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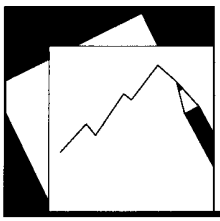

IMF Working Paper

Macroprudential Policies and Housing Prices—A New Database and Empirical Evidence for Central, Eastern, and Southeastern Europe

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Abstract

Several countries in Central, Eastern and Southeastern Europe used a rich set of prudential instruments in response to last decade's credit and housing boom and bust cycles. We collect detailed information on these policy measures in a comprehensive database covering 16 countries at a quarterly frequency. We use this database to investigate whether the policy measures had an impact on housing price inflation. Our evidence suggests that some—but not all—measures did have an impact. These measures were changes in the minimum CAR and non-standard liquidity measures (marginal reserve requirements on foreign funding, marginal reserve requirements linked to credit growth).

JEL Classification Numbers: E52, E44, G21

Keywords: Macroprudential policies, Central Eastern and Southeastern Europe, Housing prices.

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Contents Page

I. INTRODUCTION

Despite much interest among policymakers at the global level since the onset of the recent financial crisis, the econometric evidence on the effectiveness of macroprudential policies (MPPs) available to date is limited, as Galati and Moessner (2011) point out in their recent survey. In Central, Eastern and South-Eastern Europe (CESEE), a significant number of countries went through large and synchronized credit and housing boom-bust cycles during the last decadeand macroprudential policies were actively used, thus the region seems fertile ground for an investigation of the effectiveness of these policies.[2] In some CESEE countries policymakers did not attempt to curb credit expansion through macroprudential policies while in others many instruments were deployed, including capital requirements, loan classification and provisioning rules, reserve or liquidity requirements, and credit eligibility criteria.[3] In some cases, policies were tightened late, when the cycle had already turned. In others yet, policies were relaxed during the expansion for exogenous reasons, notably the pressure or desire to harmonize regulation upon joining the European Union. When policymakers took action, they did it through different instruments and with different intensity. This experimentation probably reflected different macroeconomic conditions and institutional settings, but also, possibly, the lack of a well-established rulebook for the use of macroprudential policies. In any case, to the advantage of the researcher, the experience of the CESEE is very rich in terms of policy actions. Our objective in this paper is to contribute to the policy debate on the usefulness macroprudential policies by exploiting this rich regional experience using a systematic and quantitative approach to the assessment of the effectiveness of macroprudential policy tools.

An important contribution of our paper is the construction of a comprehensive database at a quarterly frequency of all the major prudential measures—grouped into 29 categories—that were adopted in sixteen CESEE countries from the late 1990's or early-2000's to end-2010.[4] To the best of our knowledge, information at this level of detail in a cross-section of countries has not been available to date and we hope that this effort will be useful to future researchers. In addition, for the purposes of our own quantitative analysis, we also devise scoring rules to quantify each measure's intensity over time and across types.

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[2] See Bakker and Klingen (2012) for a comprehensive account of this episode.

[3] In some cases (e.g., the Czech Republic and Slovakia), the banking sector remained sounds throughout the period under consideration, suggesting that credit and housing price developments remained consistent with fundamentals. Confidence in banking sector stability likely explained the lack of policy "activism" in these cases.

[4] The database considers all the major prudential policy measures that may affect the price or availability of credit to the private sector in the country. We do not claim that all of these measures were adopted for macroprudential reasons (as opposed to, for example, microprudential ones).

The specific question we ask in this paper is whether MPPs were a significant determinant of housing price inflation in CESEE during the last decade. The reason for our focus on housing price inflation as a source of systemic risk is twofold. First, a large literature (summarized recently in Crowe et al., 2011) emphasizes the dangers of asset price bubbles and the linkages between housing booms and financial instability episodes. The amplitude of the housing cycle in the CESEE region was spectacular, with countries such as the three Baltic countries (Estonia, Latvia, and Lithuania) witnessing housing price inflation in the range of 120–160 percent between the first quarter of 2004 and the first quarter of 2007. Second, focusing on housing prices rather than domestic credit (as has been done in some of the literature) allows us to avoid a significant measurement problem. Because foreign-exchange denominated or indexed loans are very common in the CESEE region, changes in the stock of credit (expressed in domestic currency) are strongly affected by valuation effects associated with exchange rate movements.[5] Unfortunately, the currency breakdown of domestic credit aggregates which is necessary to correct for these valuation effects is available only for some countries or short time periods. Thus, truly meaningful series of quarterly real credit growth are not widely available about half of the countries we are focusing on. At the same time, we acknowledge that housing price data also have drawbacks, such as uneven quality and cross-country comparability as well as, for some countries, short time series. We also acknowledge that demand by foreign investors was significant in some market segments in several CESEE countries during the boom years and therefore that in those cases housing price dynamics responded to some extent to shifts in foreign investors' interest and access to foreign financing.[6,7]

In line with the empirical literature (e.g., Malpezzi, 1999, Capozza et al., 2002, Egert and Mihaljek, 2007), we model housing price dynamics using an error correction model in which a long-run relationship between housing prices and output per capita exists. It turns out the estimated elasticity we obtain from the regressions is about one, making our model equivalent to one where a measure of housing affordability - the ratio of housing prices to income per capita- is included as a determinant (as in Igan and Loungani, 2012) . As for the short-run, our evidence suggests that one type of capital measure (changes in the minimum capital adequacy ratio (CAR) as well as two types of non-standard liquidity measures

[5] Among CESEE countries with a floating exchange rate regime during the past decade (or part of it), only the Czech Republic and Slovakia had a negligible amount of household foreign currency loans

[6] See for example regional market reports by REAS (2008-2012). It is estimated that foreign investors represented 10 to 15 percent of the demand for flats in Warsaw during the boom years (National Bank of Poland, 2006).

[7] An analysis of MPP-effectiveness based on domestic credit volumes would suffer from the same problem, with the additional twist that some MPPs were circumvented by domestic agents through cross-border lending or lending by non-banks. Indeed in a number of cases foreign banks with subsidiaries in CESEE markets simply booked some loans with the parent institution or a non-bank subsidiary instead of their local bank affiliate to avoid prudential regulation on local banks.

(changes in marginal reserve requirements on foreign funding and changes in marginal reserve requirements linked to credit growth) had an impact on housing price inflation. The economic significance of their effect is meaningful. For example, a change by one percentage point of the minimum CAR has on average a cumulative effect of 8.5 percent on housing prices after four quarters. This compares with mean quarterly real housing price inflation of 0.92 percent in our sample. We do not find robust evidence that changes in standard average reserve requirements, provisioning rules, or eligibility criteria (loan-to-value ratio, debt-service-to-income ratio) had any significant effect.

We also study whether the effect of each of the three types of MPPs mentioned above was different depending on whether the policies were tightened rather than loosened or depending on whether the change in policy occurred during the expansionary phase of the cycle rather than during the contraction. We find that the three policies had a significant impact when tightened and that only changes to the minimum capital adequacy ratio had a significant impact when eased. The four policies had a strong impact during the boom years, while the impact during the bust was less robust.

In interpreting these results, it is important to recognize the limitations of our methodology. In particular, the endogeneity of the policy measures to macro-financial developments—for example if policymakers tighten MPPs in anticipation of an increase in housing price inflation—is likely to bias the estimates of policy impact downwards, leading us to conclude that some measures were ineffective. In addition, some measures may be calibrated so as not to be immediately binding, so their effect may be discernible only after several quarters. Finally, measures may have been anticipated and their effects may have occurred before the implementation date. These are limitations common to most studies that do not rely on "clinical experiments" for policy evaluation, and they certainly apply to our paper as well.

Among the few recent contributions to the econometric literature on the effectiveness of MPPs, some are more supportive of average reserve requirements, provisioning rules and eligibility requirements than ours. Tovar et al. (2012) find that average reserve requirements and a composite of other types of macroprudential policies had a moderate and transitory effect on credit growth and played a complementary role to monetary policy rates in a panel of five Latin American countries during 2004–11. Jiménez et al. (2012) find that dynamic provisioning requirements in Spain helped smooth the credit cycle and supported credit supply in bad times. Igan and Kang (2011) find that the adoption of maximum loan-to-value (LTV) and debt-service-to-income (DTI) ratios in Korea in the second half of the 2000s was successful in slowing down housing price inflation and the growth of transaction volumes. Craig and Hua (2011) find that curbs on LTVs and stamp duties on property transactions helped slow down property price inflation in Hong Kong S.A.R. Wong et al. (2011) offer evidence of LTV effectiveness in reducing delinquencies after property busts in a few Asian economies (including Hong Kong S.A.R.). Lim et al. (2011) find that several instruments (LTV, DTI, credit growth ceiling, foreign currency lending ceiling, reserve requirements,

dynamic provisioning, countercyclical capital requirements) reduce the procyclicality of credit and/or bank leverage in a panel of 49 countries during 2000–10. Dell'Ariccia et al. (2012) construct a composite measure of six MPPs (differential treatment of deposit accounts, reserve requirements, liquidity requirements, interest rate controls, credit controls, and open foreign exchange position limits) and find that stricter MPPs reduce the incidence of credit booms and decrease the probability that booms end badly.

In the CESEE region, the only two available econometric studies focus on Croatia. Galac (2010) finds that credit growth limits (i.e. marginal reserve requirements related to credit growth) were successful in reining in domestic private sector credit growth but that they did not reduce total private sector credit growth because domestic credit was substituted by cross-border credit. Kraft and Galac (2011) fine-tune Galac's analysis by breaking down the private sector into households and corporations and find that the credit growth limits were effective in slowing down household credit, but not corporate debt (because of the circumvention through cross-border loans). Both papers also find that marginal reserve requirements on foreign funding were instrumental in building banks' capital buffers. Our finding about the effectiveness of marginal reserve requirements on foreign funding and marginal reserve requirements linked to credit growth is therefore consistent with these analyses.

The effectiveness of MPPs has also been studied using the event analysis methodology or through narratives. The results of Tovar et al. (2012)'s and Lim et al. (2011)'s event analyses are consistent with the econometric results mentioned above. Pereira da Silva and Eyer-Harris (forthcoming) find that making risk-weights on certain types of consumer loans contingent on loan-to-value and maturity had the desired effect on the flow, maturity and interest rates of these loans in Brazil. Terrier et al. (2011) describe a wide variety of MPP instruments that have been used in Latin America without systematically analyzing their effectiveness. As to the CESEE region, a series of World Bank Policy Research Working Papers published in 2011 describes the experience with macroprudential policies of the Czech Republic, Estonia, Macedonia, Poland, and Turkey.[8, 9] These papers generally argue that macroprudential policies implemented during the boom helped improve the resilience of the banking system during the bust. Dimova, Kongsamut, and Vandenbussche (forthcoming) analyze through a large number of event analyses the experience of the four Southeastern European countries (Bulgaria, Croatia, Romania, and Serbia) that were most active in using MPPs in the CESEE region. Their conclusions are consistent with ours and those of Kraft and Galac (2011): the strictest measures—including credit growth limits and strict capital

[8] See Frait, Gersl and Seidler (2011); Sutt, Korju and Siibak (2011); Celeska, Gligorova and Krstevska (2011); Kruszka and Kowalczyk (2011); Banai, Király and Nagy (2011); and Kenc, Turhan and Yildirim (2011).

[9] Experiences with MPPs in CESEE during the first half of the boom can also be found in the book edited by Enoch and Otker-Robe (2007).

ratios—had a noticeable impact on credit growth, the composition of credit and/or housing prices.

The rest of the paper is structured as follows. The next section contains a description of the housing price and MPPs data. Section III presents the empirical model, regression results are discussed in Section IV, and Section V concludes. Two appendices contain further details on data sources and scoring rules used to quantify the intensity of prudential policy measures.

II. A First Look at the Data

In this section, we preview the main data series used in the empirical analysis and explain what the MPP database covers and how it was constructed.

A. Housing Prices

We compile housing prices data from the BIS, national statistical offices, local and international real estate companies, and the Central Bank of Albania. All in all, we manage to gather quarterly housing price series for 16 CESEE countries covering different time periods, generally beginning in the early 2000s.[10] When several data series are available for one country, we choose the longest one.[11] The series are not fully harmonized across countries as they sometimes cover different types of residential real estate or different geographical entities within a country, but this is the only way to have a reasonable coverage along both the cross-country and the time dimensions. In our econometric analysis below, the inclusion of country fixed effects will help deal with possible concerns raised by this cross-country heterogeneity in types of real estate. We deflate all nominal series with the national CPI and then seasonally adjust all real housing prices series. Details on data availability, sources, and coverage are provided in Table A1 in Appendix 1.

Real housing prices developments differed substantially across countries in the CESEE region over the sample period. While our data show a pronounced boom and bust cycle over the last decade in the Baltic countries and Ukraine, real house price inflation was more contained in other countries such as Croatia, Serbia, and Slovenia (Figure 1).

[10] The 16 countries are: Albania, Bulgaria, Croatia, the Czech Republic, Estonia, Hungary, Latvia, Lithuania, Poland, Romania, Russia, Serbia, Slovakia, Slovenia, Turkey, and Ukraine.

[11] One exception is Estonia, for which the longest available series has an implausible quarter-on-quarter jump of 33 percent in 2002Q3 followed by a 12 percent decline in 2002Q4, an the second longest series ends in 2009Q4.

Figure 1. Selected CESEE Countries: Seasonally-Adjusted Real Housing Price Index, 1997:Q1–2011:Q1

Sources: BIS housing price statistics, Global Property Guide, Central Bank of Albania, FHB, REAS, Reidin, IFS, and authors' calculations.

B. Fundamental Macroeconomic and Demographic Variables

Following the literature, we hypothesize that the three fundamental variables driving real housing prices are real income per capita, real interest rates, and working-age population. Because foreign currency lending is widespread in most of the countries in our sample, we include both a domestic currency interest rate and a foreign currency effective interest rate. Most macroprudential policies are expected to affect lending rates through intermediation spreads; therefore we use interest rate variables that are related to the liability side of banking systems' balance sheets rather than lending rates. Since some countries in our sample do not have a monetary policy rate (e.g. because they have a currency board arrangement), we use the domestic deposit rate as our measure of the domestic currency interest rate. For the foreign currency interest rate, we use the Fed Funds rate in countries that are partially dollarized (Russia, Turkey, and Ukraine) and the ECB policy rate in all others. Swiss franc mortgages are widespread in Croatia, Hungary, and Poland, but we do not add a second foreign currency rate in the regressions in order to economize on degrees of freedom. To construct our effective interest rate, we adjust the series by the year-on-year appreciation of

the local currency against the dollar or the euro, as applicable.[12] We seasonally adjust the GDP per capita series, as we did for the housing price series. Demographic variables are often included as determinants of housing prices in the literature. Following Igan and Loungani (2012), we use the year-on-year change in working-age population. Some authors have included mortgage credit growth (or total credit growth) in the list of determinants of housing price inflation. However, because prudential measures affect housing price inflation *through* credit, including a measure of credit as a control variable is not appropriate in our setup as it would obscure the relationship we are interested in. We do not include a measure of construction costs either, for lack of available data. Table A2 in Appendix 1 contains further details on macroeconomic and demographic data sources.

C. Macroprudential Policies

The main hypothesis we want to test is that housing price inflation is affected at least temporarily by policies (other than interest rates) that indirectly affect the cost and availability of bank credit in general and mortgage credit in particular. We refer to these policies as "macroprudential policies", though some of them are sometimes used as traditional monetary policy instruments (e.g., standard reserve requirements).

Data sources

We construct a novel dataset of macroprudential measures in 16 CESEE countries at a quarterly frequency for the purposes of performing the analysis presented in this paper. To do so, we exploit a wide variety of sources. Our main sources are documents posted on national central banks' or national banking supervisors' websites such as annual reports, inflation reports, financial stability reports, prudential regulations, press releases, as well as IMF Staff Reports and Financial System Assessment Program documents. We cross-check this information with that contained in country-level studies mentioned in the introduction and in specific chapters of the book edited by Enoch and Őtker-Robe (2007). We keep track of all prudential measures that we deem most relevant for credit supply in general and, through retail and mortgage lending, housing prices. We strive to collect information for time periods covering at least those for which housing prices data are available in each particular country. It is important to point out that some of our MPP measures only capture *changes* in the policy stance from the beginning of the sample, because we have no way of measuring and comparing across countries the initial "tightness" of some types of prudential regulation. In any case, we only use changes in policies, not their "levels" in the regressions.

[12] Results are not affected if we do not adjust for year-on-year appreciation and include a simple foreign currency interest rate.

In parallel to the MPP database, we compile information on fiscal and other regulatory policy measures that are directly relevant to the real estate market and household borrowing, such as changes in mortgage interest payments deductibility or the inclusion of non-bank credit institutions into the regulatory perimeter, whenever such information was present in the sources listed above or in "Taxation trends in the European Union" published yearly by Eurostat.[13]

Categorization

We compile data on twenty-nine categories of prudential measures, which we gather into five groups: capital measures, provisioning measures, liquidity measures, loan eligibility requirements, and other quantitative restrictions. We discard moral suasion measures, which were used almost universally according to the documents we consulted, because we view them as weak policy instruments that are unlikely to have any measurable impact. Information on the use of the various measures is provided in Figure 2 (the mapping between the name of a measure and its full description is provided in Appendix 2, while the mapping between measures and the countries that implemented them is provided in Appendix 3).

Capital measures affect the amount or type of capital that banks must hold and consist of twelve different types of measures that change the following regulatory parameters: minimum CAR; minimum target CAR; minimum CAR related to credit growth; definition of regulatory capital; maximum ratio of loans to households relative to capital; maximum ratio of loans in foreign currency to capital; risk-weights used in the calculation of risk-weighted assets for mortgage loans (in local and foreign currency) or loans to households (in local or foreign currency) or on corporate loans (in foreign currency) or on bank exposures exceeding a threshold related to credit growth. Among this category of measures, changes in the minimum CAR, changes in risk-weights on mortgages, changes in capital eligibility, and changes in the ratio of household loans to capital were used most frequently (see the top 2 panels of Figure 2)

Provisioning measures consist of changes in the rules for general provisions, and changes in the rules for specific provisions on domestic currency loans or foreign currency loans. While the use of general provisioning is limited in the countries in our sample, changes in specific provisioning rules have not been infrequent.

Liquidity measures cover prudential measures related to reserve requirements or liquidity ratios: minimum reserve requirement ratios for demand deposits in domestic currency or in foreign currency; the definition of the base used to calculate reserve requirements and the

[13] Other more indirectly relevant forms of taxation, such as capital gains taxes, are not accounted for.

minimum reserve requirement ratios for liabilities other than demand deposits; marginal reserve requirements on foreign borrowing (i.e., reserve requirements imposed only on increments in the stock of foreign borrowing); special reserve requirements on liabilities of banks arising from issued securities; marginal reserve requirements related to credit growth; liquidity ratios; and foreign currency liquidity requirements. Changes in average reserve requirements were by far the most commonly used instrument in our dataset. Marginal reserve requirements related to credit growth were used in two countries (Bulgaria and Croatia) while the other three of the other four liquidity measures were used only in one country (Croatia), which explains the low frequency of their use.

Loan eligibility requirements consist of four different types of measures: a maximum loan-to-value ratio for local currency loans or foreign currency loans; and a maximum debt-service-to-income ratio for domestic currency loans or foreign currency loans. These measures were used only sparsely in the CESEE region, as can be seen in the bottom right panel of Figure 2.

"Other quantitative restrictions" measures consist of limits on the amount of foreign currency lending as a share of total lending, whether in stock or flow terms, including outright bans on certain types of lending. Our dataset contains four observations for that category of measures and they all belong to the bust period.

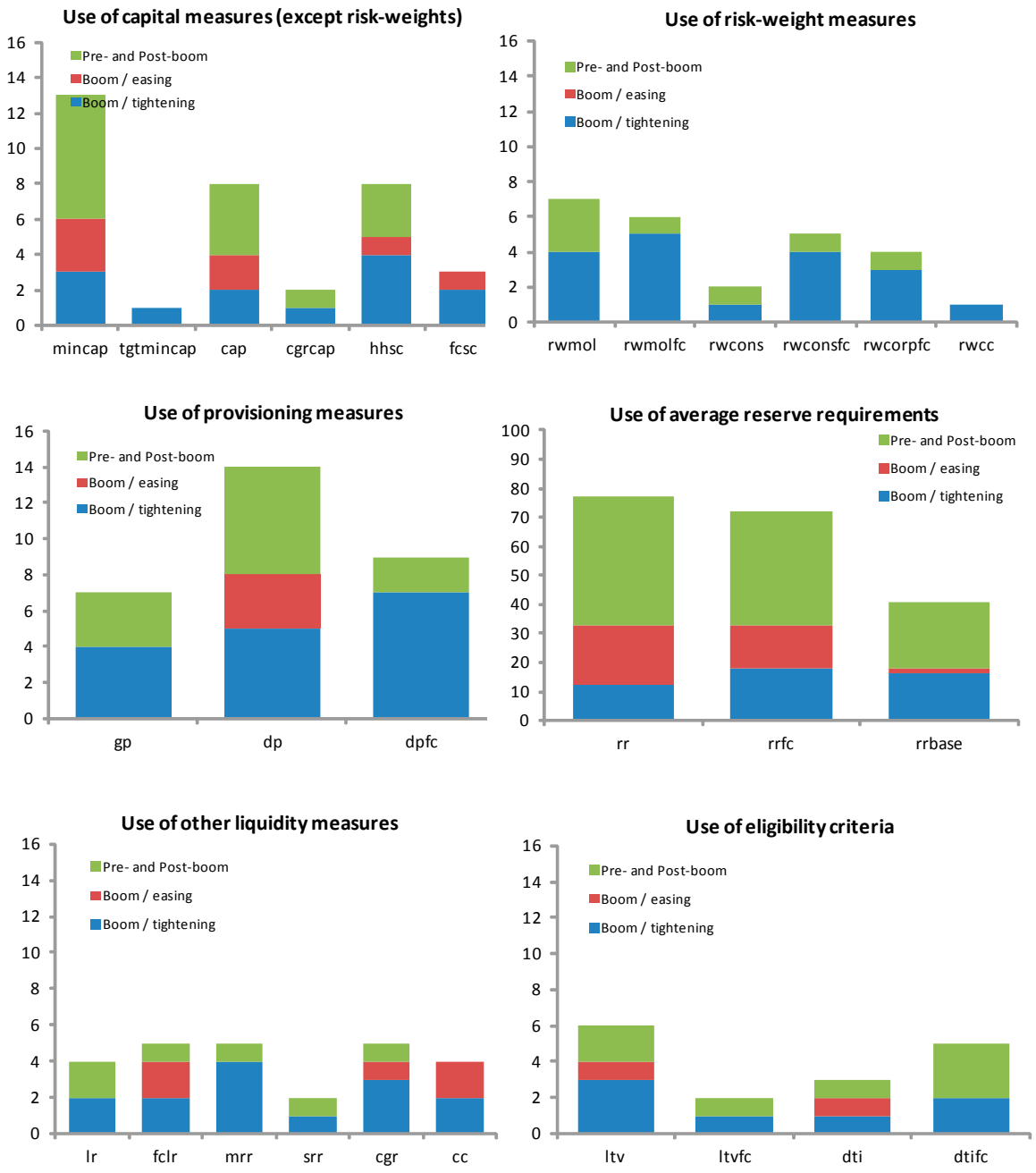
Quantifying the strength of the policy measures

From the descriptions of the policy measures, we proceed to code numerically the strength of changes in the regulation in each category to capture their relative variation, both over time and across categories of measures. We believe that this approach is preferable to one used commonly in the emerging literature on MPP effectiveness that relies only on dummy variables to capture changes in regulation. We acknowledge that our approach involves judgment to a large degree but it is the logical consequence of the observation that policy measures vary in intensity and that both financial prices and quantities can be expected to react to this intensity. To take an example, a 1 percentage point change in reserve requirement rates cannot be expected to have the same impact as a 10 percentage point change. It is a very challenging task to capture interactions between various prudential policies—for example the interaction between reserve requirements and liquidity requirements—and we do not attempt to do so here.[14]

For regulation that can be summarized in a simple number (e.g. maximum or minimum ratios), our rule is to use a simple linear transformation of that number. For regulation that

[14] The only exception is for bans of foreign currency mortgages, where we take into consideration the existence of prior measures targeting foreign currency loans to unhedged borrowers (see the description of the *otherfc* measure in Appendix 2).

Figure 2. Number of Macroprudential Policy Changes in the Dataset
(by category of measure)



Notes: See Appendix 2 for a definition of the variables. Data for "Other bank regulatory measures" are not shown on the Figure.
Source: Authors' calculations.

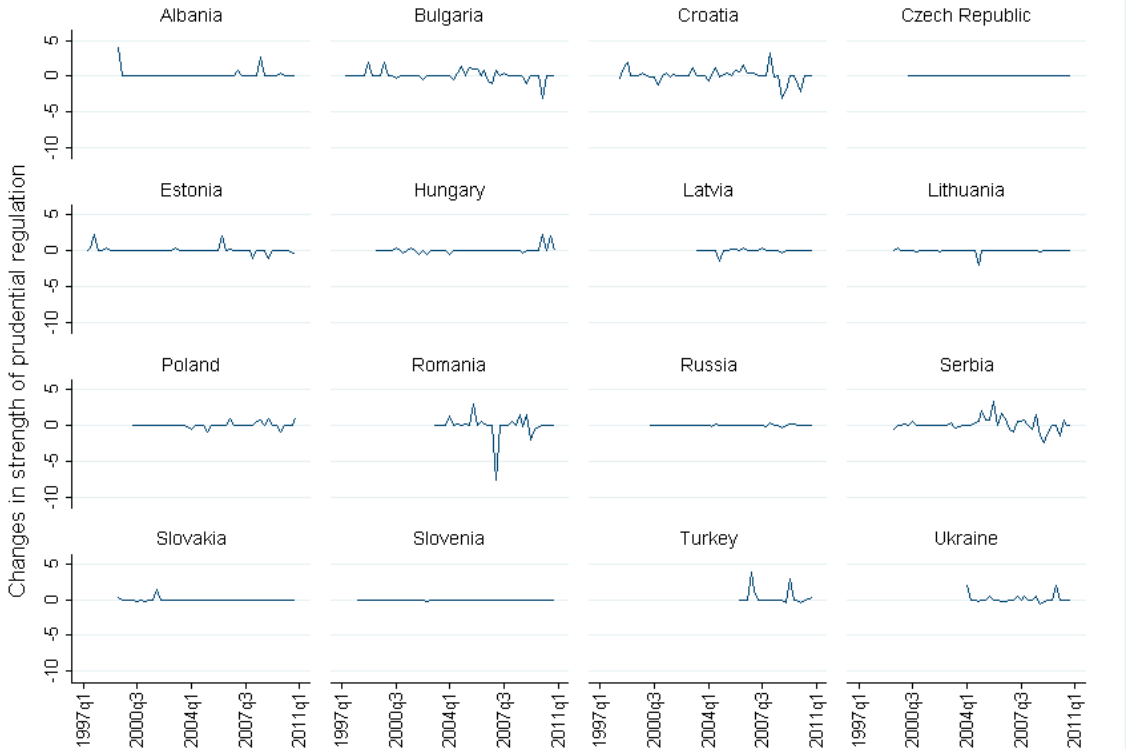
involves a small (but greater than one) number of variables (e.g. risk-weights on mortgages that are conditional on the loan-to-value ratio), we use a formula that takes into consideration all variables. For more complex cases, we use a rule where a tightening (resp. loosening) would increase (resp. decrease) an index summarizing the strength of the regulation by a fixed amount (0.25, 0.5, or 1 depending on the measure). Since we are only interested in the effect of the *change* in the various categories of regulation, the level of our measure of the strength of regulation is irrelevant and can be arbitrarily set to an arbitrary value (e.g. zero) during the quarter preceding the start date of our data sample.

As an example, for changes in the minimum CAR, the score is simply the quarterly change in the minimum ratio. This rule yields a score of zero during times when the minimum ratio is constant and a score of two during a quarter when a country moves from an eight percent to a ten percent minimum ratio. For across-the-board changes in risk-weights on mortgages, we first compute for each quarter the difference between risk-weights on domestic currency mortgages in the actual regulation and in the Basel capital standards (Basel I or Basel II) otherwise used in the country, then divide this number by 25, and then take the quarterly change in that series. This rule yields a value of two when a country operating under Basel I deviates from the standard by implementing a risk-weight of 100 (instead of 50) on mortgages. For changes in risk-weights on foreign currency mortgages relative to those in domestic currency mortgages, we first compute the difference between risk-weights on mortgages in foreign currency and those on mortgages in domestic currency, then divide this number by 50, and then take the quarterly change in that series. This rule yields a score of one during a quarter when a penalty of 50 percentage points is imposed on mortgages in foreign currency. The full list of the rules we apply is provided in Appendix 2.

By summing the scores across all categories, we obtain a summary representation of the intensity of the change in prudential regulation in each quarter of the sample period in each country (Figure 3). Positive values indicate a tightening and negative values an easing of prudential regulation. Then, by taking the cumulative sum of quarterly changes, we obtain a representation of the cumulative change in the macroprudential policy stance during the boom and bust (Figure 4).

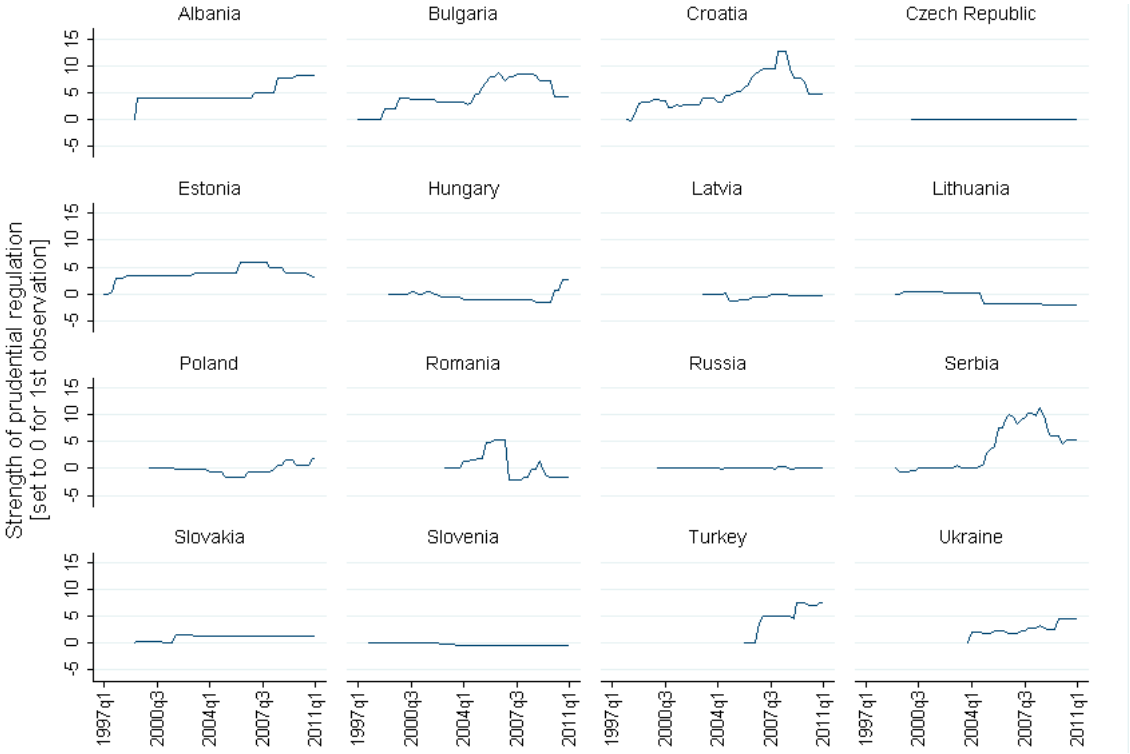
There are clear differences among countries in terms of their policy "activism." In a number of countries (Czech Republic, Russia, Slovakia, Slovenia) hardly any MPP measures were taken, despite considerable housing price inflation in some cases. In other countries, prudential regulation displays a clear countercyclical pattern (e.g. Bulgaria, Croatia, and Serbia), and in others yet it even appears to be mildly procyclical at times (e.g. Latvia and Lithuania in 2004:Q4, Romania in 2007:Q1, when some prudential policies were relaxed upon joining the European Union). Hungary displays procyclical policy during the downside of the cycle, as the authorities started tightening prudential regulation during the recession (in the beginning of 2010) as the drawbacks of excessive reliance on foreign currency debt became clear following the sharp depreciation of the forint.

Figure 3. Selected CESEE Countries: Quarterly Changes in Strength of Prudential Regulation, 1997:Q1–2011:Q1



Source: Authors' calculations.

Figure 4. Selected CESEE Countries: Cumulative Changes in Strength of Prudential Regulation, 1997:Q1–2011:Q1



Source: Authors' calculations.

Table 1 shows summary statistics for the dependent variable, macroeconomic control variables, and the individual MPPs.[15]

Table 1. Summary Statistics

Variables	Variable name	Mean	Std. Dev.	Min	Max
Dependent variable and macro control variables (changes in:)					
Housing price (percent, qoq)		0.92	5.63	-32.33	24.61
GDP per capita (percent, qoq)		0.84	2.12	-11.72	7.51
Local currency real interest rate (pps, qoq)		-0.02	1.68	-6.78	9.49
Effective foreign currency real interest rate (pps, qoq)		0.07	5.34	-30.69	35.63
Working age population (percent, yoy)		0.09	0.57	-2.34	2.21
Capital measures (qoq changes in:)					
Minimum capital adequacy ratio	mincap	0.01	0.23	-2.00	2.00
Regulatory capital definition	cap	0.00	0.12	-1.00	1.00
Minimum capital as a function of credit growth	cgrcap	0.00	0.13	-2.08	2.08
Maximum household loans/capital	hhsc	0.00	0.10	-1.00	1.00
Maximum forex loans/capital	fcsc	0.00	0.03	0.00	0.75
Maximum loans/capital ratio	lsc	0.00	0.10	-1.00	1.00
Risk weights on:					
mortgages	rw mol	0.00	0.13	-1.04	2.00
forex mortgages	rw molfc	0.00	0.08	-1.00	1.00
total mortgages	rw moltot	0.01	0.16	-1.04	2.00
consumer loans	rw cons	0.00	0.06	-1.00	1.00
forex consumer loans	rw consfc	0.00	0.07	-1.00	1.00
total consumer loans	rw constot	0.00	0.09	-1.00	1.00
mortgages+consumer	rw	0.00	0.17	-2.04	2.00
forex mortgages+consumer	rw fc	0.01	0.15	-2.00	2.00
total mortgage+ consumer	rw tot	0.01	0.22	-2.04	2.00
credit growth	rw cc	0.00	0.01	0.00	0.33
All risk weight measures	rw tot2	0.01	0.22	-2.04	2.00
Provisioning measures (qoq changes in:)					
General provisioning rules	gp	0.00	0.07	-1.00	0.50
Specific provisioning rules	dp	0.00	0.09	-1.00	0.50
Specific provisioning rules forex	dpfc	0.01	0.06	-0.50	0.50
All provisioning rules	dptot	0.00	0.13	-1.00	1.00
Liquidity measures (qoq changes in:)					
Reserve requirement rate	mpprr	-0.02	0.14	-1.73	1.10
Reserve requirement base	rrbase	0.01	0.12	-0.50	0.50
Total reserve requirement (rate+base)	rrtot	-0.01	0.18	-1.50	1.60
Marginal reserve requirement on foreign funding	mrrtot	0.00	0.14	-2.75	1.20
Liquidity regulation	lr	0.00	0.03	0.00	0.50
Foreign currency liquidity ratio	fclr	0.00	0.02	-0.21	0.50
Marginal reserve requirement on credit growth	cgrr	0.00	0.10	-1.18	1.18
Eligibility criteria measures (qoq changes in:)					
Loan-to-value ratio	ltv	0.00	0.06	0.00	1.25
Loan-to-value ratio on forex loans	ltvfc	0.00	0.03	0.00	0.50
Total LTV	ltvtot	0.01	0.08	0.00	1.75
Debt-to-income ratio	dti	0.00	0.03	0.00	0.67
Debt-to-income ratio forex loans	dtifc	0.00	0.05	-0.50	0.50
Total DTI	dtitot	0.00	0.07	-0.50	1.17
All eligibility measures	elig	0.01	0.12	-0.50	2.25
Other bank regulatory measures (qoq changes in:)					
Quantitative restrictions on forex lending	otherfc	0.01	0.18	0.00	3.00

Source: Authors' calculations.

[15] For the purpose of the regressions, we lump together the reserve requirement rate on domestic currency deposits and the rate on foreign currency deposits by taking their average. Given their similarity, we also lump together the credit growth ceiling measures imposed by Bulgaria and Croatia (the penalty took the form of marginal reserve requirements *stricto sensu* in Bulgaria, while it took the form of compulsory holdings of low-yield central bank bills in Croatia). Finally, we also aggregate Croatia's marginal reserve requirement on foreign funding and special reserve requirement on securities issued domestically to foreigners, as the latter was only implemented as a way to fight the circumvention of the former.

III. ECONOMETRIC MODEL AND CHOICE OF SPECIFICATION

We start our econometric analysis by checking the order of integration of these series. The Maddala and Wu (1999) panel unit root test indicates that both the log of real GDP per capita and the log of real housing prices are I(1) variables. One of the two Westerlund (2007) ECM panel cointegration tests rejects the null of no cointegration between these two variables while the other does not.[16] We proceed by modeling housing price dynamics in our sample in an error correction framework, where changes in the log of (seasonally adjusted) real house prices are explained by lagged changes in the log of (seasonally adjusted) real GDP per capita, lagged changes in the domestic currency real interest rate, lagged changes in the effective foreign currency real interest rate, lagged changes in MPPs, and an error correction term. We include country fixed effects to account for time-invariant country-specific characteristics captured by intercepts in the short-run and the long-run equations, and include time dummies to account for common shocks across the region. The latter include conditions in global capital markets that would influence capital flows to CESEE. We later check that our key results also hold when the error correction term is not included.

Our panel is unbalanced. For most countries, the sample period starts in the early 2000's but for Romania, Slovakia and Turkey housing price data availability is a constraint and the sample only starts later. The sample ends in 2011:Q1.

Ideally, we would want to run regressions including all individual policy variables, since all of them can potentially affect housing prices. In addition, from the point of view of a policymaker it is important to know which specific measures are effective. However, a regression including all individual MPPs would exhaust most or all of our degrees of freedom, so we need to pare down the number of MPPs that enter separately in the regression. To this end, we run some preliminary regressions including the first two lags of each policy variable and the first two lags of an aggregate index of the remaining MPP changes constructed as the sum of the scores for each of these individual measures. In addition, to further economize on degrees of freedom we drop the second lag of the change in real GDP and the second lag of the change in the real interest rate, which are insignificant across all specifications. Thus, for each MPP variable x, we estimate the following equation using the fixed effects estimator:[17]

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[16] We use Stata's *xtwest* command (Persyn and Westerlund, 2008) including a constant and two lags, and setting the width of the Bartlett kernel window to 4. The p-values we obtain are 0.06 for the P_a test, and 0.11 for the P_t test. To allow for cross-sectional dependence, we then bootstrap robust critical values for the test statistics (choosing the maximum number of replications, i.e. 800). The respective robust p-values are now 0.09 and 0.16.

[17] More precisely, we use the *Stata* command *xtpmg* with the options *dfe* (fixed effects) and *cluster* (standard errors clustered by country) to obtain robust estimates (see Blackburne and Frank, 2007).

$$\Delta h_{i,t} = \varphi\left(h_{i,t-1} - \theta y_{i,t-1}\right) + \sum_{j=1}^{2}(\rho_j \Delta h_{i,t-j}) + \alpha_1 \Delta y_{i,t-1} + \alpha_2 \Delta r_{i,t-1} + \alpha_3 \Delta r^*_{i,t-1} + \alpha_4 \Delta_4 wp_{i,t}$$
$$+ \sum_{j=1}^{2}(\beta_j \Delta x_{i,t-j} + \gamma_j \Delta C^x_{i,t-j}) + \sum_{j=1}^{4} ukr_j + \delta_i + \mu_t + \varepsilon_{i,t}$$

where the subscripts *i* and *t* represent a country and a time period respectively, δ is a country dummy variable, μ is a period dummy variable, Δ is the first difference indicator, Δ_4 is the four-quarter difference indicator, *h* is the log of real housing prices, *y* is the log of real GDP per capita, *r* is the domestic real interest rate, *r** is the effective foreign currency real interest rate (defined as the foreign currency policy rate minus the rate of year-on-year CPI inflation and minus the y-o-y appreciation of the local currency against its natural cross), *wp* is the log of the working age population, C^x is a control variable aggregating all MPPs other than *x* as well as relevant tax and non-bank regulatory policy measures. To account for possible non-linear effects of the devaluation in Ukraine in the last quarter of 2008, we include four dummies (*ukr1, ukr2, ukr3,* and *ukr4*) corresponding to the three periods following the devaluation. The α's,β's,γ's,ρ's, θ, and φ are coefficients to be estimated, and ε is an error term.

These preliminary regressions allow us to identify a core set of policy variables which seem to have a significant impact on housing prices. We then estimate a baseline regression with all the variables in this core set included separately and the rest included as an aggregate.

To check whether the impact of measures might be different depending on whether the policy is being tightened or eased, we also estimate an equation where the coefficient of a policy variable is allowed to differ when it represents a tightening or an easing of the policy.

We are also interested in whether the effects of the policy measures vary based on the phase of the economic cycle. Therefore in an alternative specification we allow the coefficients of the policy to vary depending on whether the economy is in a boom or a bust. Capital inflows to CESEE accelerated in late 2002 and came to a sudden stop once the U.S. financial crisis spilled over to CESEE in full force after mid-September 2008 (IMF, 2010). We thus define the boom period to run from 2002:Q4 to 2008:Q3.[18] The bust period runs from 2008:Q4 until the end of our sample, i.e. 2011:Q1.

[18] For Estonia and Latvia, however, the boom ended earlier, so we consider 2007:Q3 as the last observation for the boom period in these two countries.

IV. ESTIMATION RESULTS

A. Preliminary Regressions

Table 2 presents results of the preliminary regressions, which include the change in each MPP one at a time together with the change of an aggregate of the rest of the policy changes. In addition to individual measures, we also look at changes in selected combinations of individual measures of the same type (e.g. a combination of all risk-weight measures). As explained above, the regressions also include time and country dummies and real per capita GDP growth and real interest rates (these coefficients are not reported). The MPPs are grouped in the same five categories as discussed above: bank capital measures, provisioning rules, liquidity measures, borrower eligibility criteria, and other quantitative restrictions. The estimated coefficients for the prudential measures are negative if a tightening (easing) in prudential regulation is followed by a deceleration (acceleration) in housing prices.

Among capital measures, changes in the minimum CAR appear to significantly affect housing prices in the expected direction in the first quarter following the change in policy. The effect during the second quarter is in the expected direction as well, but it is marginally below conventional significance levels. Changes in maximum ratio of household lending relative to capital were also followed by changes in housing price inflation in the expected direction, though the coefficient for the second lag is positive and insignificant. Changes in risk weights on loans to households used in the computation of capital requirements, on the other hand, do not seem to have consistent effects on house price growth.

We also find little evidence that changes in provisioning rules, whether related to general or specific provisions, and whether across the board or for foreign currency loans only, had any impact on housing price inflation. Since standard provisioning rules do not bind until loans start to become non-performing, which does not happen on a significant scale until after the cycle has turned, it might be that the tightening effect of measures related to specific provisions only materialized with a longer lag (and might have been pro-cyclical if the measures were not reversed during the bust). It is perhaps more surprising to find that changes in rules for general provisions, which are closer to a truly dynamic provisioning system where provisions are built even against performing exposures, do not show a more robust effect, but we have only a very small number of observations of that type of measure in the sample.

Changing average reserve requirements also does not seem to have had an effect on housing price inflation, nor does changing the foreign currency liquidity ratio, a Croatia-specific instrument, or changing the liquidity regulation. In several cases, changes in the reserve requirements rate on demand deposits took place at the same time as changes in the base, with the two changes working in opposite directions. If we combine changes in the rate and changes in the base into a composite measure for reserve requirements, then the coefficients remain insignificant. A possible explanation for this lack of significance is that reserve

Table 2. Macroprudential Policies and Housing Prices -- Preliminary Regressions

Category of measure	Instrument	Policy change t-1		Policy change t-2	
		[coefficient]	[p-value]	[coefficient]	[p-value]
Capital measures					
	Minimum capital adequacy ratio	-4.19***	(0.00)	-1.00	(0.12)
	Regulatory capital definition	0.29	(0.76)	1.14	(0.51)
	Minimum capital adequacy ratio as a function of credit growth	0.65*	(0.07)	-0.38	(0.12)
	Maximum household loans/capital	-2.85***	(0.00)	0.27	(0.59)
	Maximum forex loans/capital	8.34***	(0.00)	-4.42	(0.50)
	Maximum loans/capital ratio	-1.32	(0.47)	-1.09	(0.54)
	Risk weights on:				
	mortgages	-0.86	(0.62)	0.70	(0.54)
	forex mortgages	4.24**	(0.01)	4.56	(0.25)
	total mortgages	0.49	(0.79)	1.71	(0.13)
	consumer loans	1.83***	(0.00)	-0.21	(0.80)
	forex consumer loans	5.04***	(0.01)	2.07	(0.47)
	total consumer loans	3.97***	(0.00)	1.05	(0.46)
	mortgages+consumer	-0.49	(0.72)	0.39	(0.68)
	forex mortgages+consumer	1.94**	(0.02)	1.70	(0.36)
	total mortgage+ consumer	0.64	(0.53)	0.99	(0.27)
	credit growth	-14.89***	(0.00)	26.68***	(0.00)
	All risk weights	0.57	(0.56)	1.11	(0.24)
Provisioning measures					
	General provisioning	1.54	(0.13)	0.40	(0.84)
	Specific provisioning rules	-1.00	(0.38)	1.60	(0.38)
	Specific provisioning rules forex	-4.53	(0.32)	6.00*	(0.08)
	All Provisioning rules	-1.33	(0.28)	2.15	(0.18)
Liquidity measures					
	Reserve requirement rate	1.66	(0.14)	0.00	(1.00)
	Reserve requirement base	1.36	(0.47)	0.40	(0.64)
	Total reserve requirement (rate+base)	1.65	(0.25)	0.04	(0.96)
	Liquidity ratio	3.95*	(0.05)	-1.42	(0.45)
	Forex liquidity ratio	3.52**	(0.04)	-0.75	(0.61)
	Marginal reserve requirement on foreign funding	-1.39**	(0.04)	-0.11	(0.80)
	Marginal reserve requirement on credit growth	-2.19***	(0.00)	-1.16**	(0.05)
Eligibility measures					
	Loan-to-value ratio	-0.61	(0.72)	-4.32	(0.13)
	Loan-to-value ratio on forex loans	0.31	(0.93)	1.38	(0.49)
	Total LTV	-0.55	(0.64)	-2.56	(0.23)
	Debt-to-income ratio	(dropped)		-8.94***	(0.00)
	Debt-to-income ratio forex loans	6.64*	(0.08)	6.13	(0.15)
	Total DTI	6.61*	(0.09)	-2.61***	(0.00)
	All eligibility measures	0.41	(0.67)	-1.51*	(0.06)
Other bank regulatory measures					
	Quantitative restrictions on forex lending	-1.00	(0.29)	-0.55	(0.41)

Note: The dependent variable is the log difference of the real housing price index. The regressions include time and country fixed effects. P-values in parentheses.

*, **, and *** denote statistical significance at the 10 percent, 5 percent, and 1 percent confidence levels respectively.

Source: Authors' calculations

requirements may have been used to sterilize foreign exchange intervention following a surge in capital inflows. In this case, the policy might have simply have forestalled a further acceleration of credit (and housing prices) rather than caused a deceleration. In other words, endogeneity bias might be particularly strong for reserve requirements, if this policy was used as the "first line of defense" to counter excessive credit market froth. It may also be, as discussed in Gray (2011), that reserve requirements may have been used for various—and sometimes contradictory—objectives across countries. In addition, it may be that changes in reserve requirements were in some cases made concurrently with changes in other monetary instruments such as central bank bills and we do not account for the latter. Furthermore, reserve requirements are a multidimensional instruments, and we do not capture some of these dimensions such as the eligibility of some assets (e.g. cash in vault) to meet the requirements, or variations in averaging rules. While changes in "plain vanilla" average reserve requirements seemed to have had little impact, more unorthodox measures, i.e. marginal reserve requirements on foreign borrowing and marginal reserve requirements on credit in excess of a certain threshold are both associated with a significant changes in housing prices in the "right" direction.

Turning to eligibility measures, coefficients are generally insignificant, suggesting that these measures did not have much of an impact in CESEE, in contrast with the findings for some East Asian countries. Coefficients on across-the-board LTV and DTI measures have the right sign, but coefficients on stricter eligibility requirements for foreign currency borrowers don't.[19] A composite of all loan eligibility measures yields a significant coefficient in the right direction for the second lag, but the coefficient on the first lag is positive and insignificant. Since these measures were implemented only in a handful of cases in our sample, we do not wish to draw too firm conclusions from this lack of statistical significance overall.

Based on the results in the preliminary regression, we select the three MPPs for which the regression coefficient has the expected negative sign for both lags and is statistically significant for at least one lag and include them as separate regressors in the baseline specification.[20] These policies are changes in the minimum CAR (used in Croatia, Latvia, Lithuania, Romania, Serbia, and Ukraine), marginal reserve requirements related to foreign borrowing (used in Croatia), and marginal reserve requirements related to credit growth (used in Bulgaria and Croatia). The other MPPs together with relevant tax and non-bank

[19] The coefficient of the first lag of the maximum DTI is dropped because we only have one such policy change in the sample.

[20] The same set of three policy variables would be chosen if three lags were included instead of two in the regressions, and the results in terms of significance and orders of magnitude would be very similar in a baseline regression including three lags.

regulatory policies are included as an aggregate index as a control variable.[21] Each of the three MPPs in the core set was changed between seven and nine times during the sample period.

B. Baseline Regression

Column (1) in Table 3 shows estimation results for our baseline regression, which includes the same control variables as the preliminary regressions as well as the three MPP variables in our core set, i.e. minimum bank CAR, marginal reserve requirements on foreign funding, and marginal reserve requirements on credit growth, and an aggregate of all other policies.

Going through the explanatory variables in Table 3 from top to bottom, we see that the long term effect of per capita GDP is positive, as expected, albeit not significant (upper panel). The estimated coefficient is close to one, suggesting housing prices and GDP per capita co-move one-for-one in the long run, keeping housing affordable. The error correction coefficient, which measures the speed at which deviations from the long-term equilibrium self-correct, is negative and highly significant. Both autoregressive terms are significant, showing that housing price inflation is persistent. Surprisingly the coefficient estimates for our set of macroeconomic and demographic fundamentals (lagged changes in per capita GDP and interest rates, changes in working-age population) are not significant.[22]

With respect to the MPP policy variables, changes in the minimum CAR, changes in marginal reserve requirements related to foreign borrowing, and changes in marginal reserve requirements related to credit growth are all significant, consistent with the results of the preliminary regressions. Moreover, the estimated coefficients are very similar to those obtained in the preliminary regressions. The estimated coefficient for the aggregate of all other policy measures is not significant, suggesting that other policy measures had, on average, no measurable effect on the housing cycle, at least not during the first two quarters following their implementation.

To assess the economic magnitude of the effects, we compute the dynamic multipliers tracing out the response of housing price inflation to changes in each of the three MPPs in the core set over the following ten quarters (Figure 5). The charts also report 95 percent confidence intervals. In each of the policy experiments the MPP index is increased by one point, which

[21] If we construct aggregates of each of the five categories of measures and introduce them separately in the regression, none of them is significant. Results are available from the authors upon request.

[22] Crowe et al. (2011) also find only small effects of interest rates on housing prices in a large cross-country sample using a VAR approach, while Dell'Ariccia et al. (2012) argue that monetary policy can only be expected to have very small effect on credit booms and that macroprudential measures are needed.

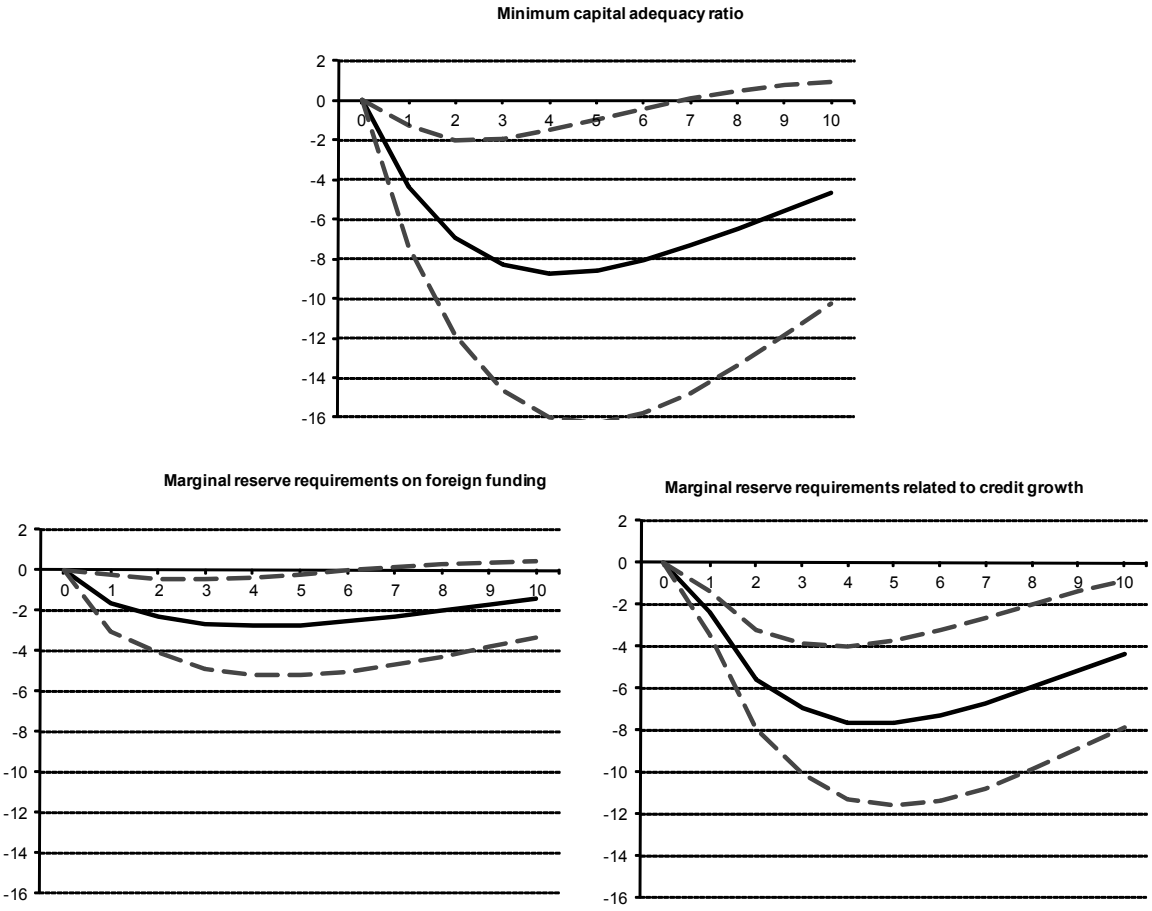
Table 3. Prudential Policies and Housing Prices -- Baseline Regression

	(1) Baseline Regression	(2) Regression without EC term
Error-correction (EC) equation		
L.GDP growth	1.23	
	(0.17)	
Short-run equation		
Error correction term	-0.06***	
	(0.00)	
Δ(log housing price index) t-1	0.42***	0.42***
	(0.00)	(0.00)
Δ(log housing price index) t-2	0.17***	0.13**
	(0.00)	(0.05)
Δ(log GDP/capita) t-1	-0.11	-0.13
	(0.46)	(0.22)
Δ(domestic currency real interest rate) t-1	-0.02	-0.00
	(0.93)	(0.98)
Δ(effective foreign currency real interest rate) t-1	-0.05	-0.03
	(0.41)	(0.62)
Δ(log working age population)	-0.44	-0.2
	(0.37)	(0.78)
Δ(mininum capital adequacy ratio) t-1	-4.32***	-4.53***
	(0.00)	(0.01)
Δ(minimum capital adequacy ratio) t-2	-1.06	-0.99
	(0.12)	(0.26)
Δ(marginal reserve requirements on foreign funding) t-1	-1.62**	-1.93**
	(0.02)	(0.01)
Δ(marginal reserve requirements on foreign funding) t-2	-0.08	-0.21
	(0.84)	(0.64)
Δ(marginal reserve requirements on credit growth) t-1	-2.37***	-2.43***
	(0.00)	(0.00)
Δ(marginal reserve requirements on credit growth) t-2	-2.37***	-2.36***
	(0.00)	(0.01)
Δ(other policies) t-1	-0.23	-0.29
	(0.52)	(0.39)
Δ(other policies) t-2	0.31	0.23
	(0.39)	(0.52)
R-sqr	0.532	0.499
adj.R-sqr	0.467	0.431
Number of observations	541	541

Notes: The dependent variable is the log difference of the real housing price index. The regressions include time and country fixed effects. P-values in parentheses. *, ** and, *** denote statistical significance at the 10 percent, 5 percent and 1 percent confidence levels respectively.

Source: Authors' calculations

Figure 5. Dynamic Multiplier of Shock to Selected Macroprudential Policies



Note: Each shock represents an increase by one unit in the intensity of the policy variable. The cumulative change in house prices is shown on the vertical axis (in percent). Time (in periods) is on the horizontal axis.
Source: Authors' calculations.

has a different interpretation depending on the index (again, see Appendix Table 2) but in each case corresponds to a policy change of a plausible magnitude.

Based on the estimated coefficients, an increase in the minimum capital requirement by one percentage point would have its maximum impact after four-to-five quarters, when housing prices are 8.5 percent lower than they would have been without the policy change. Subsequently, the effect starts to die down and after ten quarters the cumulative decline is of 4.5 percent. Standard errors around this point estimates, however, are quite large, indicating that a precise quantification of the magnitude of the effect is not possible within our sample and empirical framework. Nonetheless, these results suggest that the countercyclical capital buffer under Basel III, which can reach up to 2.5 percentage points (corresponding to a score of 2.5 in our scoring system), could potentially have a large impact on housing price dynamics in the short and medium term. Therefore the recent experience in CESEE provides support for actively using the countercyclical capital buffer to address concerns about housing bubbles.

Turning to the other MPPs in the core set, the effect of marginal reserve requirements on foreign borrowing, while negative and econometrically significant, is relatively small: an increase by 20 percentage points lowers housing prices by only 3 percent at the peak. Finally, a one-point increase in the index of marginal reserve requirements on excessive credit growth (a relatively large increase since the maximum observed in the sample is 1.18 points) lowers housing prices by 8 percentage points after one year. [23]

Given that the estimated long-run relationship between housing prices and GDP per capita is not statistically significant in the baseline regression and, as mentioned above, one of the two Westerlund (2007) panel tests does not reject the null of no cointegration between housing prices and GDP per capita, we run an alternative regression that includes the same variables as the baseline except for the error-correction term. As shown in Column (2) of Table 3, the significance and the order of magnitude of the effects of the four MPPs in the core set are consistent with those obtained under the baseline.

C. Are the Effects of MPPs Asymmetric?

We further explore whether the effects of MPPs in the core set differ depending on whether they are loosened or tightened, or depending on the different parts of the cycle when they occur.

In the regressions in the middle panel of Table 4, we re-run the baseline specification allowing for separate coefficients for tightening and loosening of the MPPs; the top panel of the table reports the coefficients in the baseline regression for ease of comparison. The results show that for the minimum CAR, the effect on housing prices was stronger and more prolonged when the regulation was loosened (as in Latvia, Lithuania and Romania during the boom) than when it was tightened.[24] For the other two types of measures, only tightening seems to have had a robust effect, but the coefficients are bigger and more statistically significant than in the baseline.

Before reading too much into these asymmetries, however, we should point out that they may reflect different endogeneity biases. For instance, if capital requirements tended to be tightened in response to an expected acceleration in housing prices while they tended to be loosened for exogenous reasons (i.e., harmonization with EU minima following EU entry), the endogeneity bias would be much smaller for the loosening coefficient than for the tightening coefficient.

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[23] Given our scoring rule, a change of 1 point would correspond for example to the introduction of marginal reserve requirements of 100 percent on credit growth in excess of 10 percent per year.

[24] Capital adequacy requirements were eased in Latvia and Lithuania in 2004Q4 and in Romania in 2007Q1, i.e. soon after they became European Union members.

Table 4. Macroprudential Policies and Housing Prices: Are the Effects Asymmetric?

	Minimum capital adequacy ratio	Marginal reserve requirements on foreign funding	Marginal reserve requirements related to credit growth
	(1)	(3)	(4)
Policy change t-1	-4.32***	-1.62**	-2.37***
	(0.00)	(0.02)	(0.00)
Policy change t-2	-1.06	-0.08	-2.37***
	(0.12)	(0.84)	(0.00)
Policy tightening t-1	-2.68***	-3.49***	-2.18**
	(0.00)	(0.00)	(0.03)
Policy tightening t-2	-0.73	-1.84*	-4.18***
	(0.15)	(0.05)	(0.00)
Policy easing t-1	-7.38**	-1.08	-2.48
	(0.01)	(0.19)	(0.13)
Policy easing t-2	-1.38	0.67	0.00
	(0.10)	(0.12)	(1.00)
Boom			
Policy change t-1	-4.52**	-3.89***	-2.72***
	(0.05)	(0.00)	(0.00)
Policy change t-2	-1.35**	-2.39**	-1.98***
	(0.02)	(0.02)	(0.00)
Bust			
Policy change t-1	-4.98***	-1.03	1.65
	(0.00)	(0.21)	(0.22)
Policy change t-2	1.72**	0.50	-13.16***
	(0.04)	(0.24)	(0.00)

Note: The dependent variable is the log difference of the real housing price index. The regressions include time and country fixed effects.

P-values in parentheses. *, **, and *** denote statistical significance at the 10 percent, 5 percent and 1 percent confidence levels respectively.

Source: Authors' calculations.

Distinguishing between boom and bust periods, we observe that the effects are very strong and significant during the boom period for the three measures. In particular, they are much more significant during the boom than during the whole sample period for the marginal reserve requirement on foreign funding. Accordingly, the effects during the bust are not very robust, although they go in the expected direction when both lags' coefficients are combined.

V. CONCLUSIONS

After the 2008–09 global financial crisis, preventing credit and housing price booms has become a major priority for policy-makers in both advanced and emerging market countries. To this end, policy instruments beyond those in the conventional macroeconomic policy toolkit are being considered, and many countries are in the process of developing an

institutional framework to use them on a regular basis. The interest around these new potential "macroprudential" instruments is so far not matched by the quantity of empirical evidence supporting their effectiveness. Furthermore, as the list of possible macroprudential instruments is long, the question of which levers should be used is equally important.

This paper has attempted to shed light on these questions taking advantage of the experience in CESEE countries during the boom-bust cycles of the last decade. Using a novel database we constructed on twenty-nine types of macroprudential policy changes, we have tested whether changes in these policies affected housing price inflation in the last decade.

We found that some macroprudential policies did have an impact, while others did not. In particular, raising the minimum CAR was followed by a significant deceleration in housing prices. This finding bodes well for one of the main macroprudential tools introduced as part of the Basel III reforms, i.e. the countercyclical capital buffer. An equally important result, especially against the background of the current debate on maximum harmonization in the context of the EU's new Capital Requirements Directive and the future banking union, is the finding that allowing banks to hold *less* capital (typically following EU entry) was followed by a sizeable acceleration in housing prices. While we do not find that standard reserve requirements had an impact on housing price inflation, marginal reserve requirements targeting specific excesses, such as those related to credit growth or to foreign funding were found to have an effect.

This study is not a perfect policy experiment: endogeneity may bias coefficients downwards, thus some tighter policies that appear ineffective may do so only because they were adopted when policymakers anticipated accelerating housing price inflation. Effects may have become visible only after the two-quarter horizon we use in our empirical framework, or may have taken place as soon as the policy change was announced and before its actual implementation. The coding of the intensity of the various policy measures, a complicated process relying on subjective judgment, may also be less-than-fully adequate in some cases. Nonetheless, we believe that the evidence this study provides is informative and can be useful to policymakers.

As to future research, an interesting avenue would be to explore alternative dependent variables to capture the boom, such as construction activity, real estate transaction volumes, or credit growth once sufficiently detailed data on the currency composition of loans becomes available.

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Appendix 1. Data Sources

Table A1. Housing Price Data

Country	Source	Description / remarks	No. obs	Start	End
Albania	CB	House price index for Tirana	49	1999Q1	2011Q1
Bulgaria	NSO	Average market price of dwellings, Bulgaria. We only include data from 1999 onwards so as to avoid the 1997 hyperinflation episode and the ensuing banking crisis.	49	1999Q1	2011Q1
Croatia	GPG	Property price index. We only include data from 1999Q4 onwards so as to avoid the time period of the 1998-1999 banking crisis.	45	1999Q4	2010Q4
Czech Republic	NSO	Property prices, apartments, transfer prices according to tax returns	49	1999Q1	2011Q1
Estonia	BIS	Residential property prices, all flats, per square meter, Estonia	31	2003Q3	2011Q1
Hungary	FHB	House prices, actual sales prices, Hungary.	48	1999Q1	2010Q4
Latvia	GPG	Average price of apartments, Riga	29	2004Q1	2011Q1
Lithuania	BIS	Residential property prices, all dwellings, per square meter, Lithuania	49	1999Q1	2011Q1
Poland	GPG	Average price of apartments, Warsaw	41	2000Q4	2010Q4
Romania	REAS	Average asking price per sq. m of residential floor area, Bucharest	18	2006Q4	2011Q1
Russia	BIS	Residential property prices, existing dwellings, per square meter, Russia	41	2001Q1	2011Q1
Serbia	GPG	Price of Dwellings of New Construction, Serbia. We only include data from 2002 onward so as to avoid the very high inflation episodes of 1999-2001.	37	2002Q1	2011Q1
Slovakia	CB	Residential Property Prices, Slovakia	25	2005Q1	2011Q1
Slovenia	GPG	Average Advertised Prices of Apartments, Ljubljana	56	1997Q1	2010Q4
Turkey	Reidin	House sales price index, composite for major cities.	16	2007Q2	2011Q1
Ukraine	GPG	Price of flats, Kiev	38	2001Q4	2011Q1

Notes: CB=Central Bank; NSO=National Statistical Office; BIS=Bank of International Settlements. FHB, GPG, REAS and Reidin are private companies providing real estate services.

Table A2. Macroeconomic and Demographic Data Sources

Control variables	Description / Sources
GDP/capita	Quarterly real GDP from IFS (line 99b). For Albania we combine information from IFS (until 2004) with data from the national statistical institute (from 2005 onwards). We seasonally adjust all series and calculate GDP per capita using interpolated annual data on population (line 99z).
Domestic real interest rate	Domestic deposit rates from IFS (line 60l) or Haver if IFS is not available. We deflate all series with year-on-year inflation (line 64).
Foreign real effective interest rate	Fed Funds Rate for Russia, Turkey and Ukraine. European Central Bank policy rate for all other countries. Series are adjusted for domestic year-on-year inflation (line 64) and yoy appreciation of the local currency against the USD (for Russia, Turkey and Ukraine) or against the Euro (all the other countries). Data on bilateral exchange rates is obtained from IFS, Haver or the ECB.
Working population data	Share of working age population from World Development Indicators and total population from IFS. The yearly series are interpolated to a quarterly frequency.

Appendix 2: Description of Macroprudential Policy Measures and the Scoring Rules to Measure Their Intensity

name of variable / prudential measure	name of combination of variables	measure description	series description	operationalization
CAPITAL MEASURES (EXCEPT RISK_WEIGHTS)				
mincap		Minimum required capital adequacy ratio	minimum required capital adequacy ratio (in percent)	minimum capital adequacy ratio
tgtmincap		(Target) capital adequacy ratio below which restrictions are imposed	capital adequacy ratio below which restrictions are imposed (in percent)	[in the database but not in the sample]
cap		Capital eligibility	index with a change of 1 for tightening/easing the capital base calculation	index with a change of 1 for tightening/easing the capital base calculation
cgrcap		Minimum required capital adequacy ratio as a function of credit growth (if above a threshold)	minimum required capital adequacy ratio (in percent) annual threshold (in percent) penalty rate (in percent)	(10/annual threshold) * [minimum required capital-mincap+((penalty rate-100)/100)]
hhsc		Maximum ratio of household loans to share capital	index with a change of 1 for implementing/abandoning the measure and increase/decrease of the maximum ratio, change of 0.5 for a change in penalties and for changes in the base	index with a change of 1 for implementing/abandoning the measure and increase/decrease of the maximum ratio, change of 0.5 for a change in penalties and for changes in the base
fcsc		Maximum ratio of fc loans to own funds	maximum ratio of fc loans to own funds	3/ratio
	lsctot	Maximum ratio of a targeted type of loans to capital		hhsc + hhscfc
RISK WEIGHTS MEASURES				
rwmol		Risk weights / mortgage loans	risk-weight on mortgage loans in lc (in percent)	(rw mortgage loans - basel risk weights for mortgage loans) / 25
			[for Bulgaria only] risk-weight on mortgage loans in lc above LTV threshold (in percent) and LTV threshold	(100 - threshold ltv)/50 * (rw mortgage loans - basel risk weight for mortgage loans)/25
rwmolfc		Risk weights surcharge/ FC mortgage loans	risk-weight on mortgage loans in fc (in percent)	(rw mortgage loans in fc - rw for mortgage loans in lc) / 50
			[for Bulgaria only] risk-weight on mortgage loans in fc above LTV threshold (in percent) and LTV threshold	(100 - threshold ltv)/50 * (rw mortgage loans - basel risk weight for mortgage loans)/25
	rwmoltot	Risk weights / mortgage loans (combined)	risk-weight on mortgage loans (in percent)	rwmol + rwmolfc
rwcons		Risk weights / consumer loans	risk-weight on consumer loans in lc (in percent)	(rw consumer loans - basel risk weights for consumer loans) / 25
rwconsfc		Risk weights surcharge/ fc consumer loans	risk-weight on consumer loans in fc (in percent)	(rw consumer loans in fc - rw for consumer loans in lc) / 50
	rwconstot	Risk weights / consumer loans (combined)	risk-weight on consumer loans (in percent)	rwcons + rwconsfc
rw		Risk weights / mortgage and consumer loans in lc (combined)	risk-weight on mortgage and consumer loans in lc (in percent)	rwmol + rwcons
rwfc		Risk weights surcharge / mortgage and consumer loans in fc (combined)	risk-weight on mortgage and consumer loans in fc (in percent)	rwmolfc + fwconsfc
	rwtot	Risk weights / mortgage and consumer loans (combined)	risk-weight on mortgage and consumer loans (in percent)	rw + rwfc
rwcorpfc		Risk weights on fc corporate loans	Risk weight on fc corporate loans (in percent)	[Not included in regression]
rwcc		Risk weights on loans above a threshold related to credit growth	risk-weights on loans above threshold (in percent) and annual threshold (in percent)	(10/annual threshold) * (risk weight-100) / 50
	rwtot2	Risk weights (total except corporate)		rw + rwfc + rwcc

name of variable / prudential measure	name of combination of variables	measure description	series description	operationalization
PROVISIONING MEASURES				
gp		Rules for general provisions	index with a change of 0.5 for tightening/loosening general provisioning rules (index=0 if measure is dropped)	index with a change of 0.5 for tightening/loosening general provisioning rules (index=0 if measure is dropped)
dp		Rules for specific provisions	index with a change of 0.5 for tightening/loosening loan loss provisioning or loan classification	index with a change of 0.5 for tightening/loosening loan loss provisioning or loan classification
dpfc		FC -loans rules for specific provisions	index with a change of 0.5 for tightening/loosening fc-loan loss provisioning or fc-loan classification above that for lc-loan classification/provisioning	index with a change of 0.5 for tightening/loosening fc-loan loss provisioning or fc-loan classification above that for lc-loan classification/provisioning
	dptot	Provisioning rules (combined)		gp + dp + dpfc
LIQUIDITY MEASURES				
rr		Reserve requirements rate on lc deposits	minimum reserve requirement ratio on lc demand deposits (in percent)	
rrfc		Reserve requirements rate on fc deposits	minimum reserve requirement ratio on fc demand deposits (in percent)	
	mpprr	Reserve requirement rate		if rrfc>0: (rr/10 + rrfc/10)/2 if rrfc=0: rr/10
rrbase		Reserve requirements base	index with a change of 0.5 for change in reserve base, a change of 0.25 for a change in ratio on any other than demand deposits in domestic and foreign currency (if different from change in ratio for demand deposits)	index with a change of 0.5 for change in reserve base, a change of 0.25 for a change in ratio on any other than demand deposits in domestic and foreign currency (if different from change in ratio for demand deposits)
	rrtot	Reserve requirements (combined)		rr + rrbase
lr		Liquidity regulation	Index with a change of 0.5 for a tightening/easing of the regulation	index with a change of 0.5 for a tightening/easing of the regulation
fclr		Foreign currency liquidity requirement	ratio of liquid fc assets to fc liabilities (in percent)	(fclr rate/10) / 4 +/- 0.5 for change in the base
mrr		Marginal reserve requirements	marginal reserve requirements on foreign funding (in percent)	(mrr rate/10) / 2
srr		Special reserve requirements	special reserve requirements on funds raised by domestic bond issuance to nonresidents (in percent)	(srr rate/10) / 8
	mrrtot	Marginal and special reserve requirements		mrr + srr
cgr		Credit growth reserve (banks need to hold low-yield CB bills if their credit growth is above a threshold)	annual threshold (in percent) Penalty rate (in percent)	(10/annual threshold) * (penalty rate/100)
cc		Marginal reserve requirements on credit growth above a threshold	penalty rate is a step function with up to three thresholds.	[(10/lowest threshold) * (lowest penalty rate/100)] + [(10/second threshold) * (second penalty rate/100)]+ [(10/third threshold) * (third penalty rate/100)]
	cgrr	Credit-growth-related reserve requirements		cgr + cc

name of variable / prudential measure	name of combination of variables	measure description	series description	operationalization
ELIGIBILITY MEASURES				
ltv		Loan-to-value ceiling	Loan-to-value ceiling (in percent)	(100 - maximum LTV) / 20 [default=100]
ltvfc		FC loan-to-value ceiling	index with a change of 0.5 for tightening/easing the ltv ratio for loans in fc relative to the ltv-ratio for loans in lc	index with a change of 0.5 for tightening/easing the ltv ratio for loans in fc relative to the ltv-ratio for loans in lc
	ltvtot	Loan-to-value ceiling (combined)		ltv + ltvfc
dti		Debt-service-to-income ceiling	Debt-service-to-income ceiling (in percent)	(1 - (maximum DTI / 60)) * 4 [default=60]
dtifc		FC debt-service-to-income ceiling	index with a change of 0.5 for tightening/easing the dti ratio for loans in fc relative to the dti-ratio for loans in lc	index with a change of 0.5 for tightening/easing the dti ratio for loans in fc relative to the dti-ratio for loans in lc
	dtitot	Debt-service-to-income ceiling (combined)		dti + dtifc
	elig	All eligibility measures combined		ltv + ltvfc + dti + dtifc
OTHER BANK REGULATORY MEASURES				
otherfc		Other quantitative limits on fc-lending as a share of total lending	index with a change of 0.5 for measures taken to impede fc-lending and a change of 3 - ltvfc - dtifcd - dpfc - rwfc - hhscfc for prohibiting fc-lending or fc-mortgage lending [if	index with a change of 0.5 for measures taken to impede fc-lending and a change of 3 - ltvfc - dtifcd - dpfc - rwfc - hhscfc for prohibiting fc-lending or fc-mortgage lending [if
TAX POLICY AND NON_BANK REGULATORY POLICY MEASURES				
tax		Tax measures regarding real estate / mortgages	index that changes by 0.5 if taxation of real estate/ mortgages (e.g. interest rate subsisides, property tax) changes	index that changes by 0.5 if taxation of real estate/ mortgages (e.g. interest rate subsisides, property tax) changes
other		Regulatory measures on non-banks	index that changes by 0.5 for other tightening/easing measures on regulation of non-bank credit institutions	index that changes by 0.5 for other tightening/easing measures on regulation of non-bank credit institutions
	rest	Tax and non-bank measures combined		tax + other

Appendix 3: Macroprudential Policy Measures and Countries Where They Were Used

variable	prudential measure	ALB	BGR	HRV	CZE	EST	HUN	LVA	LTU	POL	ROM	RUS	SRB	SVK	SVN	TUR	UKR
CAPITAL MEASURES (EXCEPT RISK-WEIGHTS)																	
mincap	Minimum capital adequacy ratio	■	■	■		■		■	■		■		■				■
tgtmincap	(Target) capital adequacy ratio below which restrictions are imposed															■	
cap	Capital eligibility		■							■	■						
cgrcap	Minimum capital adequacy ratio as a function of credit growth			■													
hhsc	Maximum ratio of household loans to share capital												■				
fcsc	Maximum ratio of fc loans to own funds	■									■						
RISK-WEIGHTS MEASURES																	
rwmol	Risk weights / mortgage loans		■			■											
rwmolfc	Risk weights surcharge/ FC mortgage loans	■		■						■			■				
rwcons	Risk weights / consumer loans		■														
rwconsfc	Risk weights surcharge/ FC consumer loans	■		■									■				
rwcorpfc	Risk weights on fc corporate loans			■									■				
rwcc	Risk weights/ credit growth	■															
PROVISIONING MEASURES																	
gp	Rules for general provisions			■									■			■	
dp	Rules for specific provisions		■	■						■	■		■			■	
dpfc	FC -loans rules for specific provisions	■		■							■		■				■
LIQUIDITY MEASURES																	
rr	Reserve requirements rate on lc deposits		■	■		■	■	■	■	■	■	■	■	■	■	■	■
rrfc	Reserve requirements rate on fc deposits		■	■		■	■	■	■	■	■	■	■	■	■	■	■
rrbase	Reserve requirements base		■	■		■	■	■			■	■	■	■	■	■	■
lr	Liquidity regulation	■							■	■						■	
fclr	Foreign currency liquidity requirement			■													
mrr	Marginal reserve requirements			■													
srr	Special reserve requirements			■													
cgr	Credit growth reserve (max permissible growth, for exceeding growth banks need to hold low yielding CB bills)			■													
cc	Marginal reserve requirements on excess credit growth		■														
ELIGIBILITY MEASURES																	
ltv	Loan-to-value ceiling						■	■			■			■		■	
ltvfc	FC loan-to-value ceiling						■			■							
dti	Debt-service-to-income ceiling									■	■						
dtifc	FC debt-service-to-income ceiling						■			■	■						
OTHER BANK REGULATORY MEASURES																	
otherfc	Other quantitative limits on fc-lending as a share of total lending						■									■	■