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## **LTV and DTI Limits—Going Granular**

Luis I. Jácome and Srobona Mitra

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**I N T E R N A T I O N A L M O N E T A R Y F U N D**

**IMF Working Paper**

Monetary and Capital Markets Department

**LTV and DTI Limits—Going Granular<sup>1</sup>****Prepared by Luis I. Jácome and Srobona Mitra**

Authorized for distribution by Karl Habermeier and James Morsink

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**Abstract**

There is increasing interest in loan-to-value (LTV) and debt-service-to-income (DTI) limits as many countries face a new round of rising house prices. Yet, very little is known on how these regulatory instruments work in practice. This paper contributes to fill this gap by looking closely at their use and effectiveness in six economies—Brazil, Hong Kong SAR, Korea, Malaysia, Poland, and Romania. Insights include: rapid growth in high-LTV loans with long maturities or in the number of borrowers with multiple mortgages can be signs of build up in systemic risk; monitoring nonperforming loans by loan characteristics can help in calibrating changes in the LTV and DTI limits; as leakages are almost inevitable, countries strive to address them at an early stage; and, in most cases, LTVs and DTIs were effective in reducing loan-growth and improving debt-servicing performances of borrowers, but not always in curbing house price growth.

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## I. INTRODUCTION

Six years after the global financial crisis, a number of countries are facing a new round of surging house prices and increasing private sector leverage (IMF Global Housing Watch). To a great extent, this is the result of a prolonged period of very low interest rates aimed at fostering economic recovery in the advanced economies. In some countries—like China, Malaysia, and Turkey—the credit-to-GDP ratio grew more than five percentage points and real house prices by more than five percent in 2013. Risks related to rapid growth in consumer and real estate loans are well-known. There is ample empirical literature supporting the notion that financial crises typically have been preceded by periods of rapid credit growth, often accompanied by asset price bubbles.<sup>2</sup>

To cope with the systemic risks associated with a surge in house prices and credit extension, limits on loan-to-value (LTV) and debt-service-to-income (DTI) ratios are becoming increasingly popular. As part of the macroprudential policy toolkit, these limits help to create buffers and curb excessive private sector leverage and this helps mitigate the effects of shocks on the housing sector, and thus on economic and financial stability (IMF, 2013a, 2013b, 2014a, and 2014b). According to the IMF's Global Macroprudential Policy Instruments (GMPI) database, 47 countries have introduced limits on LTVs, although only 27 have changed these limits over time to mitigate, and build resilience, against systemic risks.<sup>3</sup> The use of limits on DTI ratios is less popular to date as 36 countries have them in place and only 10 have actively changed them through time (Figure 1). Nonetheless, DTI limits can offer an important complement to LTV ratios, since they tie indebtedness to household income (IMF, 2014a and 2014b).

LTVs impose a down-payment requirement by capping the size of mortgage loans relative to the value of the property associated with the loan. The limits on DTI restrict the size of debt service payment to a fixed share of household income. LTV limits ensure that borrowers have 'skin in the game' while taking out a mortgage loan, and prevent buyers without savings from borrowing for house purchase. Thus the LTV limits work like an entry barrier in the mortgage market for borrowers, working through a credit demand channel (IMF 2014b). Borrowers with lower LTVs are less likely to buy for speculative reasons. Lower LTV limits also improve borrowers' resilience against future house price shocks and lead to lower losses on mortgage loans in case house prices decline. DTI caps ensure affordability of mortgage

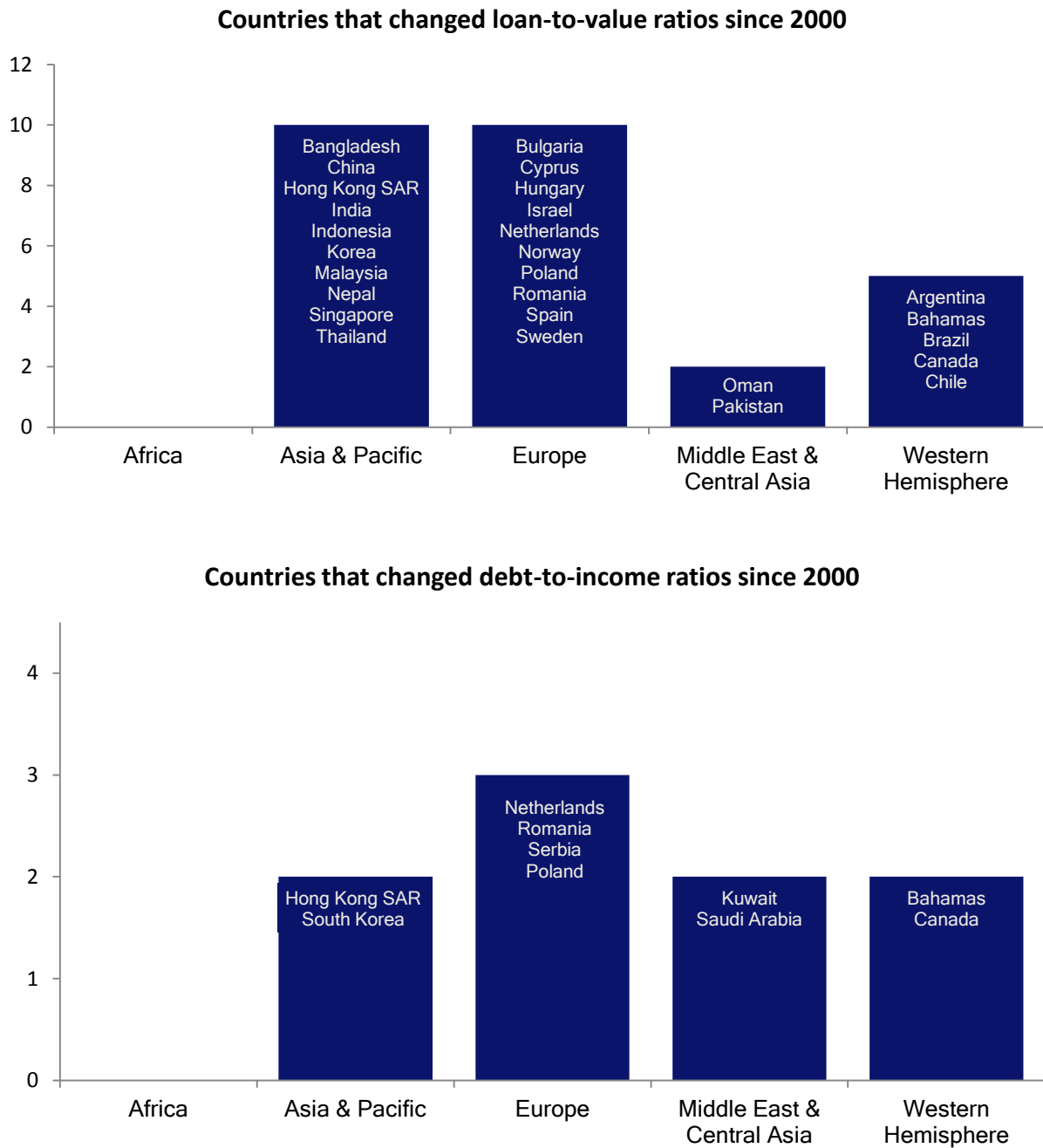
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<sup>2</sup> See Claessens, Kose and Terrones (2012), Arregui and others (2013), Crowe and others (2011), IMF (2011), and the references therein.

<sup>3</sup> The GMPI compiles the information from a survey conducted by the IMF from its membership. The survey contains answers to questions about the implementation of 17 macroprudential instruments, as of end 2013, and has responses from 133 countries.

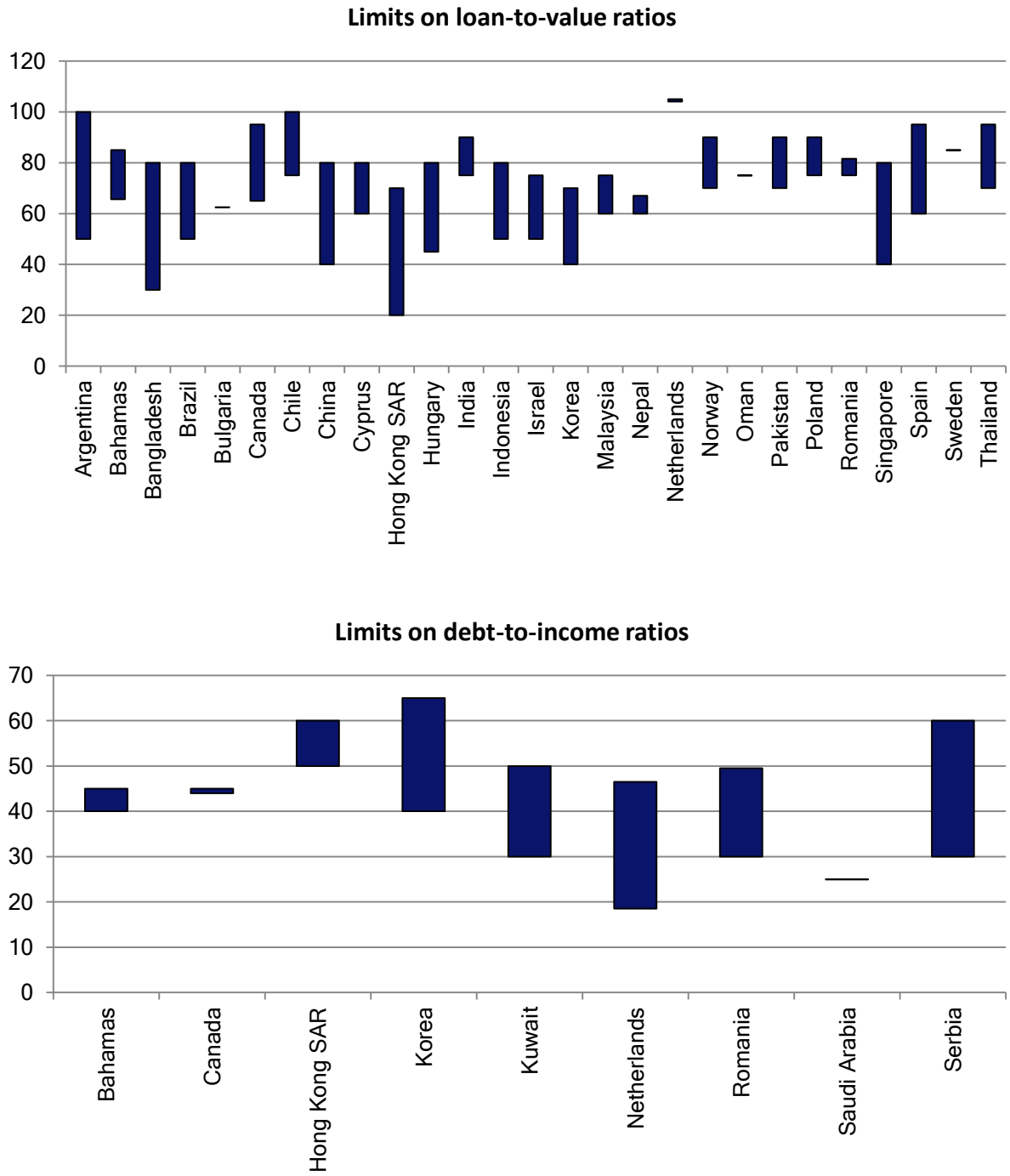
payments and liquidity of the buyers in the face of income and interest rate shocks (IMF, 2014b).

Figure 1. Use of LTV and DTI as Macroprudential Tools 2000–13



Sources: Global Macroprudential Policy Instruments database; IMF staff calculations.

Figure 2. Range of Limits on LTV and DTI, 2013



Sources: Global Macprudential Policy Instruments database; IMF staff calculations.  
 Note: A few countries, like Norway, do not have strict regulatory limits, but only supervisory guidance on such limits.

Yet little granular information is available on how exactly these tools have worked in practice. It is known that countries have set different limits on LTV and DTI ratios, between 40 and 100 percent on LTVs and between 30 and 50 percent on DTIs (Figure 2). But aside from this, there is a gap in the understanding of how countries actually implemented those tools. For instance, which indicators triggered a tightening of the instruments? Which institutions were responsible for the tools? What were the levels of LTV/DTI limits, and by how much were they typically adjusted? How were the limits applied, enforced, and communicated to the public? What were the typical interactions of these instruments with monetary and fiscal policies? How was regulatory arbitrage prevented? And, finally, are LTV/DTIs effective and, what kind of models can be used to evaluate their effectiveness on an ongoing basis?

This paper seeks to fill this gap by holding a “magnifying glass” on the experience of five jurisdictions that set LTV and DTI limits on residential mortgages and one country that used them on car loans. It discusses the findings from country-case studies (coordinated by the authors) prepared by central bank staff from those six jurisdictions—Brazil, Korea, Hong Kong SAR, Malaysia, Poland, and Romania. The studies describe in detail the implementation of the tools and their effectiveness in their respective jurisdictions.<sup>4</sup> The studies treat LTV and DTI limits as complementary measures and, hence, do not try to test their individual impact or their relative strength. The six jurisdictions include advanced and emerging economies. They feature a diverse set of economic and financial structures with various elements of systemic risk: foreign currency mortgages in Poland and Romania; persistently high demand for housing in Hong Kong SAR; speculative demand for housing in Malaysia; region-specific real estate booms in Korea; and, auto loans growth in Brazil.

The use of limits on LTV and DTI ratios through the cycle is relatively new and evolving. Therefore, this paper does not aim at identifying best practices. Yet, this granular review of experiences with these prudential instruments and their effectiveness shed light on practical challenges, and can thereby provide country-specific information that complements IMF’s detailed guidance on macroprudential policies (IMF, 2014a and 2014b).

The studies summarized in this paper provide valuable insights. The practice of systemic risk monitoring involves a wide variety of indicators, from credit and house price growth to household indebtedness, speculative activities and qualitative indicators on financial sector risk-taking. Calibrating the limits on LTV/DTIs can be helped by paying close attention to nonperforming loans (NPLs) by loan characteristics. The studies revealed that limits were effective in reducing loan-growth and improving debt-servicing performances of the borrowers. Moreover, targeting the tools towards the loan segment most at risk, like speculative properties, were found more effective than aiming at overall credit or mortgage loans.

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<sup>4</sup> See Afanasieff and others (2015), Bierut and others (2015), Kan (2015), Kim (2015), Abdul Rani and Lau (2015), and Neagu and others (2015).

The paper is organized as follows. The next section sets the stage for LTV and DTI ratios in the six jurisdictions analyzed. Section III discusses the indicators and data used by the country authorities to analyze systemic risks and trigger policy decisions. Section IV describes how the tools were calibrated, applied, enforced and discussed with stakeholders. Section V lays out the organizational structures for taking decisions and dealing with leakages. Section VI discusses the models that were used for evaluating the effectiveness of LTV-DTI measures and their findings. Section VII spells out the ten main takeaways and identifies areas for further research.

## II. STYLIZED FACTS

The six country experiences reviewed in this paper cover mostly episodes starting in the late-2000s, after the global financial crisis. At that time interest rates worldwide had fallen to record low levels and domestic credit to the housing market in most of the countries in the sample was growing at double-digit rates—in Poland and Romania, however, rapid credit expansion had started in the mid-2000s (Figure 3).

The limits on LTV and DTI ratios adopted in the six countries aimed at mitigating sector specific credit booms including, in most cases, large financing to the housing sector. In the majority of cases, the stated objective was to stem excessive credit growth and prevent house price booms. In Hong Kong SAR measures were also explicitly aimed at strengthening the resilience of financial institutions and borrowers, while in Brazil, risk weights (guided by LTV ratios) were used to slow the rapid growth in new auto loans and preserve loan quality.<sup>5</sup>

Most countries were experiencing large capital inflows when they decided to tighten LTV/DTI limits. Also, countries differed in the extent of flexibility of their exchange rates and whether they were targeting inflation. Poland and Romania differ from the other four countries in that they have a high level of foreign currency lending.<sup>6</sup>

The prevailing rate of growth of (sectoral) credit when countries started to tighten the limits on LTV/DTI ratios varied widely. Hong Kong SAR started tightening those limits when year-on-year growth in nominal mortgage loans was six percent. In Romania, in comparison, credit was growing at 60 percent. In the other countries, credit growth was in the range of 10–25 percent (Figure 3). On the other hand, real house price growth was only moderately high, except in Hong Kong SAR and Malaysia, when tightening on the basis of credit growth was going on (Figure 4). Real estate prices were declining in Poland and Romania, from the fallout of the global financial crisis.

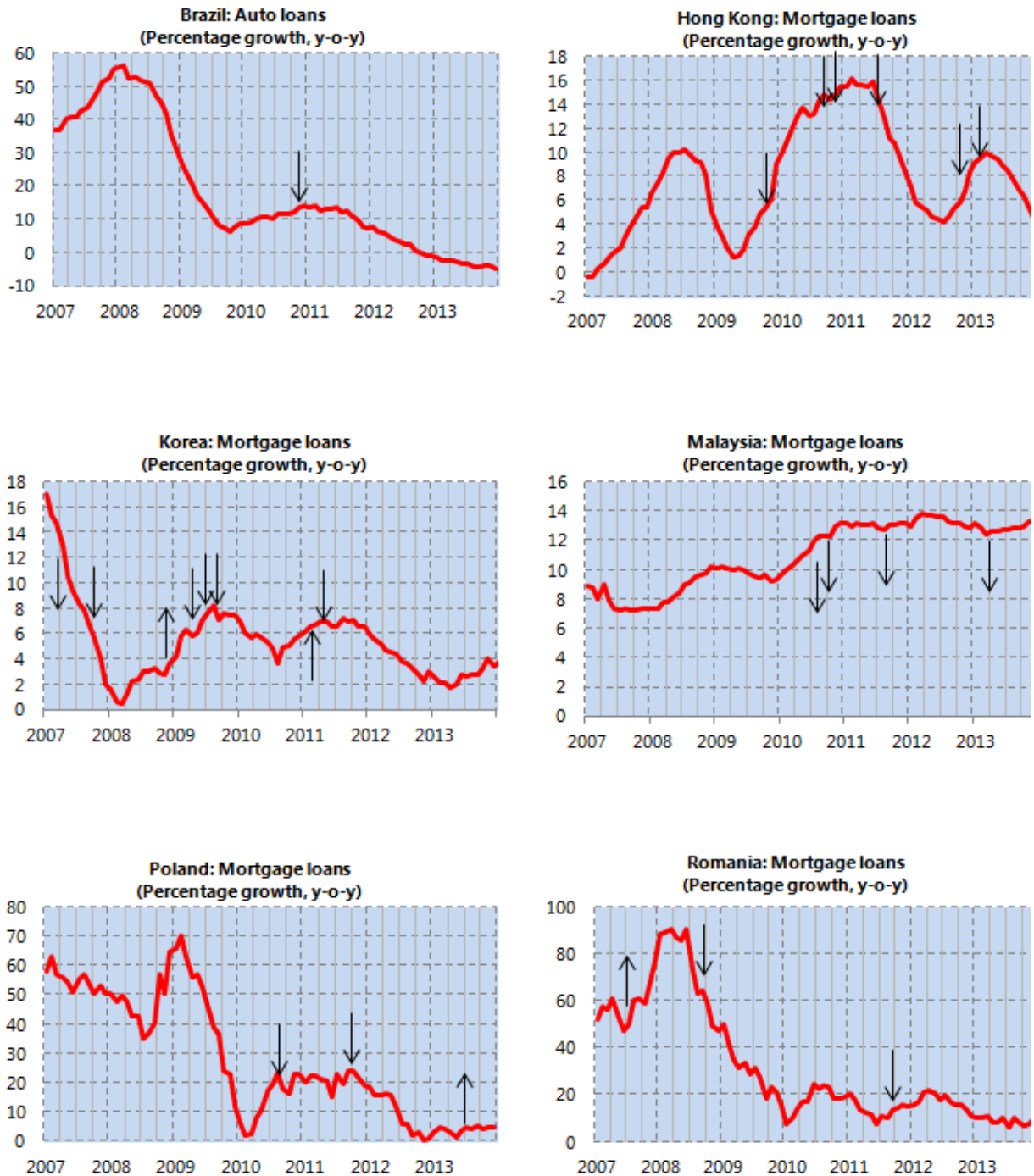
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<sup>5</sup> In November 2011, the Central Bank of Brazil recalibrated this measure, removing the link between risk weights and LTV ratio for consumer loans. For detailed information, see Table 5 in the 2012 Brazil FSAP technical note on macroprudential policy (<http://www.imf.org/external/pubs/ft/scr/2013/cr13148.pdf>).

<sup>6</sup> In Poland, more than 50 percent of housing loans were denominated in foreign currency; in Romania that figure exceeded 90 percent before the global financial crisis.

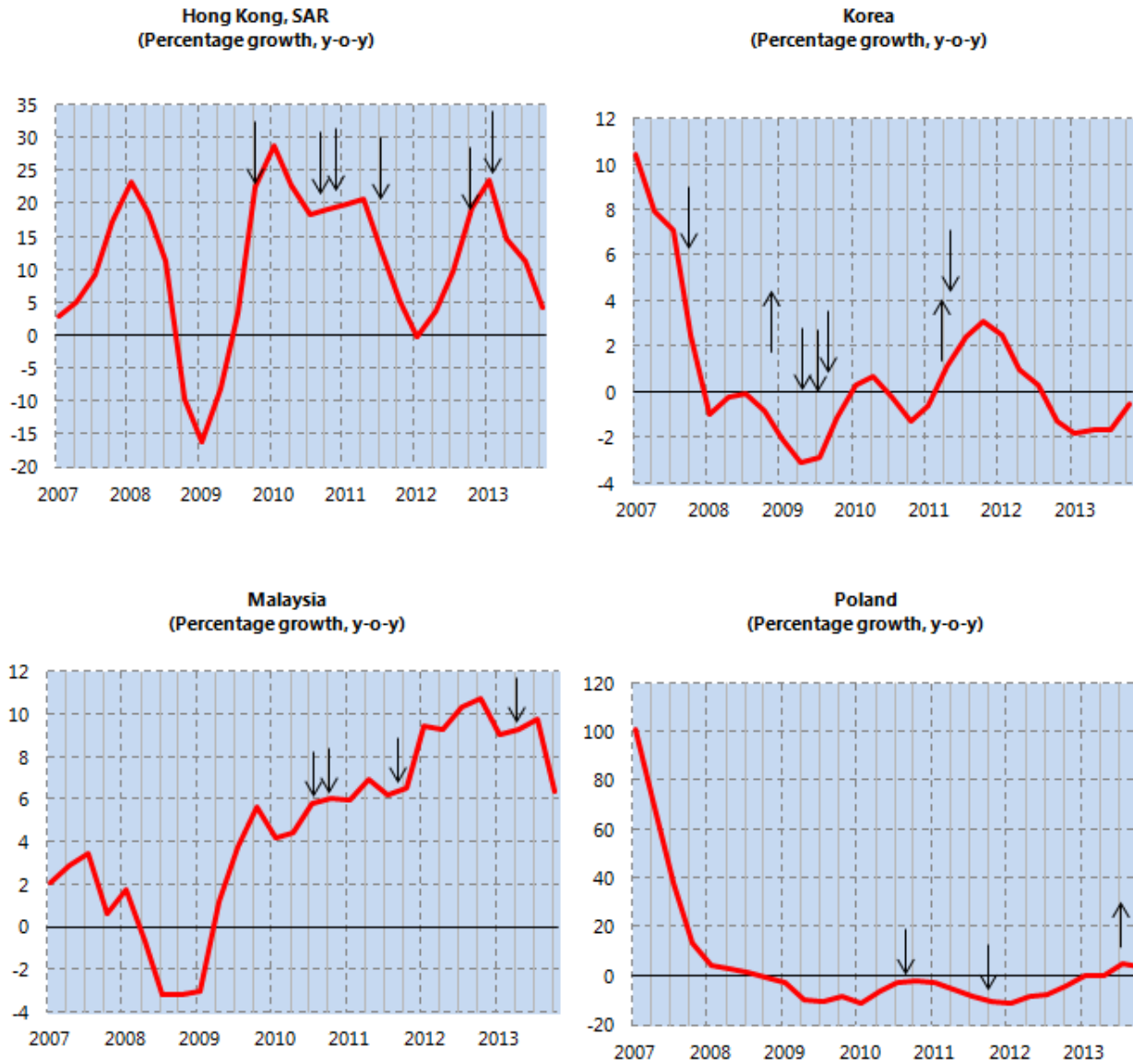


Figure 3. Nominal Credit Growth and Changes in LTV and DTI Ratios, 2007–13  
(↓ = tightening)



Sources: Central banks from the countries in the sample, Afanasieff and others (2015), Bierut and others (2015), Kan (2015), Kim and others (2015), Abdul Rani and Lau (2015), and Neagu and others (2015).

Figure 4. Real House Price Growth and Changes in LTV and DTI Ratios, 2007–13  
(↓ = tightening)



Sources: Central banks; IMF Global Housing Watch; IMF staff calculations, and, Bierut and others (2015), Kan (2015), Kim and others (2015), and Abdul Rani and Lau (2015).

The countries in the sample used very similar definitions to calculate the LTV and DTI limits. For LTVs, most countries used the value of the mortgage loan or consumer loan in the numerator and the value of the house price as the denominator. Korea, however, includes the value of other debt and lease deposit together with the mortgage loan in the numerator, and the value of the collateral in the denominator. For DTI, Romania, Hong Kong SAR, and Poland imposed it on overall debt service, while the others imposed it on different types of loans (Table 2).

LTV and DTI ratios were often accompanied by other prudential and fiscal policies in order to strengthen their effectiveness. For example:

- Malaysia increased risk weights for housing loans from 75 to 100 percent for loans with LTV ratios higher than 90 percent and capped the tenor of property loans at 35 years. The government supplemented these measures by increasing the property gains' tax to limit speculative activities, discriminating non-residents by imposing higher rates on them.
- In Hong Kong SAR, a uniform 15 percent risk-weight floor for new residential mortgage loans was introduced in February 2013; this followed the September 2012 cap of the tenor of new property mortgage loans at 30 years. The 15 percent risk-weight was extended in February 2015 to cover the entire residential mortgage loan portfolios. In addition, Hong Kong SAR imposed stamp duties in order to dampen property transactions.
- Korea raised the risk weight of risky mortgage loans from 35 to 50 percent and introduced a range of taxes (local tax, composite real state tax, and income tax) to tame the overheated housing market.
- Romania used prudential measures—such as restrictions on banks' direct and indirect exposures to exchange rate risk and increases in reserve requirements—to mitigate systemic risks. Monetary policy was also tightened sometimes.
- Poland raised the minimum risk weight for foreign currency mortgage loans in 2007 and then again in 2012.

### III. WHEN TO TIGHTEN—MONITORING SYSTEMIC RISK

The global financial crisis has underscored the importance of monitoring systemic risks. In response, many countries have developed models and selected indicators and data that can serve as warnings to alert policymakers about potential market distress.<sup>7</sup> The six countries developed their indicators drawing from various data sources to gauge systemic risk. Five key features of the indicators used in these countries are worth highlighting.

**Countries used granular data.** Countries find that monitoring systemic risk can be helped by monitoring developments/conditions in credit and housing markets, broken down into sectors, sub-indicators and regions (Table 1). The indicators monitored cover both the supply side (e.g., concentrations of financial institutions) as well as the demand side (e.g., borrower characteristics such as indebtedness and debt-service ratios). Some countries closely monitor the aggregate NPL ratio along with NPLs by LTV, loan-tenors and income levels to assess the need for changes in policy settings. Detecting speculative activities is a key concern, but

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<sup>7</sup> See IMF (2011), IMF (2013a), IMF (2014b) and the references therein. See also Arregui and others (2013b) and IMF (2014b) for risk measurements in the structural dimension.

indicators in this area are scarce. Also, qualitative information typically supplements quantitative monitoring.

**The indicators monitored come from a variety of sources.** The case studies illustrate the usefulness of having multiple data sources at hand and making creative use of indicators. Property prices and credit growth, especially mortgage credit growth (including those in foreign currencies) and consumer loan growth, are the indicators most commonly monitored.<sup>8</sup> Banks' concentration risk on real estate and consumer loans are also fairly common. The canvas of risks assessed include the banking sector, households, corporates, asset prices, macroeconomic indicators and qualitative information on lending practices (Table 1). There are attempts at monitoring household indebtedness and debt service capacity, sourcing data from credit registries and household surveys. Residential house price is a key indicator that is used in a variety of forms (growth, in asset pricing models, as forecasts, and in assessments of overvaluation or bubbles). Information on LTV (and DTI) is typically gathered from bank lending surveys, periodic household surveys, and credit bureaus. While most countries get information on average LTVs granted by banks, a few countries also try to get the range (maximum, minimum) of LTVs used in banks' internal norms.

A key takeaway from the six case studies is that information on loan tenors and LTVs, together with data on mortgage (or auto) lending growth and property price growth can provide useful signals. In fact, the combination of high LTV and long mortgage loan maturities for new lending activity can alert policy makers that lending standards are being relaxed. The difference in lending rates between comparable loans (such as auto loans and payday loans in Brazil) is also an indicator that lending standards are being relaxed.

**Speculative activities are a key concern for countries.** A key motivation for tightening LTV/DTI ratios in many countries has been to stop speculative activities in the housing market. Korea, for instance, developed criteria to designate certain regions in the "speculative zone."<sup>9</sup> A couple of relatively simple indicators together raise concerns for such activity: growth of mortgage loans together with the number of borrowers with multiple outstanding loans. Other indicators are confirmor transactions—deals in which properties are sub-sold, before the original transaction is completed—short-term resales, and the rate of subscription competition for new dwellings.

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<sup>8</sup> These indicators are identified as core indicators in the IMF's framework for risk assessment in housing markets, see IMF (2014b).

<sup>9</sup> Korea uses the following criteria (IMF, 2014b): a region is a 'speculative zone' if (a) monthly nominal house price index (HPI) rose more than 1.3 times nation-wide inflation rate in the previous month; and (b) either a previous two-month average of the regional HPI growth rate (y-o-y) was 1.3 times higher than the two-month average of the nation-wide HPI growth rate (y-o-y), or the 12-month average of the regional HPI growth rate (y-o-y) was higher than the 12-month average of the nation-wide HPI growth rate (y-o-y) in the last three years.

**Table 1. Systemic Risk Monitoring Indicators and Models**

	Romania	HK SAR	Korea	Malaysia	Poland	Brazil
<b>Sector Indicators</b>						
<b>Banks</b>						
Concentration risk in real estate and construction						
-Exposure to real estate and construction (or auto), growth						
-Provisions and capital towards concentration risk						
-Volume of real estate collateral, book value						
-Number of borrowers with multiple housing loans, growth						
-ROA/ROE, by loan category						
<b>NPLs and Arrears, Mortgage related</b>						
-NPLs, by vintages of household disposable income						
-NPLs, by vintages of corporate sector, size/sector/currency/destination						
-NPLs, stressed by interest rate and exchange rate shocks						
-NPLs, by borrowers with different number of outstanding loans						
-Mortgage loans in negative equity						
-NPLs, by LTV						
-NPLs, by mortgage loan origination year or month						
<b>Loan tenors</b>						
-Consumer/auto loan tenures (>5 years, NPLs start increasing)						
-New residential mortgage loans						
<b>LTV/DSTI, qtrly bank lending survey/one-off surveys</b>						
-Stock						
-New lending activity						
-Max/Min internal norms						
-By loan vintages						
-High LTV x long maturities						
<b>Households</b>						
Debt Service/Disposable Income (DSTI)						
Debt/Assets						
Debt-to-net wealth						
Debt/GDP						
Share of FX loans/Total Bank Loans						
Share of Mortgage and Consumer Loans/Total Loans						
Indebtedness, credit registers						
Property price/income						
Housing loans by banks and nonbanks						
<b>Asset Prices</b>						
Property price						
-Forecasts, using a model						
-GDP per capita +						
-Real mortgage interest rate -						
-Housing supply -						
-Equity prices -						
-Exchange rate						
-Bubbles						
-Price-Rent ratio						
-Overvaluation based on forecasting model						
-House price, deviation from trend						
Property transaction volumes						
Speculative activities						
-Confirmor transactions and short-term resale						
-Rate of subscription competition (for new dwellings)						
-Mortgage loan growth x Number of borrowers with multiple outstanding loans						
Buy-rent gap						
Constructions plans and permits						
<b>Other Macroeconomic indicators</b>						
Interest rates						
Flow of funds						
GDP growth						
-Forecasts consistent with house prices						
<b>Qualitative indicators</b>						
Underwriting standards						
-Attractive loan packages						
-Risk pricing strategies, mispricing of risk						

Sources: Afanasieff and others (2015), Bierut and others (2015), Kan (2015), Kim and others (2015), Abdul Rani and Lau (2015), and Neagu and others (2015).

**Granular data on NPLs can help calibration.** Although the changes in the aggregate fraction of NPLs in gross loans are a lagging indicator of systemic risk, granular loan-by-loan data on NPLs can inform policymakers of underlying problems. For instance, in Romania, the parsing of NPLs by loan characteristics allowed the authorities to determine that NPLs increase with higher LTVs, lower income levels (Figure 5) and longer loan tenors (greater than five years). In addition, even when overall NPLs are declining (because of high credit growth) analysis of NPLs by loan characteristics can point to elevated risks in certain segments of the market. In fact, as is shown in the next section, cross-sectional information on NPLs by loan category can help calibrate adjustments in the LTV/DTI ratios.

**Countries use judgment and qualitative information in addition to quantitative indicators.** A supervisory sense of whether underwriting standards are deteriorating is generally combined with quantitative indicators to get a sense of increases in systemic risk. For example, one indicator that triggered policy action in Brazil was the steady decline in the gap between interest rates on auto loans (a sector that was overheating) and payroll-deducted loans (a comparator for auto loans). Keeping an eye out for “attractive” loan packages can also help in this regard.

Summarizing, these countries monitored not only credit and house price growth but also a wider variety of indicators. They found it useful to look at household indebtedness, speculative activities and qualitative indicators on financial sector risk-taking. Three trends especially sent an alert signal: (i) rapid growth in high-LTV loans with long maturities; (ii) rapid growth in mortgage loans and the number of borrowers with multiple mortgages; and (iii) increasing NPLs on particular loan characteristics, even if the overall NPL-ratio was declining.

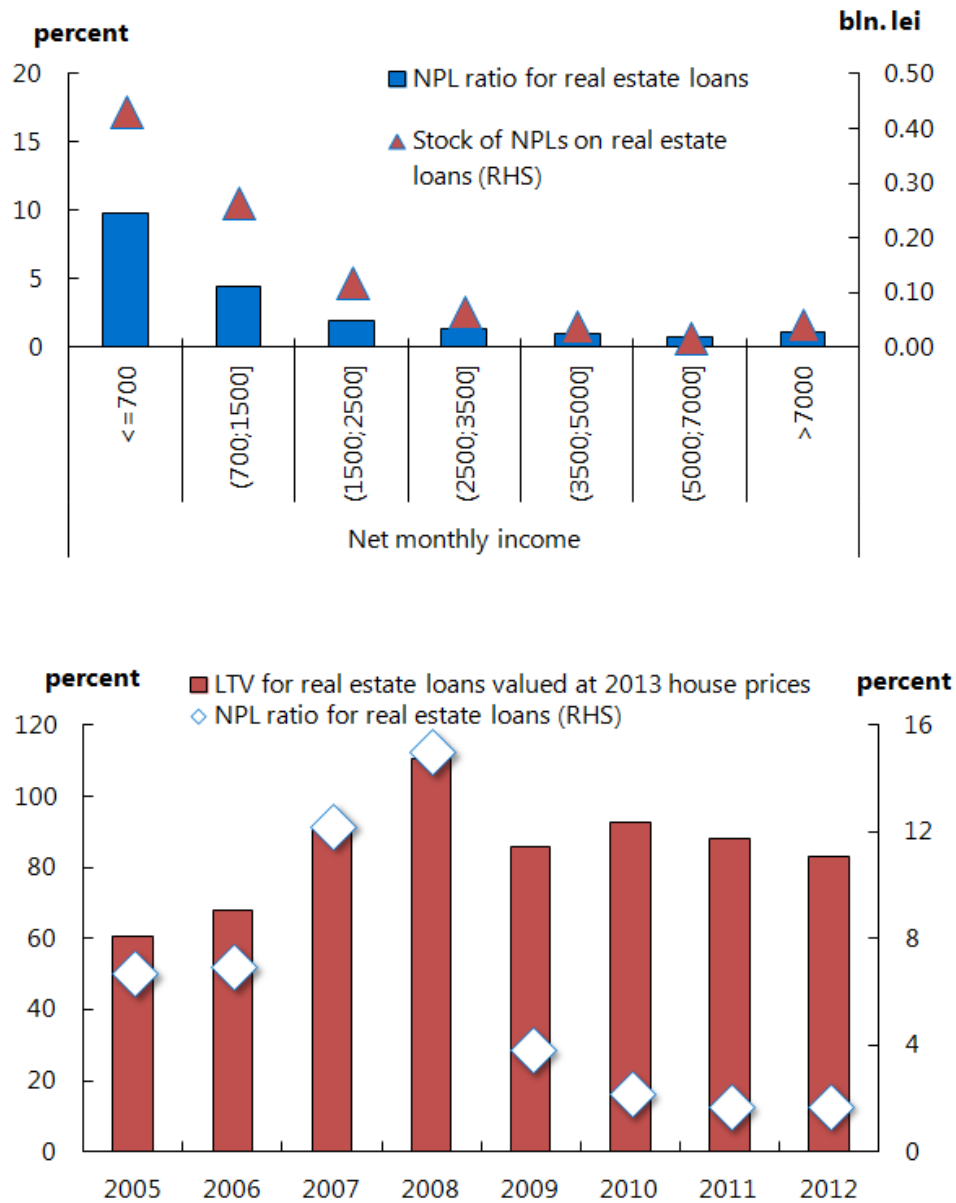
#### IV. USING THE POLICY TOOLS

This section sheds light on the operational aspects of LTVs and DTIs in the six countries, namely: factors that influence the decision on the actual limits for LTV/DTI and when to tighten or loosen; whether to enforce the measures at the time of the announcement or later, after a period of consultation; and how the measures can be communicated to market participants.

##### A. Calibration

With the exception of Brazil, the countries in the sample did not conduct formal quantitative analysis to set the level or changes of the limits; and none of the countries had an ex-ante assessment of the exact timing, along the cycle, to tighten or loosen these limits. In other words, the management of these tools was largely discretionary. In some cases, the limits were imposed initially on banks’ borrowers; over time, these were extended to borrowers from other institutions to curb leakages.

Figure 5. Romania: NPLs, Household Income and LTVs



Source: Neagu and others, 2015.

Note: The data comes from Central Credit Register, Credit Bureau, MPF and NBR. The information includes only households with bank loans and the net monthly income does not include the co-borrowers. The coverage ratio is around 70 percent of total exposures and 50 percent of NPLs (in December 2013). The LTV values are calculated at December 2013 (for all annual vintages) and therefore reflect the values of collateral in December 2013.

## No magic numbers

In most cases, the caps on LTV and DTI started in the range of 60–85 percent and 30–45 percent, respectively, for mortgage loans. Subsequently the limits were tightened or differentiated by type of borrower (Table 2). In some cases, the limits were lower for mortgages denominated in foreign currency, especially for unhedged borrowers, or for borrowers with income derived from crossborder sources. Limits on commercial properties were set at lower levels; for example, in Hong Kong SAR, where LTV was set as low as 20 percent for borrowers that had multiple mortgages and used net-worth based on income derived from abroad.

**Table 2. Calibration of the LTV-DTI Limits**

Indicators	Romania	Hong Kong SAR	Korea	Malaysia	Poland	Brazil
<b>LTV</b>						
Type						
Consumer/auto loans	75					>60->80 <sup>1</sup>
Mortgage	75	50-60	40-70		80-95	
local currency	85					
fx, hedged	80					
euro, unhedged	75					
other fx, unhedged	60					
longer maturities and meeting DTI limits						
commercial		40			75-80	
with mortgage insurance		80-90				
with income derived from outside the country and with outstanding mortgages		~ -10 pp ~ -20pp				
Only speculation prone areas or multiple mortgages				70		
Numerator						
Mortgage loan value						
Mortgage loan value plus other debt						
<b>DTI</b>						
Debt service (numerator)						
Consumer	30					
Mortgage	35		40-65			
FX loans					42	
Overall	40	40-50 <sup>2</sup>			50-65	
<b>Exemptions</b>						
First time home buyers under a government social policy		3/			3/	
<b>Quantitative exercise</b>						
Clear link between Indicators and limits on LTV and DTI						
<b>Qualitative indicators</b>						
Evaluation of debtors' capacity to repay the loan under stress scenarios						
Judgmental						
Survey of banks						

<sup>1</sup>Risk Weights on auto loans ranged from 75 percent to 150 percent depending upon the LTVs and loan tenors.

<sup>2</sup>40 percent for applicants with multiple mortgages, 50 percent for those with no multiple mortgages.

<sup>3</sup>In Hong Kong SAR, public housing under the government's scheme where the mortgages are guaranteed by the government, LTV and DTIs are not binding, even though these mortgages are expected to comply with prudent underwriting standards. Poland provides a government subsidy for downpayment to eligible first time home-buyers.

Sources: Afanasieff and others (2015), Bierut and others (2015), Kan (2015), Kim and others (2015), Abdul Rani and Lau (2015), and Neagu and others (2015).



### Use of NPLs by loan characteristics

In Brazil, LTV caps were built into banks' risk weights, calibrated by quantitative analysis of NPLs on combinations of LTVs and loan maturities on several loan vintages. For instance, it was observed that as LTVs increased and maturities increased (moving to the south-east portion of the left-side table in Table 3), so did the NPL-ratio. This cross-sectional analysis informed a decision to adjust risk weights for a combination of high LTV and/or long loan tenors from 75 percent to 150 percent.

**Table 3. Brazil: NPLs for Different LTVs and Loan Tenors Inform Risk Weights**

		Maturity (years)			Change of Risk Weight
		>1 & ≤2	>2 & ≤3	>3 & ≤4	
LTV (in percent)	≤ 60	1.0	1.9	2.4	From 75 to 150
	> 60 & ≤ 70	2.0	3.4	3.9	
	> 70 & ≤ 80	3.0	3.5	4.3	
	> 80 & ≤ 100	3.4	4.0	5.9	
		Maturity and LTV			
		2-3 and LTV > 80			From 75 to 150
		3-4 and LTV > 70			
		4-5 and LTV > 60			
		More than 5 and any LTV			

Source: Adapted from Afanasieff et al, forthcoming

### Frequent changes in caps

In all countries, there were changes to the limits of LTV/DITs typically because the authorities noted that they were not having the desired effect. In some cases, house price and mortgage growth did not fall, and in other cases, the limits did not bind. Concerned with speculative activities, authorities in some countries lowered the caps selectively either for speculative prone (geographical) areas or for individuals with multiple mortgages. In one case, the centrally set caps were removed and banks were allowed to set their own limits, validated by supervisors. However, this did not work, and stricter requirements were put back in place.

### Mostly housing mortgages, but also other loans

Although limits on LTV-DITs were most common for housing loans, in some countries they also covered commercial real estate, auto loans, and consumer credit. Typically, the loan amount was the numerator of the LTV; but in one country the numerator comprised the loan amount and other debts (senior debt plus deposits for lease). For the DIT, the numerator was typically debt service—annual repayment of principal and interest on mortgage loans—but the type of debt varied. For instance, in one case interest payments on other debt was included. The denominator for the DIT was usually disposable income, but in one country it

was changed over time to the “minimum expense required for daily existence.” The attempts in both cases were aimed at making the limits binding.

### **Starting with banks, extended to other institutions**

To curb leakages, the limits were extended in some of the countries to insurance companies, mutual funds and finance companies that advertised mortgage products. It was also extended to development financial institutions.

### **Challenges with cross-border housing demand**

LTV-DTIs may not be binding on all borrowers in situations where foreign buyers flock to buy houses with cash. A similar situation occurs if residents buy houses with foreign financing. In such cases, other policy tools that directly impact the level of transactions (such as stamp duties and capital gains taxes) have been employed. In one case, the LTV limits were lowered for individuals deriving income from cross-border sources and further lowered for those with multiple mortgages to manage financial stability risks from shocks arising in another country.

### **No quantitative cost-benefit analysis**

Possible side-effects were analyzed only in qualitatively terms. The main concern was for the first-time borrowers, for whom the limits were removed, lowered, or dealt with a separate government-sponsored scheme that lessened the burden.

## **B. Application and Enforcement**

### **Mostly immediate application**

In most countries, the caps took immediate effect, but some flexibility was kept in some cases. Where LTV and DTI ratios were changed or adopted without previous notice, there was a chance that some loan requests had been made just before the announcement of the new ratios. To deal with these cases, Hong Kong SAR allowed financial institutions to be flexible and exempt those buyers who had already signed the provisional sales and purchase agreements from being subject to the new regulations. Korea allowed periods of 5 to 15 days between the date of announcement and the date when the new regulation became effective, to provide time for financial institutions to do preparatory work. In Romania this period varied between 30 and 60 days. Because its measure involved capital requirements, the Central Bank of Brazil followed a somewhat different approach. After defining a cut-off date, it approved a seven month phase-in period for having the new risk weight enter into effect. In Poland, on the other hand, measures were always announced at least five months in advance.

### **Close monitoring**

Countries developed a variety of procedures to enforce the compliance with the new regulations. The main distortion that is likely to appear is that the same bank, or another institution, provides a loan to finance the down payment, in addition to the loan subject to the LTV limits; such co-financing would undermine the effectiveness of the limit. In the six countries, this did not seem to occur frequently as it could be detected early and be subject to penalties. Another form of circumventing the measure is when housing loans are recorded by non-individuals, like in Malaysia. In general, supervisory agencies monitor the correct implementation of LTV and DTI tightening through offsite procedures and via onsite inspections. For instance, Hong Kong SAR can take several measures in response to non-compliance, including the requirement of external auditors, holding bank staff accountable, and factoring incidents of non-compliance into their CAMEL rating system. Such non-compliance could lead to a downgrade of the composite CAMEL ratings and, hence, to an increase in the premium under the deposit insurance mechanism.<sup>10</sup> Incidents of non-compliance can also be factored into the assessment of banks' statutory minimum capital adequacy ratio.

### **C. Communication**

Communication related to prudential measures typically has two stages. The first takes place *ex ante*, when the new regulation is in a draft stage, and regulators are interested in discussing and agreeing with financial institutions the content and scope of the new legislation to enhance the effectiveness of the policy. The second occurs *ex post*, with the aim of disseminating the information on the new rules to the public on a timely, transparent, and clear basis.

#### **Usually not discussed prior to adoption**

Contrary to common practices for prudential regulations, in several countries in the sample, the introduction or changes on LTV and DTI was not preceded by discussions with the financial industry. They preferred to issue the new regulations without prior consultation, to avoid a last-minute rush toward purchasing properties or cars. Such a rush could cause acceleration of asset prices and/or a surge in credit, precisely what the new measure was trying to avoid.

Poland and Romania followed the practice of consulting with the financial industry before introducing new prudential regulations or changes to existing ones. Consultations took place at the drafting stage, sometimes eliciting adverse reactions, in particular in Poland, where

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<sup>10</sup> CAMEL refers to a system of supervisory rating that covers six aspects of soundness—Capital adequacy, Asset quality, Management capability, Earnings, and Liquidity.

banks openly criticized some of the proposals. Korea, on the other hand, gave financial institutions 5 to 15 days so as to strike a balance between the benefits and costs of pre-announcing the measure. Communicating in advance with the Ministry of Finance or the Treasury occurred in some cases in order to coordinate the LTV/DTI with tax measures, which could be used as complements to the macroprudential policies, as in Hong Kong SAR and Korea.

### **Communication strategy key**

Ex post, all the countries developed a communication strategy once decisions were made. Decision-takers sought to disseminate the content and the details of the regulation beyond the official publication.

## **V. TAKING DECISIONS**

In most countries in the sample, the institutional arrangement for decisions on LTV and DTI ratios were already in place. They pre-dated the discussion that has taken place recently on the optimal design of institutional arrangements for macroprudential policy, based on incentives that aim at avoiding an inaction bias and also at preventing the influence of possible vested interests from the financial industry.<sup>11</sup>

### **A. Institutions**

#### **Central banks monitor systemic risks in most countries**

The countries in the sample show a range of institutional arrangements. In most countries, the central bank is the key institution in charge of monitoring systemic risks—including developments in the housing market—and of executing and enforcing macroprudential policies, such as LTV and DTI ratios (Brazil, Hong Kong SAR, and Romania). In Korea, however, the implementation and enforcement of macroprudential tools is a shared responsibility between the central bank and the financial supervision agency. In Poland only the latter agency was responsible. In Malaysia, there are two committees that monitor systemic risks—the Financial Stability Committee, on entities regulated by the central bank, and the Financial Stability Executive Committee, on entities outside the bank’s regulatory perimeter. In addition, a Joint Policy Committee coordinates monetary policy and macroprudential policy decisions.

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<sup>11</sup> While there is no one-size-fits-all model, there are basic principles that should be present in any institutional arrangement to be effective. These include: (i) the central bank should play a key role; (ii) a fragmentation of agencies in charge of monitoring systemic risks and regulating corrective actions should be avoided; (iii) the participation of the treasury is important, but should not have a dominant role; and (iv) systemic risk prevention and crisis management should be assigned to separate agencies as they are different policy functions (see Nier and others, 2011). See further also IMF (2013a) and IMF (2014a).

### **Decisions on policy tools taken by different entities**

The institutional setup for decision-making on the policy tools is somewhat more diverse. There is a first group of countries, comprising Brazil and Romania, where there is a single committee in charge of taking decisions on both monetary policy and financial stability, chaired by the central bank governor.<sup>12</sup> In Hong Kong SAR, there is a Macro Surveillance Committee (MSC) within the Hong Kong Monetary Authority (HKMA), which meets regularly to assess emerging risks in the monetary and financial systems and formulate appropriate policy responses. The MSC is chaired by the Chief Executive of the HKMA. In turn, Malaysia has a dedicated committee, the Financial Stability Executive Committee, also chaired by the central bank governor.

The institutional arrangement in Korea and Poland has evolved in recent years. Until 2012, macroprudential policy in Korea was coordinated through different institutions, but there was no formal policy-decision inter-agency committee. In 2012, the Macroeconomic and Finance Meeting was established, with a mandate to provide recommendations on macroprudential policies. However, the recommendations of this committee are not binding since the responsibility for approving and executing macroprudential policies remain with the regulatory and supervisory agencies. In Poland, banking supervision and regulation were part of the central bank until 2006, when a unified financial supervisor was created. While a Financial Stability Committee was created that same year, this committee is rather a consultative body in charge of coordinating the exchange of information and conducting crisis management.

### **Decisions rarely coordinated with monetary policy**

In the countries in the sample, decisions on LTV and DTI ratios were not always coordinated with monetary policy. The majority of countries deployed the tools to restrain mortgage credit growth without much coordination with monetary policy. Only in Korea, during 2006–08, and to some extent in Malaysia, LTV and DTI ratios were tightened at the same time as the policy rate was being raised (Figure 6).

## **B. Dealing with Policy “Leakages”**

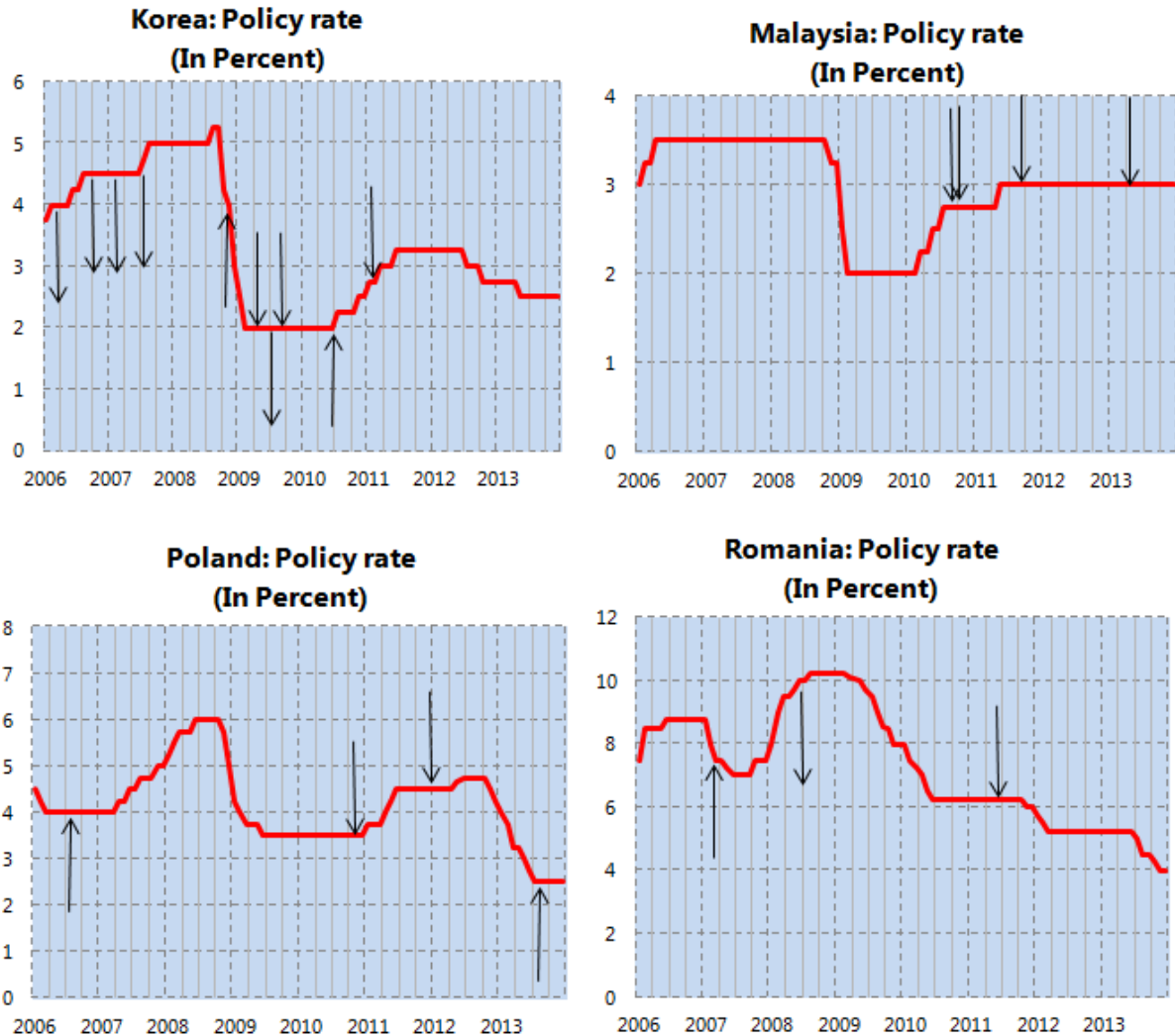
Leakages are an inevitable consequence of changes in macroprudential policy, as different kinds of financial institutions are involved in similar but slightly differentiated types of activities. In economies open to cross-border banking flows the potential for leakages is even

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<sup>12</sup> Strictly speaking, in Brazil, the National Monetary Council (CMN), chaired by the Minister of Finance and comprising the President of the Central bank of Brazil and the Minister of Planning is the highest policy-making authority for financial stability. However, the CMN delegated to the central bank the decisions on the risk weights for auto loans. In Romania, following a recommendation from the European Systemic Risk Board (ESRB), a new national committee (National Committee on Macro-prudential Supervision) will be in charge with all decisions on macroprudential policy.

higher. The six countries in the sample faced various types of leakages and responded to them in different ways. The discussion below illustrates the types of loopholes that can arise.

Figure 6. Policy Interest Rates and LTV and DTI Ratios, 2007–13  
( ↓ = tightening)



Sources: Afanasieff and others (2015), Bierut and others (2015), Kan (2015), Kim and others (2015), Abdul Rani and Lau (2015), and Neagu and others (2015).

### Regulatory arbitrage through other institutions

The LTV-DTIs in the countries in the sample, were typically enforced on banks. However, financial groups continued to evade the regulations by booking mortgage (and other) loans through their non-regulated entities (Table 4). The most common response was to bring the nonbank institutions under the regulation and to closely cooperate with the nonbank supervisors. In some cases where direct regulations were not possible, the authorities

garnered additional powers to request information from the nonbank lenders or sought to impose the LTV-DTI limits from a consumer protection perspective/agency.

**Table 4. Leakages with LTV-DTI Limits**

Leakage	Policy to curb the leakage	Romania	Hong Kong SAR	Korea	Malaysia	Poland	Brazil
Non regulated entities within financial groups	Bring nonbank institutions under the regulation; close cooperation with nonbank supervisors; additional powers to request information from nonbank lenders; consumer protection.	■		■		■	
Promotional interest rates in the first few months of the loan to fulfill the DTI requirements	Ensure debtors fulfill DTI for the entire life of the loan	■					
Lengthening maturity to fulfill DTI	Limited the maximum tenors of consumer	■					
Unregulated money lenders	Requested FIs to review their lending practices to the money lenders; close monitoring, surveys		■				
Crossborder mortgage lending by foreign financial institutions	Monitoring; strengthening cooperation and coordination with other regulators; requiring banks financing borrowers to acquire overseas properties observe applicable overseas regulatory requirement		■				
Extending mortgage loan maturity by 1 month above which LTVs are strictly enforced				■			
Foreign bank branches, especially European	Foreign bank requested to follow host regulations; home supervisor asked to support it; existence of a supranational body (ESRB)						■

Sources: Neagu and others (2015), Kan (2015), Kim and others (2015), Abdul Rani and Lau (2015), Bierut and others (2015), Afanasieff and others (2015).

Branches of foreign banks are another source of loopholes, especially in the European countries. In such cases, foreign banks were requested to follow the host-country regulations and the home-supervisors were asked to support it. Similarly, direct cross-border mortgage lending by foreign financial institutions is another possible leakage. In such cases, close monitoring was the main mode of surveillance.

### **Modifying loans to meet standards**

DTI restrictions, which have been used less than LTV limits, put a cap on monthly payments on interest and principal as a share of disposable income. A common way for financial institutions to get around that limit was to lengthen the maturity of the loan or to give promotional interest rates in the first few months of the loan. The authorities tried to curb

these practices by ensuring debtors fulfill the DTI restrictions for the entire life of the loan and by limiting maximum loan tenors.

### **Less leakages when policies are well targeted**

In Brazil and Malaysia, policies were targeted at the auto-loans market or at speculative activities (borrowers with three or more mortgage loans only), respectively. In both cases, authorities did not find significant policy leakages. In Malaysia, the bulk of the housing loans reside with regulated entities under the central bank, which minimizes both the need for extensive inter-agency coordination for implementation.

### **Supranational agencies help coordinate**

In countries with open capital accounts and free movements in crossborder banking flows, a supranational multilateral agency could help facilitate coordination between supervisors. In Europe, this role is being played by the ESRB, which helped coordinate home-host macroprudential policies among European emerging economies implementing LTV-DTI limits after it was established in 2010. Another way to contain the leakages would be to require foreign banks to be locally incorporated subsidiaries in both countries, bringing these entities naturally under the host supervisors, and discussing macroprudential policies with home supervisors of foreign banks either bilaterally or in supervisory colleges.

## **VI. EVALUATING EFFECTIVENESS**

How effective were the LTV-DTI limits in achieving their objectives? Some empirical evidence suggests that a ten percentage point increase in the maximum-allowed LTV ratio is associated with a 13 percent increase in nominal house prices (Crowe et al, 2011); while other studies find that a ten percentage point decrease in the LTV ratio is associated with a ten percentage point decline in the house price appreciation rate (Duca and others, 2011). McDonald (2015) has found that the tightening of LTV and DTI limits are more effective when credit is expanding quickly or when house prices are high relative to income. Other cross country experience, using panel data regressions and dummy variables for tightening or the loosening phases, show that LTVs and DTIs help curb, and have long-lasting effects on, credit and real house price growth.<sup>13</sup> A few other studies, like Vandenbussche and others (2015), do not find empirical support for these measures.

We investigate these questions in the six countries of our sample from a cross-country panel analysis and time-series perspectives. Specifically, we first report panel estimates on the effect of LTV-tightening on mortgage credit levels for Hong Kong SAR, Korea, Malaysia, Poland, and Romania.<sup>14</sup> The panel estimates are based on the methodology in Romer and

<sup>13</sup> See Lim and others (2011), Arregui and others (2013a), and Cerutti and others (2015) for cross-country evidence, and see Igan and Kang (2011) on Korea, Krznar and Morsink (2014) on Canada, Ahuja and Nabar (2011) and He (2014) on Hong Kong SAR, and Crowe and others (2013) for the United States.

<sup>14</sup> Brazil did not implement an LTV ratio directly and, hence, is left out of this exercise.



Romer (2004), Cerra and Saxena (2008), and IMF (2010) and the narrative description of episodes of LTV-tightening found in Lim and others (2013) and in each of the studies for the five jurisdictions.<sup>15</sup> We find that the panel estimates yield small but significant effects of tighter LTVs on mortgage credit level. Moreover, similar panel estimates for real house price growth yield small and counterintuitive effects.

These results further validate the need for taking a closer look at the time-series evidence. The time-series estimates show that the effectiveness of the measures could be evaluated on many dimensions, including on (a) curbing excessive household or consumer credit expansion; (b) moderating real estate price growth; and (c) improving the resilience of the system by curbing household leverage and banks' NPLs.

### A. Panel Estimates: Small Effects of LTV on Mortgage Credit

To ascertain the effects of tighter LTV limits (lower ratios) on mortgage credit growth, we estimate the following regression (see Annex I for details):

$$(1) \quad \Delta C_{it} = \alpha_0 + \alpha_i + \sum_{s=1}^{30} \beta_s \Delta LTV_{it-s} + \sum_{i=1}^{24} \rho_i \Delta C_{it-i} + e_{it}$$

where C is log of mortgage credit,  $\Delta C_{it}$  is the monthly growth in mortgage credit,  $\Delta LTV$  is the change in the LTV limits, and  $\alpha_i$  are country fixed effects. Our monthly sample period is July 2002–December 2013. The  $\Delta LTV$  is a simple version of a very complex policy variable. As described in earlier sections, these countries had multiple LTVs for various loan-characteristics and authorities tend to change various ratios together with other policies. Our attempt is to isolate only the LTV-tightening episodes to see if these limits work when risks are building up. We thus acknowledge that tightening and relaxing LTVs work differently, and we are attempting to capture just one side of the measure.

In the months that LTV is tightened for each of the five jurisdictions, we take the change in the limit for the most restrictive loan component. To ensure that the LTV-tightening reflects policy *ex ante*, we take the LTV-changes at the time of decisions, not at the time of implementation. We obtain this data from Lim and others (2013) and supplement it with information from the case studies of the five countries. There can be long gaps between the time of decisions and the time of implementation (see section on Application). We have also taken 24 lags of mortgage credit growth, to absorb all other sources of information that can influence the dependent variable, and 30 lags of  $\Delta LTV$ , to allow for prolonged impact of the policy on mortgage credit.

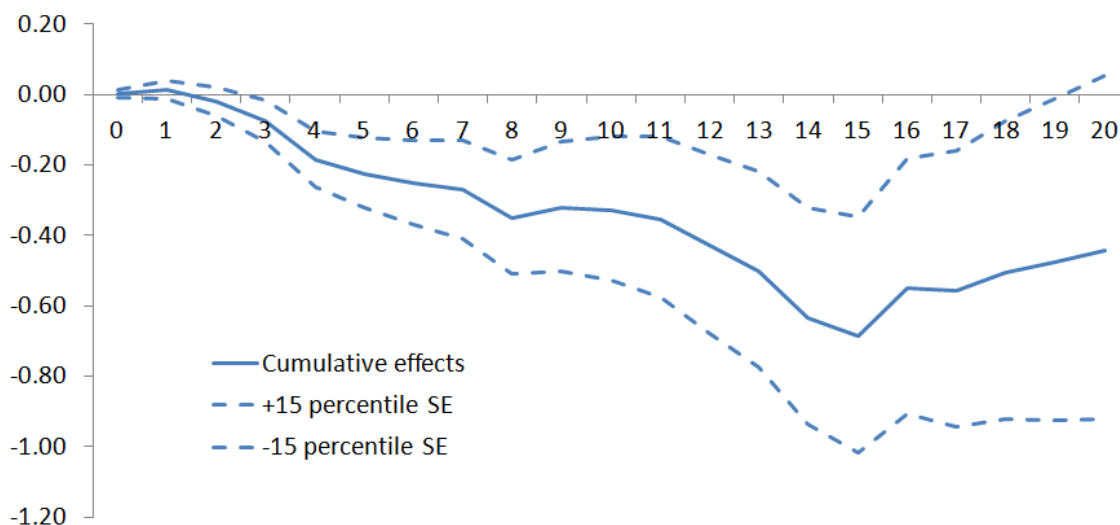
The results from the panel regression suggest that a ten percentage point tightening of LTV has a maximum cumulative impact of lowering the level of mortgage credit by about 0.7 percent (Figure 7). The data on  $\Delta LTV$  and point estimates of the panel regression are

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<sup>15</sup> See details are in Annex I.

presented in Annex 1. Results are similar when Poland and Romania (both hit by the global financial crisis) are removed from the five-country group.

Figure 7. Effects of Lowering LTV Limits by Ten Percentage Points on Mortgage Credit Level (in percent)



Sources: Authors' estimates; see Annex I for details.

When the regression is run using quarterly changes in real house price growth for the five countries (since monthly data is not available) as the dependent variable, the results are counterintuitive but not significant.

To summarize, panel estimates show that a ten percentage point lower LTV limit has a small but significant effect in lowering the level of mortgage credit by 0.7 percent over time, and counterintuitive effects on real house prices.

## B. Results from Time-Series Models with Rich Datasets

The country studies used a wide array of models to examine the effectiveness of LTV and DTI measures (Table 5). Besides, countries used a plethora of data sources, both micro and macro datasets, from various agencies (see Annex II).

- The study on Romania (Neagu and others, 2015) used a panel Generalized Method of Moments (GMM) model of loan-growth for 14 banks, and tested whether a dummy variable for quarters when LTV and/or DTI were introduced or modified had a significant effect on loan-growth. The regression controlled for monetary policy, reserve requirements, macroeconomic variables and bank-specific characteristics. The study also estimated another panel data regression using GMM to explain NPL ratios of several vintages of loans granted over a seven-year span. This regression sought to

ascertain whether prudential regulations had helped reduce NPLs, and consequently loan servicing capacity of the households.

- The study on Hong Kong SAR (HKMA, 2014) estimated a vector auto-regression (VAR) model to evaluate the short-run impact of macroprudential measures on (time-series of) mortgage loan growth, house prices and transaction volume, controlling for the impact of other economic and financial factors. The framework distinguishes between prudential tools and stamp-duty measures. The study also estimated a demand-supply econometric model for mortgage loans to evaluate how tightening LTVs strengthens banks' resilience to property price shocks by dampening both credit growth and borrowers' leverage (Wong and others 2014).

**Table 5. Effectiveness of LTV-DTI Limits—Country Experiences**

Objectives	Romania	Hong Kong SAR	Korea	Malaysia	Poland	Brazil
Curbing excessive credit growth, including speculative growth						
Consumer/auto loans	Green					
Mortgage		Green	Green	Green	Green	
Curbing house price growth	Pink		Green			
Improving the resilience of the system to future adverse shocks						
Curbing household leverage		Green			Green	
Curbing banks' NPLs	Green	Green			Green	Green
Methodology	Dynamic Panel Data, Generalized Method of Moments (GMM)	Vector Auto-Regression (VAR); Demand-Supply econometric model for mortgage loans	Global Vector Auto-Regression (GVAR)	Event Study; Quadratic regression	Survey data analysis	Difference-in-Differences
Policy	LTV, DTI: together	LTV, DTI: together	LTV, DTI: separately	LTV	LTV,DTI: separately	
Other policy instruments		Stamp duties; loan tenor cap of 30 years				Capital risk weights based on LTV

<sup>1</sup>Stated objective, successful (Green), Stated objective, unsuccessful (Pink); Not a stated objective (Blank).

Sources: Neagu and others (2015), Kan (2015), Kim and others (2015), Abdul Rani and Lau (2015), Bierut and others (2015), Afanasieff and others (2015).

- The study on Korea (Kim and others, 2015) used a global VAR model of house prices and mortgage loans, for 43 regions and estimated the impact of LTV and DTI limits (separately) on the two housing-related variables and overall GDP growth.
- The study on Malaysia (Abdul Rani and Lau, 2015) used an event study (LTV-announcements) to gauge if the growth rate of loans extended to individuals for the

third and above outstanding housing loan fell significantly and persistently following the announcement.<sup>16</sup>

- The study on Poland (Bierut and others, 2015) analyzed survey data to evaluate whether prudential measures led to changes in the distribution of (values of) LTV and DTIs, as well as proxies for credit risk within the population of borrowers.
- Finally, the study on Brazil (Afanasiëff and others, 2015) used a difference-in-differences method to investigate whether new targeted loans was affected by the measure (higher risk-weights for certain combinations of LTV and maturity), when compared to a control variable (new untargeted auto loans).

### **Effective in taming credit growth and NPLs**

The findings from the country studies broadly suggest that LTV and/or DTI measures were mostly effective in curbing credit growth but not house price growth. In Romania, for example, the estimates show that the measures arrested consumer credit growth but not mortgage credit growth or house price growth. The results for Korea, however, suggest that house price growth was indeed tamed. The results for Brazil suggest that the measures successfully curbed high-LTV loans and improved debt-servicing of the auto loans; whereas the results for Hong Kong SAR and Poland show that the measures helped to clamp down on household leverage. The study for Malaysia found the measures effective in limiting the number of speculative borrowers. The three studies that examined NPLs by loan-characteristics reported significant improvements in the performance of the loan portfolio following the prudential measures. With the exception of Korea, none of the studies found that the macroprudential measures were effective in reducing house price growth; this was especially so for countries that faced persistent housing demand and capital inflows.

### **Quantitative effects of LTV changes**

Most of the studies used binary variables to proxy for tightening LTVs (one for tightening, zero for no movement), which makes it difficult to interpret the impact on intermediate variables for systemic risk. The study on Korea (Kim and others, 2015), however, used actual LTV ratios in its cross-regional global VAR model. Results from that study suggest that a ten percentage point decrease in the LTV limit lowered the level of mortgage credit by about two percent, house prices by about 3 percent, and real GDP by 0.8 percent in the long run. In comparison, changes in DTI limits had a lower impact (Table 6).

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<sup>16</sup> Malaysia also used two other models that are explained in Abdul Rani and Lau (2015).

### Striking at the transactions level, rather than credit

The study on Hong Kong SAR shows that the stamp duties that are tied to house purchases, rather than macroprudential measures targeting housing loans, were very effective at curbing house price appreciations. The reason for this was the stamp duties directly affected prices at the level of housing transactions and were not related to the origination of mortgage credit.

**Table 6. Korea: Impact of Lowering LTV and DTI Limits**

Long run effect on: (in percent)	Ten percentage point lower LTV limit	Ten percentage point lower DTI limit
Mortgage loans	-2.2	-2.0
House prices	-2.8	-1.1
Nominal GDP	-0.8	-0.3

Source: Kim and others (2015).

Summarizing, time series evidence from each country that dug deep into the measures show that LTV limits were effective in reducing loan-growth and improving debt-servicing performances of the borrowers. However, these measures were not effective in curbing house price growth, especially in countries that faced persistent capital flows. Targeting the tools towards the loan segment most at risk, like speculative properties, were more effective than aiming at overall credit or mortgage loans.

## VII. TEN TAKEAWAYS AND SUGGESTIONS FOR FURTHER RESEARCH

The paper tries to shed light on the actual practice of macroprudential policy. Based on the evidence analyzed in the six country studies for Brazil, Hong Kong SAR, Korea, Malaysia, Poland, and Romania, granular details emerged on systemic risk measurement, institutional arrangements, calibration and enforcement of tools and their effectiveness. In these six episodes, our analysis points to key takeaways for implementing LTV-DTI policies in practice that are set out below. These observations do not attempt to distill best practice, but should be read to complement the framework for macroprudential policy instruments provided in IMF (2013a), IMF(2013b), IMF (2014a), and IMF (2014b).

### Monitoring systemic risk—going beyond credit and house prices

1. Countries monitor systemic risks, especially sectoral risks, by tracking and being attentive to a range of indicators, beyond aggregate credit and house prices (see Section III). Examples include:
  - a. Growth in high LTV loans with long maturities;

- b. Growth in mortgage loans and the number of borrowers with multiple mortgages;
  - c. Cross-sectional differences in NPLs on loans with specific characteristics based on LTV, foreign-currency, borrower income, loan tenors, even when the overall NPL-ratio (in percent of gross loans) is flat or decreasing due to rapid credit growth; and
  - d. Widening difference in interest rates on comparable loans (such as auto loans versus payday loans) suggesting that lending standards on one of them is falling.
2. Countries monitor a wide range of indicators, including those for borrowers, speculative activities and other qualitative indicators on risk-taking. Creative design and use is made of indicators (such as those listed in 1) based on macroeconomic and supervisory data, as well as from credit bureaus and surveys of households and financial institutions. In order to do this, the macroprudential authority needs access to various types of data sources.

### **Using the tools**

3. In the six countries, the range for limits on LTVs was 60–85 percent, and that for DTIs was 30–45 percent. Also, the criteria used for setting those ranges, and for changing them were mostly discretionary.
4. NPLs by LTV-specific or DTI-specific loan characteristics can help in calibrating the limit adopted. In particular, combinations of high-LTV loans with longer loan tenors were associated with higher NPL ratios. And, this information was used to increase (capital) risk-weights on auto loans from 75 percent to 150 percent in Brazil (see Section IV).
5. The LTV/DTI measures were often complemented by other prudential and fiscal measures to enhance effectiveness. For example, capital gains tax on property, stamp duties, reserve requirements, a range of taxes, and risk weights.

### **Taking decisions**

6. The case studies found that in the six countries reducing the time between announcement and implementation limited regulatory arbitrage. This suggests that, faced with emerging risks, it can be preferable to announce and implement the measures without consulting with financial institutions in advance. That said, the measures have to be well communicated to the public once adopted (see Section V).
7. Central banks are often in charge of monitoring systemic risk but a diverse set of institutions take decisions on macroprudential policy. However, for the specific exercises for the case studies, the central banks had access to a wide range of data from other institutions.

8. Some leakages are unavoidable. Their effects could be moderated where the authorities cooperate with other supervisory authorities in advance, including supranational agencies, and are flexible in closing them where they arise.

### **Evaluating effectiveness**

9. Time-series estimates from the country studies suggest that decreases in LTV and DTI limits were effective in reducing loan-growth, improving debt-servicing capacities of the borrowers and thus making the financial sector more resilient against downside risks (see Section VI). However, the measures, in general, did not affect house price growth, except in one case. Capital flows in the real-estate market and direct lending by foreign banks may hinder the effectiveness of the measures.

10. Targeted measures (those aimed at the most risky group of mortgage loans) were more effective than those applicable to overall mortgages. For instance, measures aimed at speculative properties and regions in Korea seemed to be effective in reducing the acceleration of real estate prices in these regions.

### **Issues for further research**

The vast evidence gathered in the six country studies suggests that there remain important gaps in our understanding of macroprudential policies. We would like to emphasize five areas. First, further work could look at whether there are benefits to being more rules-based when deciding on how much to tighten or loosen policies (IMF, 2013a and 2014a). Second, the exact transmission channels through which the LTV/DTIs work in practice and interact with other policies need further analysis. Third, further work is needed on how to make macroprudential policies more effective in situations where there are surges in capital flows and strong and persistent demand for housing from cross-border sources. Fourth, more work is needed to analyze the trade-off between social policies aimed at home-ownership versus the high economic costs of housing-related financial crisis. And fifth, little is known as to when, by how much, and based on what information, countries should ease LTV/DTI limits.

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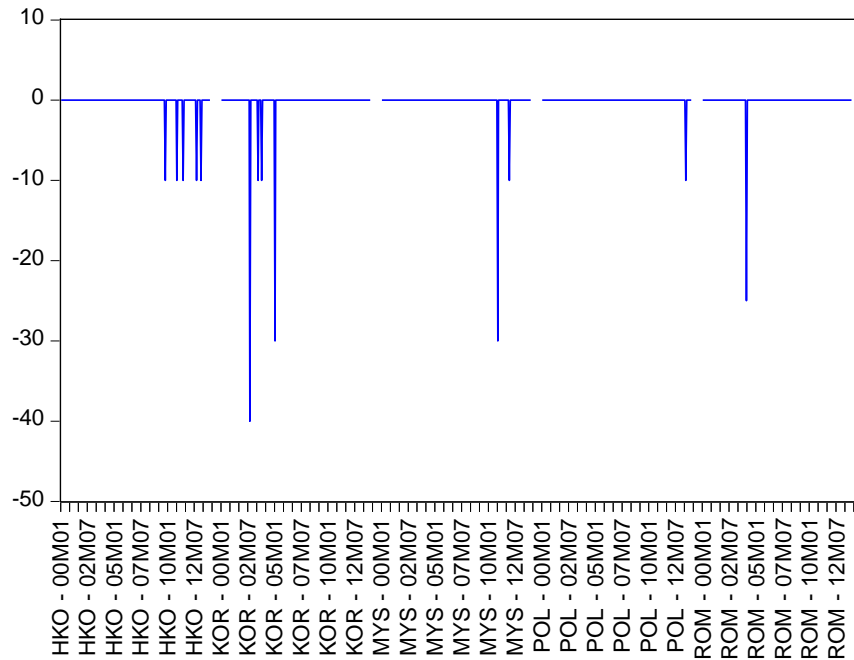
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**Annex I. Panel Estimates for the Impact of LTV on Credit**  
Change in LTV Ratios (Tightening Episodes Only)



Sources: Lim, Krznar et al (2013) and the country studies for our sample.

$$\Delta C_{it} = \alpha_0 + \alpha_i + \sum_{s=1}^{30} \beta_s \Delta LTV_{it-s} + \sum_{i=1}^{24} \rho_i \Delta C_{it-i} + e_{it}$$

Coefficient	Estimates	Standard Error	Coefficient	Estimates	Standard Error
$\alpha_0$	0.224	0.178	$\beta_{15}$	0.000	0.008
$\beta_1$	-0.001	0.009	$\beta_{16}$	-0.019	0.008
$\beta_2$	0.004	0.009	$\beta_{17}$	-0.002	0.009
$\beta_3$	0.005	0.009	$\beta_{18}$	-0.004	0.010
$\beta_4$	0.010	0.014	$\beta_{19}$	-0.002	0.008
$\beta_5$	0.001	0.008	$\beta_{20}$	-0.001	0.006
$\beta_6$	0.000	0.007	$\beta_{21}$	0.002	0.005
$\beta_7$	-0.001	0.012	$\beta_{22}$	0.006	0.007
$\beta_8$	0.006	0.007	$\beta_{23}$	0.002	0.006
$\beta_9$	-0.005	0.007	$\beta_{24}$	0.001	0.006
$\beta_{10}$	0.000	0.011	$\beta_{25}$	-0.002	0.009
$\beta_{11}$	0.002	0.008	$\beta_{26}$	0.004	0.009
$\beta_{12}$	0.007	0.010	$\beta_{27}$	0.016	0.009
$\beta_{13}$	0.005	0.006	$\beta_{28}$	0.005	0.007
$\beta_{14}$	0.010	0.006	$\beta_{29}$	0.007	0.004

Coefficient	Estimate	Standard Error	Coefficient	Estimate	Standard Error
$\beta_{30}$	0.001	0.007	$\rho_{13}$	0.058	0.076
$\rho_1$	0.150	0.093	$\rho_{14}$	0.032	0.072
$\rho_2$	0.186	0.088	$\rho_{15}$	0.015	0.076
$\rho_3$	0.100	0.086	$\rho_{16}$	-0.075	0.070
$\rho_4$	0.063	0.087	$\rho_{17}$	0.102	0.072
$\rho_5$	0.002	0.085	$\rho_{18}$	0.106	0.087
$\rho_6$	-0.021	0.075	$\rho_{19}$	-0.116	0.085
$\rho_7$	-0.016	0.083	$\rho_{20}$	-0.036	0.069
$\rho_8$	-0.009	0.078	$\rho_{21}$	0.095	0.071
$\rho_9$	0.062	0.080	$\rho_{22}$	-0.008	0.064
$\rho_{10}$	-0.025	0.066	$\rho_{23}$	0.009	0.069
$\rho_{11}$	0.078	0.077	$\rho_{24}$	-0.034	0.063
$\rho_{12}$	0.064	0.069			
$R^2 = 0.33$ DW = 1.99 Country Fixed Effects, unbalanced panel Cross-section: Hong Kong SAR, Korea, Malaysia, Poland and Romania Time: July 2002–December 2012, monthly Number of observations: 501 Standard Errors: White corrected					

The estimated responses of mortgage credit growth in the months following one percentage point lower LTV tightening are calculated as follows (Figure 7, top panel):

$$\text{Month 1} = \beta_1$$

$$\text{Month 2} = \beta_2 + \rho_1 \beta_1$$

$$\text{Month 3} = \beta_3 + \rho_1(\beta_2 + \rho_1 \beta_1) + \rho_2 \beta_1$$

.....and so on.

The cumulative impact (Figure 7, bottom panel) on the level of credit is derived by adding up the monthly effects:

$$\beta_1 + (\beta_2 + \rho_1 \beta_1) + (\beta_3 + \rho_1(\beta_2 + \rho_1 \beta_1) + \rho_2 \beta_1) + \dots\dots\dots$$

The standard error bands are derived by generating the distribution of coefficients from 1000 random draws based on the estimated variance-covariance matrix for the coefficients.

## Annex II. Data Sources for Country Case Studies

<b>BRAZIL (Afanasieff et al, 2015)</b>		
Variable	Data	Sources
<b><i>Dependent Variable</i></b>		
Auto loans	Auto loan granting	BCB's Financial System Monitoring Department
<b><i>Explanatory Variables</i></b>		
1. Dummy treatment	Zero for new untargeted loans and one for new targeted loans (new loans with certain LTV and maturities combinations)	BCB's Financial System Monitoring Department
2. Dummy measure	Dummy measure is zero before the event and one after the event (the events are the introduction of the measure in the first case study and its withdrawal in the second case)	BCB's Financial System Monitoring Department
3. Dummy treatment * dummy measure	The interaction among the two dummies	BCB's Financial System Monitoring Department
4. New auto sales	Sales of new auto	FENABRAVE

<b>HONG KONG SAR (Wong and others, 2015)</b>		
Variable	Data	Sources
<b><i>Dependent Variable</i></b>		
New mortgage loans as a share of outstanding mortgage loans	New mortgage loans drawn down during the month	HKMA
	Outstanding mortgage loans (in the previous month)	HKMA
<b><i>Explanatory Variables</i></b>		
1. Annual change in the market LTV ratio	Average LTV ratio for new loans approved during the month	HKMA
2. Returns on equity for property investment	Average LTV ratio for new loans approved during the month	HKMA
	Residential property prices	Rating and Valuation Department, HKSARG
	Rental yield of residential properties	Rating and Valuation Department, HKSARG
	Mortgage rate	HKMA

3. Unemployment rate	Three-month moving average of seasonally adjusted unemployment rate	Census and Statistics Department, HKSARG
4. Risk-adjusted return of mortgage loans on capital ( <i>RAROC</i> )  $RAROC = \frac{(1-t)*(r-c)}{k}$ where <i>t</i> = the profit tax rate <i>k</i> = the estimated amount of regulatory capital required per Hong Kong dollar of mortgage loans <i>c</i> = the total cost of mortgages <i>r</i> = mortgage rate.	Profit tax rate (applicable to corporations)	Inland Revenue Department, HKSARG
	Risk weight for residential mortgage loans	HKMA
	Composite interest rate	HKMA
	Cost-to-income ratio of retail banks	HKMA
	Three-month delinquency ratio of mortgage loans	HKMA
	Mortgage rate	HKMA
5. Annual growth rate of residential property prices	Residential property prices	Rating and Valuation Department, HKSARG
6. An interactive term between a dummy variable for capturing the effect of the special stamp duty (SSD) and <i>ROE</i>	The dummy variable is defined as one for observations since November 2010 and zero otherwise	
6. A dummy variable for stricter debt servicing ratio (DSR) requirements in 2010	The dummy variable is defined as one for observations since August 2010 and zero otherwise.	
7. A dummy variable for DSR tightening in 2012	The dummy variable is defined as one for observations since September 2012 and zero otherwise.	
<b>Controls</b>		
Unemployment rate, annual growth rate of Hong Kong dollar deposits,		

<b>KOREA (Kim and others, 2015)</b>		
Variable	Data	Sources
<b>Dependent Variable</b>		
1. Mortgage loan growth, regional	Increase in mortgage loan, percent	NICE
2. House price growth, regional	Increase in house price index, percent	Kookmin Bank
3. Real GDP growth	Increase in Real GDP, percent	Bank of Korea
<b>Explanatory Variables</b>		
1.LTV	LTV ratios	Bank of Korea, dataset based on the press release by the Financial Supervisory Service (FSS).

2.DTI	Debt Service to Income Ratios	Bank of Korea
3.Interest rate	Overnight call rate	Bank of Korea
4.SPA	Dummy for Speculative Area	Bank of Korea, dataset based on the press release by the Ministry of Strategy and Finance

<b>MALAYSIA (Abdul Rani and Lau, 2015)</b>		
<b>Variables</b>	<b>Data</b>	<b>Sources</b>
<b>Event study</b>		
<ul style="list-style-type: none"> <li>Loans for residential property, by individuals</li> <li>Loans for residential property, domestic businesses</li> <li>Housing loans by loan-to-value (LTV) ratio buckets (&lt;60 percent, 60-&lt;70 percent, 70-&lt;80 percent, 80-&lt;90 percent and <math>\geq</math>90 percent)</li> <li>Third and above outstanding housing loans per borrower</li> </ul>	<p>Outstanding RM amount of housing loans granted to individuals by banks and non-bank lenders<sup>17</sup> in Malaysia</p> <p>Outstanding RM amount of housing loans granted to domestic businesses (including sole proprietors) by banks and non-bank lenders in Malaysia</p> <p>Ratio of outstanding RM amount of total housing loans to outstanding RM value of the financed property for banks in Malaysia</p> <p>Annual growth of borrowers with three and above outstanding housing loans from banks and non-bank lenders in Malaysia</p>	<p>Central Credit Reference Information System, CCRIS<sup>18</sup> (BNM)</p> <p>CCRIS (BNM)</p> <p>CCRIS (BNM)</p> <p>CCRIS (BNM)</p>

<b>POLAND (Bierut et al, 2015)</b>		
<b>Variables</b>	<b>Data</b>	<b>Sources</b>
1. Average LTV for new mortgage loans	Bank survey	NBP surveys
2. LTV structure for new mortgage loans	Volumes of new mortgage loans by LTV	Polish Bank Association
3. Average DTI for indebted households	DTI calculated using self-reported debt payments and disposable income per household	Annual Polish Household Budget Survey (PHBS) carried out by the Central Statistical Office of

<sup>17</sup> Comprises non-bank lenders that report credit data in CCRIS, including development financial institutions and cooperative banks

<sup>18</sup> CCRIS collects credit information on individuals, businesses (sole proprietors and partnerships), companies, and even Government entities borrowers.

		Poland
4. Share of households with high DTI	See above	See above
5. Average LTV for households with mortgage	Mortgage value estimated using self-reported mortgage debt service payments and information on mortgage maturity, currency composition and interest rates  Real estate values estimated based on information on location and size (from the household survey) and unit price information	National Bank of Poland estimations based on PHBS, banking sector statistics for maturity and currency structure and interest rates (source: NBP) and Pont-Info database (real estate prices)
6. Share of households with high LTV	See above	See above
7. Average income buffer for indebted households	Income buffer calculated using: Self-reported debt payments and disposable income per household; Minimum existence costs per person; The average national salary	PBHS; The Polish Institute of Labor and Social Studies; The Central Statistical Office of Poland
8. Distribution of the income buffer for low- and highly-indebted households	See above	See above
7. Distribution of the income buffer for low- and highly-indebted households (measured by LTV)	Income buffer calculated as above. LTV calculated using: Self-reported mortgage debt payments; Mortgage interest rates.	See above
9. Number of housing loans in arrears of more than 90 days in relation to total number of loans extended in a given year	Credit Information Bureau definition	Credit Information Bureau (BIK)
10. Structure of debt service payments—banks and non-bank financial institutions	Self-reported debt payments (related to bank debt and non-bank debt) per household	PBHS
<b>ROMANIA (Neagu et al, 2015)</b>		
<b>Variables</b>	<b>Data</b>	<b>Sources</b>
<b><i>Dependent variables</i></b>		
1. Credit growth rate	Growth rate of total loans granted to households and its components	Public Credit Register
2. NPL ratio	Nonperforming loan to total outstanding amount for each vintage	Public Credit Register (only exposure per debtor higher than 20,000 RON).



<b><i>Explanatory variables</i></b>		
1. Real Estate Price Index	Logarithm of real estate index. The index of residential real estate prices (2009=100). The index is reconstructed for 2004-2008 period from an internal estimation on residential prices.	National Institute of Statistics, Central Bank estimations prior 2009
2. Regulation enforcement (easing) dummy	The regulation dummy variable is taking a value of one when the prudential measure that includes DSTI and/or LTV is introduced or modified (enforcement). On the contrary, the dummy variable for easing of regulation refers to the period when the measures targeting DSTI and/or LTV were removed (March 2007–September 2008).	Central Bank
3. Prima Casă dummy	This dummy variable takes the value of one starting with Q2/2009—the moment of implementation of Prima Casă program	Central Bank
<b><i>Controls</i></b>		
Monetary policy rate, minimum reserve ratio, inflation rate, real annual GDP growth rate, unemployment rate, financial expectations over the next year, size of bank, loan/deposit ratio, solvency rate, leverage ratio, interest rate, bank external debt, imports/GDP.		