the broader credit measure would breach the GFSR threshold in the period 2001-2006. Moreover, the panel logit model (Annex 5) delivers vastly different (fitted) probabilities for the two sources of credit (figure below).



Source: IMF Staff estimates, see Annex 5 for methodology.

Prepared by Nicolas Arregui and Srobona Mitra.

Box 2. Effects of Macroprudential Policies on Lending Rates: What to Expect

The effects on lending rates of macroprudential policies can be determined using a loan pricing equation. Any lending decision can be reduced to a pricing equation to determine whether a loan provides sufficient return:

$$r_L*(1-t) >= E*r_e+(D*r_d+C+A-O)*(1-t),$$

where:
r_L = effective interest rate on the loan, including the annualized effect of fees;
t = marginal tax rate for the bank;
E = proportion of equity backing the loan;
r_e = required rate of return on the marginal equity;
D = proportion of debt and deposits funding the loan, assumed to be the amount of the loan minus E;
r_d = effective marginal interest rate on D, including indirect costs of raising funds, such as from running a branch network;
C = the credit spread, equal to the probability-weighted expected loss;
A = administrative and other expenses related to the loan;
O = other income and expense items related to the loan.

In simple terms, the rate on the loan needs to cover the cost of capital and other funding sources, any expected credit losses, and administrative expenses. Similar to other regulatory reforms, macroprudential policies also affect the cost of capital, other funding, and lending rates by changing the proportion of debt and equity funding a loan. However, they may also trigger offsetting adjustments to one or more variables in the loan pricing equation that reduce the impact of macroprudential policies on lending rates. In the case of a full offset where return on capital is lower as predicted by the Modigliani-Miller proposition, countercyclical capital would have no effect on lending rates. Given the empirical evidence in the next section that macroprudential policies have an effect on reducing systemic risk in the short run and that offsetting effects in the loan pricing equation may be of a long-term nature, this paper assumes that macroprudential policies have a full impact on lending rates in the short term.

The simple loan pricing equation above is an important building block in most studies described earlier, as it allows researchers to translate costs arising from regulatory reforms into loan rate increases and GDP changes.[2] Among others, Elliott (2009 and 2010a), BCBS (2010a, 2010b), Slovik and Cournede (2011), and IIF (2011) use variations of this loan pricing equation (also named accounting-based approach) as it is flexible enough to capture many different attributes of credit provision. Individual country studies that build on the pricing equation above include Koop et al. (2010), Schanz et al. (2011), de-Ramon et al. (2012), for instance. The loan pricing equation is especially useful in economic and econometric models with no explicit behavior for bank capital or liquidity. The pricing equation above is also useful to analyze the interaction between capital and liquidity standards and macroprudential policies. Table 2 in the text summarizes the main effects of macroprudential policies on credit and lending rates.

Prepared by Andre O. Santos.

[1] See also Elliott and Santos (2012) and King (2010) for a similar approach.

[2] This is especially true in economic and econometric models that feature neither bank capital nor bank liquidity.

Box 3. Leakages through Direct Crossborder Lending: The Croatian Experience

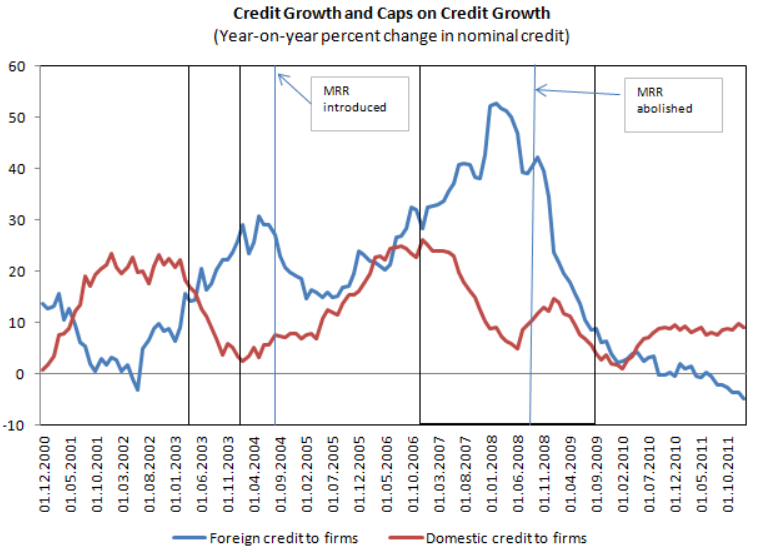
Croatian experience with macroprudential measures over the years 2003–2008 shows how leakages make macroprudential policy less effective. The measures introduced by the authorities aimed at slowing credit growth (the credit growth cap, the marginal reserve requirement), reducing capital inflows (the marginal reserve requirement), improving bank capitalization (higher risk weight), and bolstering bank liquidity (the foreign currency liquidity requirement).[1] However, most measures were accompanied by some sort of a leakage:

- **The 2003 credit growth caps:** banks cut back on holdings of securities and on unused lines of credit (both items were included in the credit aggregate) and used this to offset higher growth in other categories; banks with affiliated leasing companies encouraged clients to take leases rather than loans; banks with parent banks abroad referred clients to the parent bank, with all of the screening and paperwork carried out in Croatia, but the final contracts and funding, at least formally, coming from the headquarters outside of Croatia.[2]

- **The 2007 version of the credit growth cap:** the policy closed the line of credit loophole by limiting on- and off-balance sheet items separately and dealt with the leasing problems by capturing funding of the leasing company within the credit limit. However the issue of direct parent bank lending to clients was not resolved.

- **The marginal reserve requirement:** banks attempted to fund its expansion plans by issuing bonds on the domestic market. As a response, the central bank implemented a 55 percent reserve requirement on funds raised by bond offerings.

- **The foreign currency liquidity requirement**: banks tried to evade the requirement by offering local currency deposits indexed to an exchange rate. The central bank altered its rules to include FX indexed deposits, which display the same currency risk as foreign exchange deposits, in calculation of the requirement.



Note: MRR refers to Marginal Reserve Requirements on foreign liabilities. Caps on credit growth were in place 2003-2004 and 2007-2009.

Prepared by Ivo Krznar.

[1] See Appendix 3 and 4 in Galac (2010) for a full description of the measures and dates of their implementation.
[2] Galac (2010) finds that the credit growth cap did slow domestic lending by Croatian banks, but that this seems to have been offset by leasing and foreign borrowing, so that the measure's effect on total private sector debt turned out to be insignificant.

Box 4. Leakages through Foreign Branches: Empirical Evidence from the UK

A unique UK database permits an evaluation of the effectiveness of macroprudential policies, showing how leakages can occur through foreign branches. Recent empirical evidence based on the database suggests that such "leakages" are substantial but fall short of a full offset.

In the 1990s and early 2000s, the Financial Services Authority (FSA) imposed time-varying minimum capital requirements—so called "trigger ratios"—at the level of individual banks. These trigger ratios were set for all banks under the FSA's jurisdiction, i.e. all UK-owned banks and resident subsidiaries of foreign banks. The discretionary regime was intended to fill gaps in the early Basel I regime, which simply imposed a uniform minimum capital requirement of 8 percent of risk-weighted assets. Trigger ratios for each bank were reviewed every 18-36 months, and changes made if deemed necessary (incorporating judgments about, among other things, evolving market conditions as well as the quality of risk management and banks' systems and controls). Importantly trigger ratios were *not* imposed on an important class of UK-resident banks: *branches* of foreign banks, which were subject to home rather than host country regulation.

Aiyar, Calomiris and Wieladek (2012) exploit a unique UK database to explore macroprudential leakages. The study collects quarterly data on these regulatory minimum capital requirements from the FSA, and merges it with loan data reported by individual banks to the Bank of England. The institutional set-up allows the study to ask two questions, both of which are central to the effectiveness of macroprudential policies: (i) do changes in minimum capital requirements affect loan supply by regulated banks; and (ii) is the loan supply response by regulated banks offset, partially or in full, by an opposing supply response by unregulated entities (in this case, foreign branches)?

The authors find, first, that loan supply by regulated banks responds strongly to changes in minimum capital requirements. Changes in individual bank lending to the real economy are regressed on several lags of changes in the trigger ratio. Control variables include GDP growth and a number of bank-specific balance sheet characteristics. Data on bank-specific sectoral lending patterns are used to control for demand shocks, as in Aiyar (2011). A rise in the trigger ratio of 100 basis points is estimated to induce a cumulative reduction in the growth rate of bank lending of between 6 and 8 percentage points.

Second, the study finds a robust offsetting response by domestically-unregulated foreign branches. Changes in lending by a foreign branch are regressed on several lags of the change in lending by a reference group of regulated banks. For each foreign branch, the reference group of regulated banks comprises banks that specialize in lending to the same sectors of the economy as the branch; thus the reference group captures the relevant set of competitor banks. The average branch increases lending by about 2-3 percent in response to a regulation-induced decline in lending by its reference group of 1 percent.

A UK economy-wide assessment of leakages needs to take into account that (i) foreign branches outnumber regulated banks; and (ii) the average foreign branch is much smaller than the average regulated bank. Accounting for these factors yields an estimate of aggregate leakages of about 30 percent. The fact that the offset is only partial implies that, on balance, changes in capital requirements can induce a substantial impact on aggregate credit supply. But the results also affirm the importance of cross-country cooperation on macroprudential policies, such as the reciprocity principle enshrined in the Basel III counter-cyclical capital buffer.

Box 4. Leakages through Foreign Branches: Empirical Evidence from the UK *(continued)*

The estimate of leakages provided by the paper may be considered a lower bound, given that only one possible source of substitute credit—lending by unregulated foreign branches—is examined. But the authors argue that, in fact, this is likely to be the most potent channel of leakages. The theoretical and empirical finance literature suggests that securities offerings are not perfect substitutes for loans from intermediaries. Loans involve much more detailed contracting terms than bonds, and require monitoring and enforcement after the loan is made. Furthermore, the importance of "soft" information for limiting the screening, monitoring and enforcement costs of bank lending implies that there are limits to the ability of offshore lending to substitute for local intermediation (e.g., Aggarwal and Hauswald (2010)).

Prepared by Shekhar Aiyar.

Annex 1. Other Studies on Costs and Benefits[27]

Table A1.1. Literature Review: Measuring Costs and Benefits of Macroprudential Regulation

Reference	Focus	Instruments	Methodology
BCBS LEI, 2010	Long run benefits and costs	Capital and liquidity requirements (NSFR, not LCR) Brief coverage of countercyclical buffers	**Benefits**: Expected yearly output gain associated with the reduction in frequency and severity of banking crises. _ Draw from literature the probability and cost of a crisis. _ Estimate impact of regulation on probability of a banking crisis. _ Assume no impact of regulation on depth of a crisis. _ Brief coverage of reduced output volatility during non-crisis times. **Costs**: Steady state economic costs of higher requirements based on a variety of models. _ Estimate impact of higher requirements on lending spreads. Assume : 100% pass-through, unchanged return on equity and debt. Take into account synergies between capital and liquidity requirements. _ Estimate spreads impact on output using 13 models (structural, semi-structural and reduced form).
IIF, 2010	Response to BCBS LEI, 2010	Response to BCBS LEI, 2010	**Benefits**: Criticisms to BCBS LEI 2010. _ Any benefit will be realized in the long term while costs are likely to be felt immediately. _ Financial crises originate outside financial system itself. Regulation may not affect the likelihood of crises or the overall cost of crises by any significant extent. _ The challenge is to determine how much regulatory reform can contribute to financial stability relative to other key changes (e.g. monetary, fiscal and exchange rate framework). _ Banking crises associated with other key causes will not be made avoidable by more stringent regulation. _ Sign and size of impact of regulation on depth of a crisisis is uncertain.
European Parliament, 2011	Long run benefits and costs	Capital and liquidity requirements Counter-cyclical capital requirements Leverage ratio	**Benefits**: _ Qualitative assessment on financial stability for all instruments drawing from literature. Illustrate quantitatively when available. _ Qualitatively assess effect on probability and depth of crisis as well as on portfolio quality. _ Borrow from BCBS LEI 2010 to compute the expected cost of a banking crisis but no quantitative estimate of the impact of regulation on crisis probability and depth. **Costs:** _ Borrow heavily from BCBS LEI 2010 but consider different degrees of pass-through.

[27] Prepared by Nicolas Arregui

Table A1.1. Literature Review: Measuring Costs and Benefits of Macroprudential Regulation (Cont.)

Reference	Focus	Instruments	Methodology
Bank of Canada, 2010	Long run benefits and costs. Transition costs.	Capital and liquidity requirements	**Benefits**: _ Draw from literature the probability and cost of a crisis. _ Estimate impact of regulation on probability of a banking crisis. _ Consider spillover effects from other countries' reduced crisis probability. _ Assume no impact of regulation on depth of a crisis. **Costs**: _ Estimate impact of higher requirements on lending spreads. _ Estimate spreads impact on output using 3 models for Canada.
Bank of England, 2010	Long run benefits and costs	Capital requirements	**Benefits**: _ Draw from literature the probability and cost of a crisis. _ Estimate impact of regulation on probability of a banking crisis (structural approach). **Costs**: _ Estimate impact of higher requirements on lending spreads. Assume : 100% pass-through, unchanged return on equity and debt. _ Estimate spreads impact on output using Cobb-Douglas production function.
Miles, 2010	Long run benefits and costs	Capital requirements	Take BOE 2010 as benchmark and explore less conservative assumptions on costs estimation (30% Modigliani Miller effect, tax offset, more substitutes to bank finance and less sensitive investment).
FSA, 2009	Long run benefits and costs	Capital and liquidity requirements	**Benefits**: _ Draw from literature the probability and cost of a crisis. _ Estimate impact of regulation on probability of a banking crisis (mutivariate logit). **Costs**: _ Estimate impact of higher requirements on lending spreads. _ Estimate spreads impact on output using structural model with a banking sector.
European Parliament, 2011	Costs and Benefits	Regulatory measures regarding credit rating agencies, short sales and credit default swaps, MiFID, deposit guarantee schemes, investor compensation schemes, OTC derivatives, regulation of systemically important financial institutions, procedures for bank restructuring and resolution, bank taxes and levies, and accounting rules.	_ Qualitative assessment based on literature review. _ Impact assessments are done qualitatively using a scale from -2 (strong negative impact) to +2 (strong positive impact) for 6 objectives: reduction of procyclicality, reduction of misguided incentives, creation of level playing fields, internalization of social costs, increasing transparency and increasing consumer confidence. _ Results of a survey to a panel of "77 German financial experts" are also included.

Table A1.1. Literature Review: Measuring Costs and Benefits of Macroprudential Regulation (Cont.)

Reference	Focus	Instruments	Methodology
FRBNY, 2011[1]	Long run costs	Capital and liquidity requirements (NSFR, not LCR)	Same as BCBSE LEI 2010. Costs in terms of output level, output variability and welfare.
Slovik and Cournede, 2011	Long run costs	Capital requirements	_ Estimate regulation impact on lending spreads. _ Use OECD New Global Model to map increase in spreads into output costs. _ Additionally consider the case in which banks keep their discretionary buffers above the minimum requirements in regulation.
Elliot, Salloy and Oliveira Santos, 2012	Long run costs	Capital and liquidity requirements, derivatives and securitization regulations and taxes and fees (for Europe, Japan and the U.S.)	Benchmark scenario takes into account that the financial crisis increased safety margins demanded for other reasons in addition to regulatory requirements. Estimate impact of higher costs due to requirements on lending spreads: _Assume less than 100% pass-through as banks have mitigating responses to cost increases. _Assume that the increase in safety reduces the cost of switching to equity from debt.
BCBS MAG, 2010	Transition costs	Capital and liquidity requirements	_ Consider a set of scenarios for shifts in capital and liquidity requirements to feed a broad range of models (semi-structural, reduced-form, DSGE). Draw on diversity of models and countries (97 simulations) to capture "more" relevant mechanisms. In many cases, two step approach: _ Use satellite models to estimate the impact of prudential policies on economy wide lending volumes, credit spreads and lending standards. _ Feed those results as input into macroeconomic models. _ Consider international spillovers.

Notes: Additionally, see ICFR 2011 for a brief summary and comparative study of the literature.

[1] Same paper was published by the Banque de France.

Annex 2. Signals Based on Two Different Thresholds for Bank Credit Aggregates[28, 29]

International experience shows that credit growth can be a powerful predictor of financial crises so monitoring "excessive" credit growth should be the starting point for assessing the build-up of systemic risks. Credit aggregates could guide policy, especially to inform a tightening of policy by using appropriate thresholds. Two studies that examine thresholds are IMF (2011b) in the Global Financial Stability Report (GFSR) and Dell'Ariccia et al (2012). Comparing the GFSR threshold (3-5 percentage point annual change in the credit-GDP ratio) with the Dell'Ariccia et al threshold for defining credit booms (henceforth, Boom) shows that the GFSR threshold is triggered much more often than Boom. Relatedly, the GFSR threshold flashes (signaling a crisis coming within two years) earlier than the Boom in most cases.

Table A2.1 allows for a visual comparison of these two methodologies to flag risks. Green and yellow cells show periods in which only one of the methodologies flags risks (green for GFSR, yellow for Dell'Ariccia and others). Red cells indicate periods in which both methodologies flag risks. The table is only shown for one decade. The high preponderance of green cells shows that the GFSR methodology flags risks more often. Moreover, if the Dell'Ariccia and others methodology is flagging risks, it is likely that the GFSR is flagging risks too, but not vice versa.

[28] Prepared by Nicolas Arregui.

[29] We would like to thank Deniz Igan for kindly sharing the underlying data and credit booms dates as identified in Dell'Ariccia and others (2012).

Table A2.1. Signals based on Two Different Methodologies

Country	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Afghanistan, I.R. of								0	0	
Albania	0	0	0	0	0	1	1	1	1	
Algeria	0	0	1	0	0	0	0	0	0	
Angola	0	0	0	0	0	0	0	1	0	1
Antigua and Barbuda	1	0	1	0	0	0	0	0	0	
Argentina	0	0	0	0	0	2	2	2	0	0
Armenia	0	0	0	0	0	0	0	1	1	
Aruba	0	0	1	1						
Australia	1	0	0	1	1	1	1	1	1	0
Austria	1	0	0	0	0	1	0	0	1	1
Azerbaijan, Rep. of	0	0	0	0	0	0	0	0	0	
Bahamas, The	1	1	0	0	1	1	1	1		
Bahrain, Kingdom of	0	0	0	0	1	0	0	1	1	1
Bangladesh	0	1	0	0	0	0	0	0	0	
Barbados	0	1	1	0	1	1	1	0	0	
Belarus	0	0	0	2	2	2	3	3	3	
Belgium	0	0	0	0	0	0	3	3	1	1
Belize	0	1	1	1	0	0	0	1	0	
Benin	0	0	0	2	2	2	2	2	2	0
Bhutan	0	0	0	0	0	0	1	0	1	
Bolivia	0	0	0	0	0	0	0	0	0	
Bosnia & Herzegovina	0	0	3	3	2	3	3	3	3	0
Botswana	2	0	0	0	0	0	0	0	0	
Brazil	0	0	0	0	0	0	3	3	3	
Brunei Darussalam	0	1	0	0	0	0	0	0		
Bulgaria	0	0	3	3	3	3	3	3	3	
Burkina Faso	0	0	0	0	0	0	0	0	0	0
Burundi	3	2	3	0	0	0	0	0	0	
Cambodia	0	0	0	0	0	0	1	1	1	
Cameroon	0	0	0	0	0	0	0	0	0	0
Canada	0	1	0	0	0	1	1	0	0	
Cape Verde	0	0	0	0	0	0	1	0	1	
Central African Rep.	0	0	0	0	0	0	0	0	0	0
Chad	0	0	0	0	0	0	0	0	0	0
Chile	1	0	0	0	0	0	0	1	1	
China,P.R.: Mainland	0	0	1	1	0	0	0	0	0	1
China,P.R.:Hong Kong	0	0	0	0	0	0	0	0	1	1
China,P.R.:Macao	0	0	0	0	0	1	0	1	1	
Colombia	0	0	0	0	1	0	3	3	0	

Note: Color codes : 0 "No Signal" 2 "Only Dell'Arricia et al Signal"
1 "Only GFSR Signal" 3 "Both Signals"

Table A2.1. Signals based on Two Different Methodologies (Cont.)

Country	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Comoros	0	0	0	0	0	0	0	0	0	
Congo, Dem. Rep. of		0	0	0	0	0	0	0	1	0
Congo, Republic of	0	0	0	0	0	0	0	0	0	0
Costa Rica	3	3	0	0	0	1	0	1	1	
Croatia	0	3	3	2	2	3	3	1	0	
Cyprus	0	1	0	0	0	0	3	3	3	1
Czech Republic	0	0	0	0	0	3	3	3	1	
Côte d'Ivoire	0	0	0	0	0	0	0	0	0	0
Djibouti	1	0	0	0	0	0	0	0	0	1
Dominica	1	0	0	0	0	0	1	0	0	
Dominican Republic	2	1	0	0	0	0	0	0	0	
Ecuador	1	0	0	0	0	0	0	0	0	
Egypt	0	0	0	0	0	0	0	0	0	
El Salvador	0	0	0	0	0	0	0	0	0	
Equatorial Guinea	0	0	0	0	0	0	0	0	0	1
Eritrea	0	0	0	0	0	0	0	0	0	
Estonia	1	0	3	3	3	3	3	3	1	1
Ethiopia	0	0	0	0	0	0	0	0	0	
Fiji	3	2	0	0	0	3	3	0	1	0
Finland	0	0	0	1	1	1	1	0	1	1
France	1	0	0	0	0	0	1	1	0	0
Gabon	0	0	0	0	0	0	0	0	0	0
Gambia, The	0	0	1	0	0	0	2	2	2	0
Georgia	0	0	0	0	0	1	1	1	1	
Germany	0	0	0	0	0	0	0	0	1	1
Ghana	0	0	0	0	0	0	0			
Greece	3	3	1	1	1	3	3	3	0	0
Grenada	0	0	0	0	1	0	1	1	0	
Guatemala	0	0	0	3	0	0	1	0	0	
Guinea	0	0	0	0	0	0				
Guinea-Bissau	0	0	0	0	0	0	0	0	0	0
Guyana	0	1	0	0	0	0	0	0	0	
Haiti	0	0	0	0	0	0	0	0	0	
Honduras	0	0	0	0	0	0	3	3	0	
Hungary	3	0	0	3	3	3	3	1	1	
Iceland	3	1	1	3	3	3	3			
India	2	2	3	0	3	3	3	0	1	0
Indonesia	0	0	0	0	1	0	0	0	0	
Iran, I.R. of	0	1	0	1	0	0	1	1	0	0

Note: Color codes : 0 "No Signal" 2 "Only Dell'Arricia et al Signal"
1 "Only GFSR Signal" 3 "Both Signals"

Table A2.1. Signals based on Two Different Methodologies (Cont.)

Country	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Iraq						0	0	0	0	
Ireland	1	1	0	1	3	3	3	1	1	1
Israel	0	1	1	0	0	1	0	0	0	0
Italy	1	0	0	1	0	1	1	1	1	1
Jamaica	0	0	2	3	2	0	2	3	0	
Japan	0	0	0	0	0	0	0	0	1	
Jordan	0	1	0	0	3	3	2	0	0	0
Kazakhstan	1	1	0	1	1	1	1	1	0	
Kenya	0	0	0	0	0	0	0	0	3	
Korea, Republic of	3	3	3	0	0	0	1	1	1	0
Kuwait	0	1	0	0	0	0	0	1	0	
Kyrgyz Republic	0	0	0	0	0	0	0	1		
Lao People's Dem.Rep	0	0	0	0	0	0	0	0	1	
Latvia	1	1	3	3	3	3	3	0	0	
Lebanon	1	0	0	0	0	0	0	0	0	0
Lesotho	0	0	0	0	0	0	0	0	0	
Liberia	0	0	0	0	0	0	0	0	0	1
Libya	0	0	0	0	0	0	0	0	0	1
Lithuania	0	0	0	3	3	3	3	3	0	
Luxembourg	0	1	0	0	1	1	1	1	0	0
Macedonia, FYR	0	0	0	0	1	0	1	1	1	
Madagascar	0	0	0	0	0	0	0	0	0	0
Malawi	0	0	0	0	0	0	0	0	1	0
Malaysia	0	0	0	0	0	0	0	0	0	
Maldives	0	1	0	0	1	1	1	1	1	
Mali	0	0	0	0	0	0	0	0	0	0
Malta	0	1	0	0	1	0	1	0	1	1
Mauritania	3	2	2	2	3	0	0	1	0	1
Mauritius	0	0	0	1	0	0	0	1	1	
Mexico	0	0	0	0	0	0	2	2	0	
Micronesia, Fed.Sts.	0	0	0	0	0	0	0	0	0	0
Moldova	0	2	2	3	2	2	3	3	0	
Mongolia	0	1	1	1	0	0	0	1	0	
Montenegro				1	1	1	1	1	1	0
Morocco	1	0	0	0	0	1	1	1	1	0
Mozambique	0	0	0	0	0	2	2	0	1	
Myanmar	2	2	0	0	0					
Namibia	0	0	0	0	0	1	0	0	0	
Nepal	0	0	0	0	0	0	3	3	3	

Note: Color codes : 0 "No Signal" 2 "Only Dell'Arricia et al Signal"
1 "Only GFSR Signal" 3 "Both Signals"

Table A2.1. Signals based on Two Different Methodologies (Cont.)

Country	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Netherlands	3	0	1	1	1	1	0	1	1	1
Netherlands Antilles										
New Zealand	0	0	0	1	1	1	1	1	1	0
Nicaragua	0	0	0	1	0	1	1	1	0	
Niger	0	0	0	0	0	0	0	0	0	0
Nigeria	0	0	0	0	0	0	0	1	1	
Norway	0	1	1	0	0	1	1			
Oman	0	0	0	0	0	0	0	1	0	
Pakistan	0	0	0	0	1	0	0	0		
Panama	3	3	0	0	0	1	0	0	0	
Papua New Guinea	0	0	0	0	0	2	3	3	3	
Paraguay	0	0	0	0	0	0	0	3	3	
Peru	0	0	0	0	0	0	2	3	1	0
Philippines	0	0	0	0	0	0	0	0		
Poland	0	0	0	0	0	0	3	3	3	
Portugal	3	3	0	0	0	1	1	1	1	1
Qatar	0	1	0	0	0	1	0	1	0	
Romania	0	0	0	3	2	3	3	3	1	
Russian Federation	0	1	0	3	3	2	3	3	1	
Rwanda	0	0	0	0	0	0				
Samoa	0	0	0	0	0	1	1	0	0	0
San Marino										
Saudi Arabia	0	0	0	0	3	3	0	1	0	1
Senegal	3	0	0	0	0	3	0	0	0	0
Serbia, Republic of	1	0	0	0	1	1	0	1	1	
Seychelles	0	0	0	1	1	0	0	0	1	
Sierra Leone	0	0	0	0	0	0	0	0	0	0
Singapore	0	1	0	0	0	0	0	0	1	1
Slovak Republic	0	0	0	0	0	3	3	3	0	
Slovenia	0	0	0	0	3	3	3	3	1	1
Solomon Islands	0	0	0	0	0	1	1	1	1	
South Africa	0	1	0	1	0	1	1	1	0	
Spain	1	1	1	3	3	3	3	3	1	1
Sri Lanka	0	0	0	0	0	0	0	0	0	0
St. Kitts and Nevis	1	0	0	0	0	0	0	1	0	
St. Lucia	0	1	0	0	0	1	1	1	1	
St. Vincent & Grens.	1	0	0	0	0	0	0	0	0	
Sudan	0	0	0	0	0	0	1	0	0	
Suriname	0	0	1	0	0	0	0	3	2	

Note: Color codes :

0	"No Signal"	2	"Only Dell'Arricia et al Signal"
1	"Only GFSR Signal"	3	"Both Signals"

Table A2.1. Signals based on Two Different Methodologies (Cont.)

Country	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Swaziland	0	0	2	3	3	3	2	0	0	
Sweden	0	1	0	0	0	1	1	1	1	
Switzerland	0	0	0	1	0	1	1	1	0	1
Syrian Arab Republic	0	0	0	0	0	1	0	0	0	
São Tomé & Príncipe			0	1	1	1	1	0	0	
Tajikistan	1	0	0	0	1	0	0	1		
Tanzania	0	0	0	0	0	0	0	0	0	
Thailand	0	0	1	0	0	0	0	0	0	
Timor-Leste				1	1	1	0	0	0	
Togo	0	0	0	1	0	0	0	1	0	1
Tonga	0	0	0	0	0	1	0	1	0	
Trinidad and Tobago	0	0	0	0	0	0	0	0	0	1
Tunisia	3	0	0	0	0	0	0	0	0	0
Turkey	0	0	0	0	2	3	3	3	3	
Uganda	0	0	0	0	0	0	0	0	1	
Ukraine	0	0	3	3	2	3	3	3	1	
United Arab Emirates	0	1	0	0	0	3	3	3	3	1
United Kingdom	1	1	1	1	1	1	3	3	3	1
United States	0	0	0	0	0	0	0	0	0	
Uruguay	0	3	3	0	0	0	0	0	1	
Vanuatu	0	0	1	0	0	1	0	0	1	
Venezuela, Rep. Bol.	0	0	0	0	0	0	1	1	0	0
Vietnam	3	3	3	3	3	3	3	3	0	1
West Bank and Gaza	0	0	0	0	0	0				
Zambia	0	0	0	0	0	0	0	0	1	
Zimbabwe	0	0	1	1	0	0				

Note: Color codes :	0	"No Signal"	2	"Only Dell'Arricia et al Signal"
	1	"Only GFSR Signal"	3	"Both Signals"

Note: See Box 1 for more on the U.S. case.

Annex 3. An Output-Credit Forecasting Model[30]

An empirical model is set up to produce medium-term forecasts for output conditional upon an index of systemic financial stress (SFS). The SFS is the fraction of banks that have negative equity returns (vis-à-vis market returns) below the 5th percentile of returns given by the joint distribution of all banks, with cumulatively negative returns for the following two weeks (see Arsov et al, 2013).

The methodology combines two approaches: (i) *local linear projection method* (Jorda, 2005), also known as direct forecasts, to make the results more robust against the risk of misspecification, which is especially severe in models with episodes of large financial distress, and (ii) *smooth-transition technique* (Weise, 1999) to describe how the transmission between real economic activity (real GDP) and macro-financial developments (credit-to-GDP) change when the economy switches from normal times to distress.

For each forecast horizon, $h = 1, \ldots, H$, (in our analysis, H = 6 quarters) we estimate a simple linear autoregressive model explaining the $t+h$ values of the endogenous vector $\boldsymbol{X} = [\boldsymbol{Y_t}, \boldsymbol{C_t}]'$ (the log of the level of real GDP, and the gap in the log of the credit-to-GDP ratio, respectively) by its own time t and lagged values and exogenous shocks, where the regression coefficient can change depending on an observed state variables (here, the index of bank distress):

$$\boldsymbol{h = 1, \ldots, H}: \quad \boldsymbol{X_{t+h}} = \boldsymbol{K^h} + \boldsymbol{A^h(L)X_t} + \boldsymbol{f(w_t)}\left[\boldsymbol{\widetilde{K}^h} + \boldsymbol{\widetilde{A}^h(L)X_t}\right] + \boldsymbol{\varepsilon_t^h}$$

where $\boldsymbol{A^h(L)} + \boldsymbol{f(w_t)}\,\boldsymbol{\widetilde{A}^h(L)}$ is a polynomial in the lag operator capturing the effect of the current dates and lags of the endogenous variables on their h step ahead forecasts as a non-linear function of the level of financial stress in the system. The function $\boldsymbol{f}$ is a monotonically increasing sigmoid curve mapping the stress indicator, $\boldsymbol{w_t}$, into a range of values between 0 (no or very low stress) and 1 (very high stress):

$$\boldsymbol{f(w_t)} = \frac{\boldsymbol{1}}{\boldsymbol{1 + e^{-\gamma(w_t - \theta)}}}$$

From the point of view of our analysis, the function has $\boldsymbol{f}$ two notable features. First, it is relatively flat in the region of low values of $\boldsymbol{w_t}$ (which are observed most of the time); this way, we effectively smooth out irregular empirical fluctuations in $\boldsymbol{w_t}$ that have almost no indicative value about the changes in the financial stress. Second, after a certain threshold (determined by the two parameters $\boldsymbol{\gamma}$ and $\boldsymbol{\theta}$), the function picks up in a non-linear way meaning that the transmission characteristics from the current and lagged values of output

[30] Prepared by Jaromír Beneš.

and credit into their forecasts may change abruptly provided the data supports the hypothesis (otherwise the estimates of the coefficients in the polynomial matrix $\widetilde{\boldsymbol{A}}(\boldsymbol{L})$ will remain insignificant and close to zero).

The sigmoid function effectively separates the observed values of financial stress into two pools: normal times (no or very low stress), where the forecast functions can be approximated very well by a linear model, and times of high distress, where the forecast functions become non-linear.

The model is non-recursive: for each forecast horizon, a separate equation must be estimated: the forecasts cannot be iterated mechanically forward as is the case e.g. with VAR models. This fact makes the techniques extremely flexible and suitable for forecasting, but it is much less convenient for policy simulation experiments.

The design of the experiment we present in the main text is as follows. We select a sub-period of time (here, 2002:1 through 2012:2), and calculate the forecasts for each horizon, $\boldsymbol{X0_{t+h|t}}$, as implied by the estimated model using the actually observed data, $\boldsymbol{X0_t}$, on the right-hand side of the equations,

$$\boldsymbol{X0_{t+h|t}} = \boldsymbol{K^h} + \boldsymbol{A^h(L)X0_t} + \boldsymbol{f(w_t)}\left[\widetilde{\boldsymbol{K}}^{\boldsymbol{h}} + \widetilde{\boldsymbol{A}}^{\boldsymbol{h}}\boldsymbol{(L)X0_t}\right]$$

Then, we create a new vector of artificial observations by increasing the level of credit-to-GDP ratio on the RHS by 1 percent in each period. Denoting the new vector of observations by $\boldsymbol{X1_t}$, we re-calculate the forecasts, $\boldsymbol{X1_{t+h|t}}$,

$$\boldsymbol{X1_{t+h|t}} = \boldsymbol{K^h} + \boldsymbol{A^h(L)X_t} + \boldsymbol{f(w_t)}\left[\widetilde{\boldsymbol{K}}^{\boldsymbol{h}} + \widetilde{\boldsymbol{A}}^{\boldsymbol{h}}\boldsymbol{(L)X_t}\right]$$

and report the differences, $\boldsymbol{X1_t - X0_t}$.

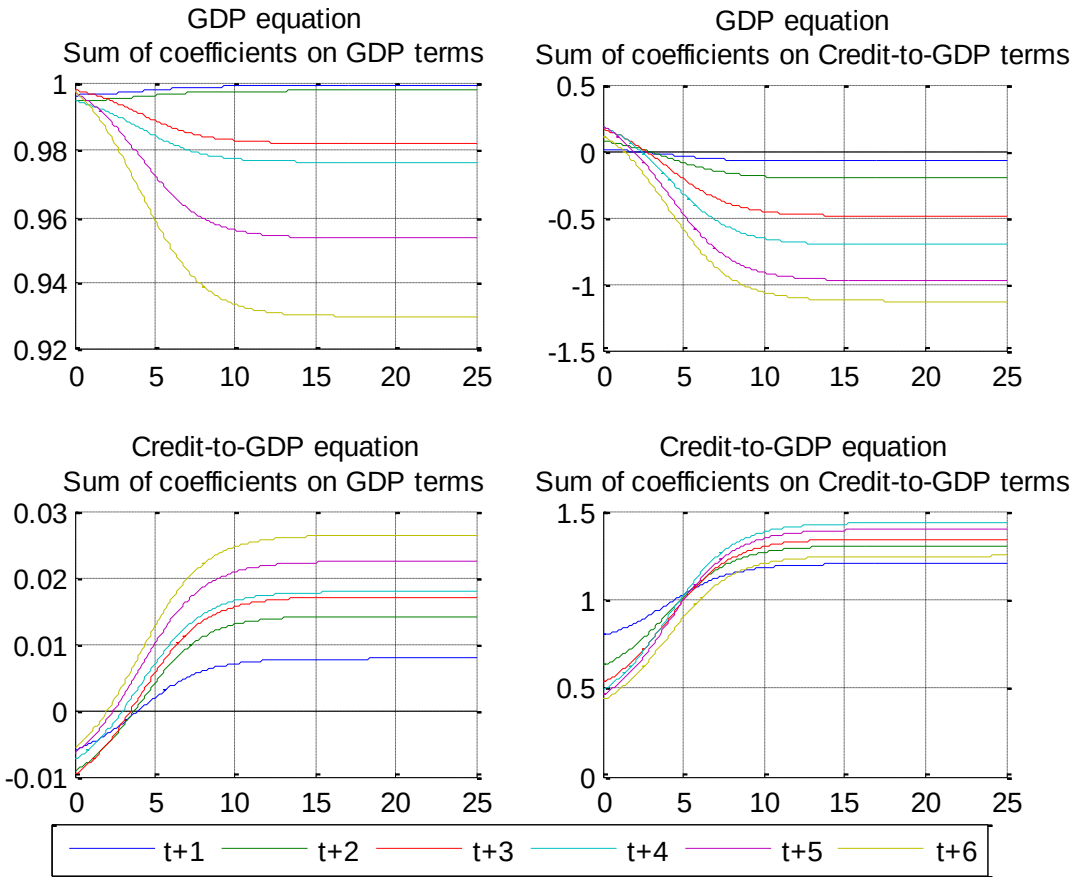
Note that the impact of an increase in the credit-to-GDP ratio on the forecasts varies, in general, with the position of the economy in the financial cycle, through the function $\boldsymbol{f(w_t)}$ and the estimated coefficients in $\widetilde{\boldsymbol{A}}^{\boldsymbol{h}}(\boldsymbol{L})$.

The main result: The role of credit for the GDP forecast changes depending on the state of the banking sector. A 1 percent increase in the credit-to-GDP ratio in normal times amount to *improvements* in the GDP forecasts by about 0.2 percent on a 4-6 quarter-ahead horizon, whereas the same increase will *reduce* the GDP forecast by about 1 percent (on the same forecast horizon) in times of large distress.

The estimates of the regression coefficients are depicted in Figure A3.1. For each forecast horizon (1, 2, 3, 4, 5, and 6 quarters ahead) we plot the regression coefficients as a function of the distress index (for values between 0 percent and 25 percent, which is approximately the range observed in the actual data). The first row is the GDP equation, the second row is the credit-to-GDP gap equation. The first column is the sum of coefficients on the current

and lagged GDP terms, the second column is the sum of coefficients on the current and lagged credit-to-GDP terms.

Figure A3.1: Estimates of regression coefficient in the output-credit forecasting model



Annex 4. Estimating the effect of intermediate targets on the cost of a financial crises: Methodology[31]

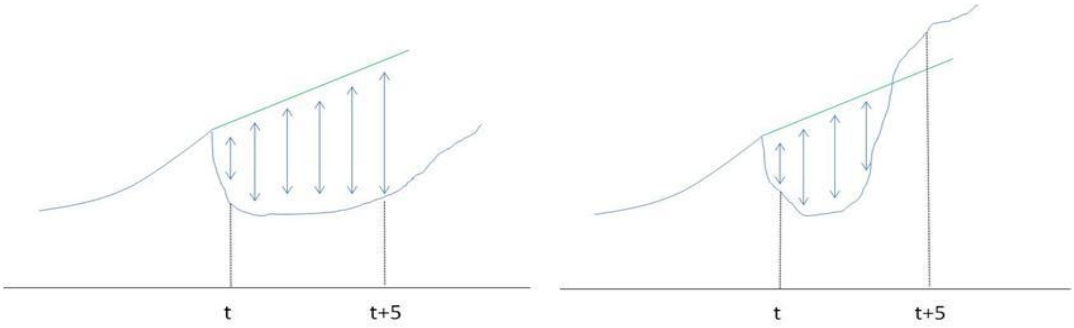
Identifying a financial crisis

We adopt the Laeven and Valencia (2010) definition under which a banking crisis is systemic if two conditions are present: (i) significant signs of distress in the banking system (as indicated by significant bank runs, losses in the banking system, and bank liquidations); and (ii) significant banking policy interventions in response to significant losses in the banking system. See Laeven and Valencia (2010) for more details. The database covers 109 countries[32] (emerging and developed), annually, from 1970 until 2010.

Measuring the cost of a financial crisis

For the purpose of the analysis in this note, we focus on GDP loss measures and ignore other costs of financial crises (e.g. fiscal costs). We measure the cost of a financial crisis as follows:

1) For each of the 5 years following the start of the crisis, compute the percentage difference from potential output (computed using the five year pre-crisis average growth rate).
2) If output exceeds potential the difference is set at zero.
3) The cost of crisis is the average over all 5 years.



The cost measure used here is therefore an average yearly cost relative to potential. For 17 percent of the countries in the sample, a financial crisis was not associated with any output cost. Around a third of the countries in the sample have recovered above the potential pre-crisis level of output by the end of the five year window. The average yearly cost of a financial crisis is estimated at 7.3 percent of potential output. The maximum average yearly cost is 34 percent and corresponds to Latvia 2008.

[31] Prepared by Nicolas Arregui

[32] The database additionally covers Congo, Eritrea, Macedonia, Santo Tome and Tanzania which are excluded from our crisis database inherited from GFSR September 2011.

Comparison to other methodologies

There is a vast literature on how to measure the costs of a financial crisis (see BCBS 2010a and Hoggarth, Reis and Saporta 2001 for a survey). To assess our cost measure, we compare the results with five different measures of the cost of a crisis.

Table A4.1: Comparing Crisis-Cost Measures

Name	References	Definition[33]
Cost 1	Reinhart-Rogoff '09, Cecchetti et al 09	Difference between GDP prior to the crisis and the subsequent trough after the onset of the crisis. Relative to pre-crisis output level.
Cost 2	Variant of IMF '09 (with different definition of potential output and end of crisis)	Difference between potential output and actual output when GDP growth rate recovers to its pre-crisis average (five year window). Relative to pre-crisis output level.
Cost 3	IMF '98, Aziz et al 00, Bordo et al '01, Demirguc-Kunt et al '05, Hutchinson-Neuberg '05	Sum of the differences between the *growth* in potential output (five year pre-crisis average) and actual output, until the end of the crisis (defined as a recovery of the growth rate to its pre-crisis average). Relative to pre-crisis output level.
Cost 4	Caprio-Klingebiel '96-'99	Sum of the differences between the *level* of potential output (computed using five year pre-crisis growth rate average) and actual output, until the end of the crisis (defined as a recovery of the growth rate to its pre-crisis average). Relative to pre-crisis output level.
Cost 5	Laeven-Valencia '08	Data obtained from LV08. Sum of the differences between the *level* of potential output and actual output, for the period [t,t+3], where t is the starting year of the crisis.

It is important to note that the cost measures are not directly comparable. Our cost measure is relative to potential output, while the others are relative to pre-crisis output. Our cost measure and costs 2 and 3 are yearly differences, while costs 4 and 5 are cumulative.

[33] For cost 1 to cost 5, we ignore crises started in 2008 that have not recovered by the year 2012 and we bound the crisis length at 5 years after the start.

Table A4.2. Summary Statistics: Cost of a Financial Crisis

Cost measure	Obs	Mean	Std. Dev.	Min.	Max.
cost1	129	4.73	5.80	0	25.02
cost2	109	11.73	15.03	0	75.55
cost3	109	10.51	12.61	0	68.89
cost4	109	31.06	52.57	0	257.67
cost5	120	30.11	33.08	0	143.43
cost	123	7.30	7.73	0	34.19

Even if the cost levels under the different measures are not directly comparable, it is informative to look at the correlation between the different cost measures. Our cost measure has a very high correlation with cost measures 2, 3 and 4 (which are in turn very highly correlated with each other).

Table A4.3. Correlation Table for Alternative Cost Measures

	cost1	cost2	cost3	cost4	cost5	cost
cost1	1					
cost2	0.56999	1				
cost3	0.6449	0.98942	1			
cost4	0.45332	0.96715	0.93506	1		
cost5	0.58126	0.4779	0.5169	0.41328	1	
cost	0.66091	0.92038	0.93808	0.86512	0.49449	1

Note that none of the cost measures allows for permanent effects on output of a financial crisis. Those are covered for instance in BCBS 2010a, Schanz and others 2011 and IMF 2009.

Intermediate targets and the depth of a crisis

We estimate the relationship between an intermediate target in the run-up to the crisis and the depth of the crisis. In particular, we consider the measure of credit expansion given by the change in credit to GDP ratio from t-3 to t-2 in percentage points, where t denotes the date of a crisis according to Laeven and Valencia (2010). Because by construction the cost of a financial crisis is bounded at zero, we estimate both an OLS (Table A4.3) and Tobit (Table

A4.4) specification. Because twin crisis are expected to be more costly, we introduce a dummy variable that is equal to one if there is a currency crisis at t-1, t or t+1.

The pre-crisis change in the credit to GDP ratio 2 years before a crisis has a significant positive relationship with the depth of a crisis. This is robust across cost measures and across estimation methodologies (OLS and Tobit).

Here are the results using change in credit to GDP growth from t-3 to t-2. The cost measure is cost 7. The coefficients of the OLS and Tobit regressions are not directly comparable as the coefficients in the latter are not the marginal effects. The marginal effect for our proposed cost measure is reported below. The marginal effects across both estimation methods are very close, roughly 0.6. This means that a 1 percentage point higher change in the credit to GDP ratio prior to the crisis is associated with a higher average yearly cost of a financial crisis of 0.6 percent, if the crisis were to materialize. The sample median of credit growth 2 years before a crisis is around 3 percentage points, and the average cost of crisis is 8 percent below potential for five years. A country with a 6 percentage points credit growth will have 8+0.6*3 = 9.8 percent below potential on average for five years.

Table A4.4. OLS and Tobit Marginal Effects

Dependent variable: cost

Explanatory variable	**OLS estimation**	**Tobit estimation**
Currency crisis dummy	3.004*	2.755*
	0.056	0.079
Change in credit to GDP (-2)	0.578***	0.575***
	0.000	0.000
Number of observations	67	67

Note: The dependent variable is the cost of a financial crisis ("cost") as described in the text. The coefficients reported for each method are marginal effects, so are directly comparable. The p-values are shown under the estimated coefficients. ***, **, and * indicate statistical significance at the 1 percent, 5 percent, and 10 percent levels of confidence based on robust standard errors, respectively.

Annex 5. Estimating the Probability of a Banking Crisis[34]

The probability of a banking crisis is estimated with a panel logit model:

(1) $Pr(y_{i,t} = 1|x_{i,t-h}) =$

$\Phi(\alpha_i + x_{i,t-h}\theta + \beta * (DUM\ if\ \Delta CtG_{i,t-h} > 3) * (RHPG)_{i,t-h})$

where $y_{i,t}$ denotes a binary banking crisis variable; $x_{i,t-h}$ is a row vector of explanatory variables, ΔCtG is the change in credit-to-GDP ratio and *RHPG* is the real house price growth; α_i denotes the random effect for country i; Φ is the cumulative distribution function of a logistic distribution; and (θ, β) is a column vector of unknown parameters to be estimated. Note that all the indicator variables are known at time $t-h$. This analysis considers forecast horizons at 2 years.

We adopt the Laeven and Valencia (2010) definition under which a banking crisis is systemic if two conditions are present: (1) significant signs of distress in the banking system (as indicated by significant bank runs, losses in the banking system, and bank liquidations); and (2) significant banking policy interventions in response to significant losses in the banking system.

The basic specification includes annual growth in real house prices and the change in the ratio of credit to GDP as explanatory variables from 1970-2010. We consider both end of period (eop) and period average (avg) real house prices. In addition, we include an interaction term between a dummy for high credit growth and real house price growth. This intends to capture the idea in Borio and Drehmann (2009) that imbalances manifest themselves in the coexistence of unusually rapid growth in private sector credit and asset prices. For simplicity, the threshold to determine the high credit growth dummy is taken at 3 percentage points (IMF, 2011b). But in actual estimation, a lower threshold of 2 percentage points also had significant effect on the crossproduct, β.

The change in credit-to-GDP ratio has a significant positive relationship with the crisis probability irrespective of the behavior in real house prices (Table A5.1). Real house price growth, however, show a significant effect on the probability of a banking crisis only during events of high credit growth. In line with Borio and Drehmann (2009), the interaction term captures the coexistence of asset price misalignments. The specification chosen to compute the crisis probability in the main text is given by

(2) $Pr(y_{i,t} = 1|x_{i,t-2}) =$

$\Phi(-3.221 + 0.0592 * \Delta CtG_{i,t-2} + 0.0734 * (DUM\ if\ \Delta CtG_{i,t-2} > 3) * RHPG_{i,t-2} -$
$0.0176 * RHPGi,t-2.$

[34] Prepared by Nicolas Arregui.

As robustness checks, a variety of alternative specifications were considered: fixed effects as opposed to random effects, a different threshold to determine the high credit growth dummy (2 percentage points) and different forecasting horizons (1 and 3 years). The coefficients on the change in credit-to-GDP and the interaction between high credit growth and real house prices growth appear to be stable under different specifications. Since the coefficient on $RHPG_{t-2}$ is small and not significantly different from zero, one can choose to ignore it; dropping this term from the regression reduces the coefficient on the crossproduct but the fitted probability estimates do not change significantly (specification 3 in Table A5.1).

Figure A5.1 shows the surface for the probability of a crisis derived from this model. The 2-dimenstion version of this surface is presented in Figure 5 in the main text.

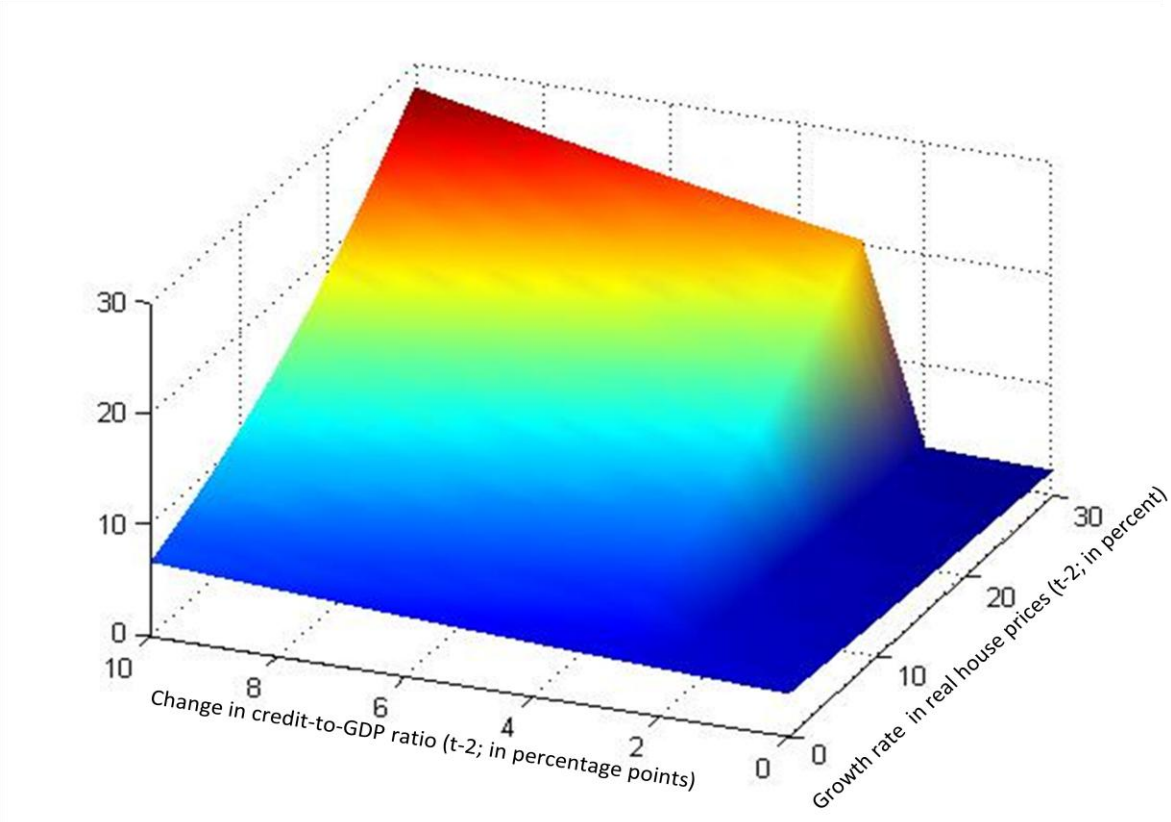
Table A5.1. Determinants of Systemic Banking Crisis

VARIABLES	1	2	3
Change in Credit-to-GDP (t-2)	0.0592**	0.0394**	0.0579**
	(0.0293)	(0.0171)	(0.0293)
Growth rate in real house prices (avg, t-2)	-0.0176		
	(0.0300)		
Growth rate in real house prices (avg, t-2) * DUM[Change in Credit-to-GDP (t-2)>3]	0.0734*		0.0565*
	(0.0416)		(0.0296)
Growth rate in real house prices (eop, t-2)		-0.0223	
		(0.0197)	
Growth rate in real house prices (eop, t-2) * DUM[Change in Credit-to-GDP (t-2)>3]		0.0644**	
		(0.0301)	
Constant	-3.221***	-3.063***	-3.223***
	(0.269)	(0.234)	(0.269)
Observations	455	473	455
Number of id	30	32	30
Sum Coefficients on House Prices = zero			
test p-value	0.0598	0.0639	--

Source: IMF Staff calculations.

Note: Standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1.
The dependent variable is a binary systemic banking crisis dummy from Laeven and Valencia (2010). DUM is a binary variable equal to one when the condition is satisfiedand zero otherwise. The model parameters are estimated using a Logit random effects model. Specification 1 (2) uses average (end of period) house prices. Specification 3 leaves out real house price growth.

Figure A5.1. Probability of Banking Crisis: A Surface Heat Map
(probability in percent)



The probability of crisis can be computed by using the estimated coefficients in (2):

$$(3)\ \text{Probability(t)} = 100*\frac{e^{\phi}}{1+e^{\phi}}$$

where $\phi = -3.221 + 0.0592*\Delta CtG_{t-2} + 0.0734*RHPG_{t-2} - 0.0176*RHPG_{t-2}$, if $\Delta CtG_{t-2} \geq 3$

$= -3.221 + 0.0592*\Delta CtG_{t-2} - 0.0176*RHPG_{t-2}$, if $\Delta CtG_{t-2} < 3$

Annex 6. Effect of Macroprudential Policy Instruments on Intermediate Targets[35]

Recent studies suggest that macroprudential policy could be effective in mitigating systemic risk. In particular, several tools can be used to deal with credit and real estate booms.

Cross-country studies

LTVs and DTIs. Almeida, Campello, and Liu (2005) find evidence that LTV limits have an effect on the financial accelerator mechanism and that housing prices are more sensitive to income shocks in countries with higher maximum LTV ratios. Wong et al (2011) show that LTV policy has been effective in reducing systemic risk in Hong Kong and other countries in terms of reducing household leverage. Ahuja and Nabar (2011) using data on 49 emerging and advanced economies finds some evidence that LTV limits slow property price growth while both LTVs and DTIs can slow mortgage credit growth. IMF (2011d) shows that high LTV ratio strengthens the effect of real GDP growth on house price growth and that government participation, including subsidies to first time homebuyers and capital gains tax deductibility, tends to exacerbate house price swings. Kuttner and Shim (2012) find that changes in maximum LTV and/or DTI ratios have strong effect on house prices and housing credit (using data from 57 economies going back as far as 1980).

Other instruments. Lim et al (2011), based on the IMF survey data, find that several macroprudential tools, including caps on the loan-to-value ratio, caps on the debt-to-income ratio, ceilings on credit or credit growth, reserve requirements, countercyclical capital requirements and time-varying/dynamic provisioning, can reduce credit growth procyclicality. Dell'Ariccia et al (2012) show that macroprudential policy, measured as a composite measure of six instruments, can reduce the incidence of credit booms and decrease the probability that booms end up badly. The existing research also suggests that various macroprudential tools can be used to deal with credit and real estate booms (mostly focusing on LTV caps). Vandenbussche, Vogel, and Detragiache (2012) find that changes in the capital requirement and liquidity measures had an impact on housing price inflation in Central, Eastern, and Southeastern Europe. Tovar et al (2012) show that an the average reserve requirement and a composite of other types of macroprudential instruments (dynamic provisioning, capital requirement etc.) have a moderate and transitory effect on credit growth in five Latin American countries.

Country studies

LTVs and DTIs. Ahuja and Nabar (2011) find that tightening LTV limits in Hong Kong reduced both transaction volumes and price growth, albeit with a lag. Moreover, Craig and Hua (2011) find that LTVs and stamp duties on property transactions helped slow down property price inflation in Hong Kong. Igan and Kang (2011) find that LTV and DTI limits seem to be associated with a decline in house price appreciation and transaction activity in

[35] Prepared by Ivo Krznar.

Korea. Krznar and Medas (2012) find that the last four measures to tighten macroprudential instruments (LTVs in particular) were associated with lower mortgage credit and house price growth in Canada.

Other instruments. Galac (2010) finds that credit growth ceiling introduced in Croatia in 2003 and 2007 reduced domestic private but not total private sector credit growth (as domestic corporate debt was substituted with foreign debt). Jimenez et al (2012) shows that dynamic provisioning introduced in Spain in 2000 mitigated credit supply cycles and had positive aggregate and firm-level credit availability and real effects. Wang and Sun (2013) find that changes in reserve requirement were effective in curbing the credit growth and house price growth in China.

Our approach

We add to the existing literature by using cross-country data to estimate the quantitative impact of macroprudential tools in cooling down the housing market (specifically house prices) and credit growth. We estimate dynamic panel regressions model for the five most frequently used policy instruments, to assess whether a tightening (loosening) of macroprudential instruments has an impact on many systemic risk measures: credit, credit/GDP, house prices, liquidity, leverage, capital flows. The sample is based on data from 38 countries, for the 2000-2011 period, which have used different instruments (LTVs, DTIs, risk weights, reserve requirements and provisioning requirements) to contain systemic risks. The regressions use a step function variable for each macroprudential instrument. This variable changes by one every time the instrument is tightened and does not change until the subsequent change of the instrument. To control for the business cycle and the price of mortgage lending we include GDP growth and long term lending rate as independent variables.

While the results suggest that LTVs, DTIs, reserve requirements and risk weights can be effective in containing credit and house prices growth (Tables A.6.1-A.6.4.), there is some evidence that reserve and provisioning requirement are associated with some “leakages” (Table A.6.5). The panel regressions provide evidence that tightening LTVs, DTIs, reserve requirements and risk weights lead to a reduction in credit/GDP and house prices growth while provisioning does not seem to have a significant impact. The control variables, interest rates and GDP growth, have the expected signs in almost all specifications of the model.

Table A6.1. Effects of Macroprudential Measures on Credit-to-GDP Ratio: Panel GMM Estimation (2000-2011)

Dependent variable: Credit/GDP y/y growth					
	I	II	III	IV	V
Credit/GDP growth $_{t-1}$	0.83 ***	0.89 ***	0.88 ***	0.90 ***	0.71 ***
	0.02	*0.01*	*0.02*	*0.01*	*0.02*
GDP Growth$_t$	0.33 ***	0.04	0.17 ***	0.00	0.02
	0.06	*0.04*	*0.05*	*0.03*	*0.06*
Lending rates$_t$	0.01	-0.14 ***	-0.02	-0.02	0.12 *
	0.02	*0.03*	*0.02*	*0.04*	*0.07*
Reserve requirement	-0.54 **				
	0.20				
Risk weights		-0.89 ***			
		0.25			
Provisioning			-0.38		
			0.31		
LTV				-0.39 **	
				0.16	
DTI					-0.82 ***
					0.26
Number of observations	638	631	542	705	374
Number of countries	15	15	13	17	9

*,**,*** indicate respectively statistical significance at the 10, 5, and 1 percent level. Standard deviations in italic.
The estimation period is 2000:1–2011:4; quarterly, seasonally adjusted data. The sample is composed of 38 countries. The regression includes individual (country) effects. Time effects are not included because of high correlation with the macroprudential policy variable.

Instrumental variables for the policy instrument (lags) and the (one-step) GMM Arellano-Bond estimator are used to address selection bias and endogeneity.

Dependent variable:

Credit/GDP is the ratio of real credits and real GDP.

Independent variables:

The lending rate is the average interest rate on the short-and medium-term financing needs of the private sector (source: IFS).

GDP growth is defined as y-o-y growth rate of real GDP (source: IFS)

A step function variable is used for all MaPP instruments (takes +1 at the time the instrument is tightened).

Table A6.2. Effects of Macroprudential Measures on Real House Price Growth: Panel GMM Estimation (2000-2011)

Dependent variable: Real House prices y/y growth					
	I	II	III	IV	V
Real house price $_{t-1}$	0.86 ***	0.84 ***	0.84 ***	0.81 ***	0.77 ***
	0.02	*0.01*	*0.02*	*0.01*	*0.02*
GDP Growth$_t$	0.36 ***	0.28 ***	0.41 ***	0.33 ***	0.16 ***
	0.06	*0.05*	*0.07*	*0.05*	*0.07*
Lending rates $_t$	-0.04 **	-0.13 ***	-0.05 **	-0.67 ***	-0.24 **
	0.02	*0.05*	*0.02*	*0.10*	*0.11*
Reserve requirement	-1.07 **				
	0.26				
Risk weights		-1.24 ***			
		0.25			
Provisioning			-0.16		
			0.35		
LTV				-0.86 **	
				0.23	
DTI					-0.52 **
					0.24
Number of observations	433	431	428	593	307
Number of countries	11	12	11	15	8

*,**,*** indicate respectively statistical significance at the 10, 5, and 1 percent level. Standard deviations in italics.

The estimation period is 2000:1–2011:4; quarterly, seasonally adjusted data. The sample is composed of 38 countries. The regression includes individual (country) effects. Time effects are not included because of high correlation with the macroprudential policy variable.

Instrumental variables for the policy instrument (lags) and the (one-step) GMM Arellano-Bond estimator are used to address selection bias and endogeneity.

Dependent variable:

The real house price is defined as house price indices deflated by CPI (source: OECD, Global Property Guide, IMF dataset)

Independent variables:

The lending rate is the average interest rate on the short-and medium-term financing needs of the private sector (source: IFS).

GDP growth is defined as y-o-y growth rate of real GDP (source: IFS)

A step function variable is used for all MaPP instruments (takes +1 at the time the instrument is tightened).

Table A6.3. Effects of Macroprudential Measures on Liquidity Growth: Panel GMM Estimation (2000-2011)

Dependent variable: Liquidity y/y growth					
	I	II	III	IV	V
Liquidity $_{t-1}$	0.8 ***	0.89 ***	0.88 ***	0.86 ***	0.67 ***
	0.02	*0.02*	*0.02*	*0.02*	*0.02*
GDP Growth $_{t}$	0.27 ***	0.23 ***	0.2 ***	0.28 ***	0.39 **
	0.05	*0.03*	*0.04*	*0.03*	*0.06*
Lending rates $_{t}$	-0.12 ***	-0.03	-0.13 ***	0.13 ***	0.06
	0.03	*0.03*	*0.03*	*0.04*	*0.09*
Reserve requirement	-0.5 **				
	0.25				
Risk weights		-0.03			
		0.2			
Provisioning			-0.2		
			0.24		
LTV				0.14	
				0.19	
DTI					-0.38 *
					0.23
Number of observations	560	550	493	635	317
Number of countries	15	15	13	17	9

*,**,*** indicate respectively statistical significance at the 10, 5, and 1 percent level. Standard deviations in italics.

The estimation period is 2000:1–2011:4; quarterly, seasonally adjusted data. The sample is composed of 38 countries. The regression includes individual (country) effects. Time effects are not included because of high correlation with the macroprudential policy variable.

A step function variable is used for all MaPP instruments (takes +1 at the time the instrument is tightened).

Instrumental variables for the policy instrument (lags) and the (one-step) GMM Arellano-Bond estimator are used to address selection bias and endogeneity.

Dependent variable:

Liquidity is measured as non-core funding (bank credit to deposits) (source: IFS, central banks).

Independent variables:

The lending rate is the average interest rate on the short-and medium-term financing needs of the private sector (source: IFS).

GDP growth is defined as y-o-y growth rate of real GDP (source: IFS))

Table A6.4. Effects of Macroprudential Measures on Capital Flows: Panel GMM Estimation (2000-2011)

Dependent variable: Capital flows y/y growth					
	I	II	III	IV	V
Capital flows $_{t-1}$	0.76 ***	0.86 ***	0.75 ***	0.77 ***	0.74 ***
	0.03	*0.02*	*0.03*	*0.02*	*0.03*
GDP Growth $_{t}$	0.79 *	0.15	1.04 ***	0.8 ***	1.07 **
	0.45	*0.15*	*0.39*	*0.19*	*0.47*
Lending rates $_{t}$	0.17	-0.09	0.1	-0.29	1.17
	0.33	*0.14*	*0.3*	*0.29*	*0.76*
Reserve requirement	-2.91				
	2.05				
Risk weights		-2.15 *			
		1.24			
Provisioning			-3.62		
			2.89		
LTV				-3.26 ***	
				1.28	
DTI					-3.63 *
					2.01
Number of observations	536	520	462	572	280
Number of countries	14	14	12	16	9

*,**,*** indicate respectively statistical significance at the 10, 5, and 1 percent level. Standard deviations in italics.
The estimation period is 2000:1–2011:4; quarterly, seasonally adjusted data. The sample is composed of 38 countries.
The regression includes individual (country) effects. Time effects are not included because of high correlation with the macroprudential policy variable.

A step function variable is used for all MaPP instruments (takes +1 at the time the instrument is tightened).

Instrumental variables for the policy instrument (lags) and the (one-step) GMM Arellano-Bond estimator are used to address selection bias and endogeneity.

Dependent variable:

Capital flows variable is the ratio of foreign liabilities to foreign assets, for bank institutions (source: IFS)

Independent variables:

The lending rate is the average interest rate on the short-and medium-term financing needs of the private sector (source: IFS).

GDP growth is defined as y-o-y growth rate of real GDP (source: IFS))

Table A6.5. Effects of Macroprudential Measures on Leakages: Panel GMM Estimation (2000-2011)

Dependent variable: Leakages y/y growth					
	I	II	III	IV	V
Leakages$_{t-1}$	0.81 ***	0.75 ***	0.81 ***	0.79 ***	0.83 ***
	0.03	*0.04*	*0.03*	*0.03*	*0.04*
GDP Growth$_t$	0.84 ***	0.70 ***	0.84 ***	0.66 ***	0.60 ***
	0.14	*0.19*	*0.12*	*0.16*	*0.22*
Interest rates$_t$	-0.17 **	-0.36 **	-0.07	0.12	-0.18
	0.09	*0.15*	*0.29*	*0.19*	*0.16*
Reserve requirement	1.21 **				
	0.65				
Risk weights		-2.13			
		1.61			
Provisioning			1.84 **		
			1.01		
LTV				-1.85	
				1.26	
DTI					-0.81
					0.78
Number of observations	270	232	331	348	197
Number of countries	10	8	10	10	6

*,**,*** indicate respectively statistical significance at the 10, 5, and 1 percent level. Standard deviations in italics.
The estimation period is 2000:1–2011:4; quarterly, seasonally adjusted data. The sample is composed of 38 countries. The regression includes individual (country) effects. Time effects are not included because of high correlation with the macroprudential policy variable.

A step function variable is used for all MaPP instruments (takes +1 at the time the instrument is tightened).

Instrumental variables for the policy instrument (lags) and the (one-step) GMM Arellano-Bond estimator are used to address selection bias and endogeneity.

Dependent variable:

Leakages refer to direct cross-border credit to private sector and is proxied by the sum of two items from IMF BOP statistics: (1) Other investment (OI) Liabilities, Net: OI Currency and Deposits Other Sector LB-BPTSTSUB 9148784..9… and (2) OI Loans Other Sectors LB-BPTSTSUB 9148775..9….

Independent variables:

The interest rate is the monetary policy rate (source: IFS).

GDP growth is defined as y-o-y growth rate of real GDP (source: IFS))

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