

Macroprudential policies in CESEE – an intensity-adjusted approach

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We assess the overall intensity with which macroprudential policies were used in eleven Central, Eastern and Southeastern European (CESEE) countries from 1997 until end-2018. To this end, we construct an intensity-adjusted macroprudential policy index, which also allows us to gauge the impact macroprudential measures had on credit growth and housing prices. Our new index reveals that some of the eleven CESEE countries had already intensively implemented macroprudential policy tools before the global financial crisis (GFC), while others became more active in this respect only in its aftermath. The considerable macroprudential tightening evident since 2010 mainly reflects the introduction of borrower-based measures, like loan-to-value (LTV) and debt service-to-income (DSTI) limits, and the implementation of capital buffers. In the empirical assessment, we find that macroprudential measures are associated with lower private sector credit growth, in particular for households. Moreover, borrower-based macroprudential measures tend to have a larger and more robust impact on credit growth than other macroprudential instruments that also include capital- and liquidity-based measures. These findings also hold for the impact of macroprudential measures on house price growth.

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Research on macroprudential policies (MPPs) in Central, Eastern and Southeastern Europe (CESEE) provides important lessons for other countries. Given that some CESEE countries adopted macroprudential policy measures rather early, relatively long time series lend themselves to assessing the impact of macroprudential policy on the domestic financial cycle – and on financial stability more generally.

Macroprudential policy encompasses a large number of tools. Some resemble traditional microprudential tools, e.g. capital and liquidity requirements; others target borrowers' behavior, e.g. loan-to-value (LTV) and debt service-to-income (DSTI) limits. Macroprudential tools may be gradual, such as a change in the LTV limit from 90% to 80%, binary, e.g. foreign currency (FX) loans are permitted or not, and some can change from gradual to binary or vice versa. Accurately quantifying MPP activity by capturing not only the occurrence of such policies but also their strength is thus highly challenging².

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² For a discussion of challenges related to the definition and measurement of a macroprudential policy stance, see ESRB (2019).

In fact, most of the literature on macroprudential policy captures only the extensity, i.e. the occurrence of macroprudential policies, using very simple indices. Some authors use a basic binary indicator signaling whether a certain instrument was in place at a given time (e.g. Reinhart and Sowerbutts, 2015; Cerutti et al., 2017a). Most studies use an index where a tightening measure is coded with +1, a loosening measure with –1 and ambiguous measures are not taken into account. By cumulatively summing up the values over time, a simple time series of overall macroprudential extensity can be compiled (see, for instance, Shim et al., 2013; Cerutti et al., 2017b; Ahnert et al., 2018). The intensity of the measures is, however, not taken into account. To take an example from Vandebussche et al. (2015), these indices would record a lowering of the maximum LTV ratio from 100% to 90% in the same way as a reduction from 100% to 60%. Obviously, however, the effect of these two measures is unlikely to be the same.

It is no easy task to construct an index that genuinely reflects the intensity of macroprudential policy given the difficulty of comparing and quantifying the effects that different measures have on the overall macroprudential stance. One could even argue that constructing a “perfect” index is practically impossible. However, in order to help make informed policy decisions and to explore and understand the effects of macroprudential policy on different economic developments, having an indicator that could be used for such modeling exercises would prove very useful.³

There are only few examples of intensity-adjusted macroprudential indices. Most notably, Vandebussche et al. (2015) construct an intensity-adjusted macroprudential policy index for 16 CESEE countries to investigate the effects of macroprudential measures on housing prices. Dumičić (2018) also accounts for possible differences in the intensity of measures. Richter et al. (2019) and Alam et al. (2019) both focus on LTV limits and provide detailed information on the intensity of usage of this specific instrument. However, the authors of both papers stopped short of compiling an overall MPP index.

In this paper, we build and expand on previous intensity-adjusted approaches and construct a novel, overall index for macroprudential policy in CESEE. Our macroprudential policy index (MPPI) accounts not only for “classic” macroprudential instruments but also for other requirements motivated by macroprudential objectives. The index is based on information derived from four databases of macroprudential measures and applies a set of weighting rules partly leaning on those developed by Vandebussche et al. (2015). The MPPI covers eleven CESEE EU Member States from 1997 to 2018 on a quarterly basis. The novelty of our index compared to the existing literature lies – next to the aforementioned intensity adjustment – in covering a comparatively long time span (of more than 20 years) and a large variety of MPP instruments as well as in differentiating between the announcement and implementation of macroprudential measures.

This paper is structured as follows: section 1 discusses a taxonomy of macroprudential policy measures and introduces the MPPI, with section 2 providing an overview of its country-specific development over time. In section 3, we use the MPPI to assess the impact of macroprudential policy measures on key macrofinancial variables, such as credit growth and house prices. Section 4 concludes.

³ Additionally, it might also be very useful for communication purposes to have an index which could more clearly explain to both financial institutions and the general public the stance of the overall macroprudential policy and its various segments.

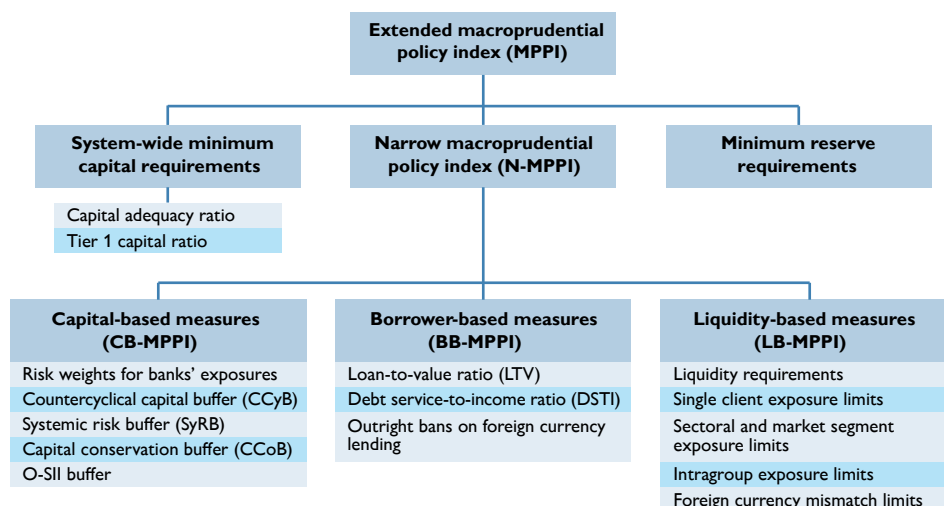
1 Constructing an intensity-adjusted macroprudential policy index

To construct our macroprudential policy index (MPPI), we first decided on its components. Besides “classic” macroprudential instruments, such as capital buffers or borrower-based instruments, we include system-wide (Pillar 1) minimum capital requirements and reserve requirements. Capital requirements are typically seen as microprudential tools and are set by relevant (banking supervision) authorities. However, they clearly also have an impact on systemic financial sector risk. Reserve requirements are usually seen as a monetary policy tool but have often also been used for macroprudential purposes.

Chart 1 provides a hierarchical overview of the various subindices and other components we draw on to construct the MPPI. Classic (“narrow”) macroprudential instruments are grouped into three subindices for capital-based, borrower-based and liquidity-based measures, respectively. First, the capital-based macroprudential policy subindex (CB-MPPI) comprises the countercyclical capital buffer (CCyB), the systemic risk buffer (SyRB), the capital conservation buffer (CCoB), institution-specific buffers for other systemically important institutions (O-SII buffer) and risk weights (RWs)⁴. Second, the borrower-based macroprudential policy subindex (BB-MPPI) encompasses limits in the LTV ratio for new collateralized house purchase loans, the DSTI ratio and outright bans on foreign currency lending. Other borrower-based instruments like debt-to-income (DTI) or loan-to-income (LTI) limits, having only played a negligible role in the CESEE countries, have not been included so far.⁵ Third, the liquidity-based macroprudential policy subindex (LB-MPPI) consists of liquidity requirements (like short-run liquidity ratios) and a variety of other prudential measures, such as limits on large exposures and specific sectors. It also

Chart 1

Components of the macroprudential policy index (MPPI)



Source: Authors' compilation.

⁴ Risk weights play an important role in determining banks' risk-weighted assets and, by extension, the total amount of capital banks need to hold.

⁵ In fact, in our sample, only Slovakia issued a binding DTI limit, and the Czech Republic issued a respective recommendation, both in the second half of 2018.

captures intragroup exposure limits and rules on foreign currency mismatches. The three “classic” macroprudential subindices taken together constitute what we call the narrow macroprudential policy index (N-MPPI).

To obtain the extended version of the macroprudential policy index, or MPPI, we include the additional measures mentioned at the beginning of this section. First, we account for system-wide (Pillar 1) minimum capital requirements, comprising both the applicable capital adequacy ratio and the tier 1 capital ratio. Second, we include minimum reserve requirements. Many macroprudential measures, in particular in the CESEE countries, differentiate between local and foreign currencies, with foreign currency requirements being usually stricter than national currency requirements to account for exchange rate risks. Foreign currency requirements were not included in the MPPI as a separate subindex. Instead, they are taken into account within the various subindices.

The second step in the construction of the MPPI is weighting and aggregating the individual measures, which is a difficult and, to a certain extent, inevitably arbitrary task, as already alluded to in the introduction. To go beyond simple binary indicators, it is necessary to define specific weights for the various macroprudential instruments included in the MPPI. Increasing the CCyB by 50 basis points might, for example, constitute a more, or less, severe change in the intensity of overall macroprudential policy than, say, reducing the upper limit on the LTV ratio by 5 percentage points. Depending on the nature of the macroprudential instruments, we apply three different *weighting rules* to the individual instrument feeding into the MPPI. Many of these rules are fully or partly based on Vandenbussche et al. (2015), which, to our knowledge, reflects the most comprehensive previous attempt to calculate an intensity-weighted macroprudential index. However, the database used in Vandenbussche et al. (2015) ended nearly ten years ago and does not include newer instruments, such as capital buffers. Moreover, the database provides only the implementation dates of measures and not the announcement dates. Our three weighting rules are as follows:

First, we use *face value aggregation* for instruments that are captured by a single number and where a change clearly indicates a tightening or loosening of macroprudential policy intensity. For example, a 1-percentage-point increase of the CCyB leads to a 1-index-point increase in both the extended and the narrow MPPI as well as in the CB-MPPI.

Second, for more complex measures or measures where a decrease represents a tightening of macroprudential intensity, a *formula-based aggregation* is used. This usually involves a default limit from which the actual limit is subtracted and a weighting scheme to ensure that the impact of changes in the measure concerned is appropriately reflected. For instance, a 5-percentage-point reduction in the LTV limit is equivalent to a 1-index-point increase in the MPPI.

Third, for macroprudential instruments that are too specific or too complex to be properly captured through a formula, such as changes in definitions for the calculation of minimum capital requirements, we use an *augmented dummy approach*. It works similarly to the approach used in many other studies and assigns fixed positive (negative) values for tightening (loosening) incidents. However, even for such cases we introduce some nuances in the scoring. For example, a change in the type of capital required for overall reserve requirements has a stronger impact on the MPPI than a change in the type of capital applicable only to certain exposures.

This approach allows us to include a range of macroprudential measures that are hard or impossible to quantify otherwise. In total, around one-third of the measures included in the overall index were coded in this way.

Another important aspect when aggregating the MPPI is that many instruments included in the MPPI may either be *recommendations* or legally binding acts. Given that the former are not as stringent as the latter, the weight attributed to recommendations in the index is lower than the weight attributed to equivalent measures that are legally binding.

As we focus in our analysis on changes in the intensity of the various types of macroprudential measures, the *initial level* of the indices is of secondary importance. In this study, we subtract the value of the index in the first period from the whole series thereafter. This way, the index and each subindex start at zero. Positive (negative) values in the subsequent periods then signal a net tightening (loosening) of aggregate macroprudential policy. Moreover, given that most CESEE countries in our sample had implemented only few if any macroprudential policy measures before the mid-1990s, it is realistic to assume that cross-country differences in the macroprudential policy stance were not that large in 1997, when our index starts.

For compiling the MPPI, we use and cross-check information derived from four MPP databases: the ECB’s Macroprudential Policies Evaluation Database (MaPPED) documented in Budnik and Kleibl (2018), the CESEE-related database of Vandebussche et al. (2015), the IMF iMaPP database described in Alam et al. (2019), and the database of the European Systemic Risk Board (ESRB) described in Kochanska (2017).⁶ All these databases provide *implementation dates*, i.e. the dates when certain measures take effect. MaPPED and the ESRB database also provide *announcement or decision dates*. In the econometric analysis, we generally use the announcement dates for tightening and the implementation dates for loosening incidents. The rationale behind this is that a credit institution is likely to react to the announcement of a tightening measure, e.g. an increase in minimum capital requirements instantaneously by building up capital reserves if needed. In contrast, the announcement of a loosening policy action for the same instrument is unlikely to trigger an immediate reaction given that the old regulations stay in place until the date of implementation.

The online supplement to this article, available on the OeNB’s website, provides more details on underlying data sources, the categorization of the different macroprudential policy measures and the applied weighting rules. In it, we moreover show the evolution of each subindex by country over time.

2 Country-specific analysis of macroprudential policies

Chart 2 displays the macroprudential policy index (dark red line) as constructed for all 11 CESEE countries in our sample for the period from 1997 to 2018 and illustrates the role of the different components of the MPPI.^{7,8} An unweighted CESEE

⁶ Our MPPI covers only MPP measures recorded in existing databases. Therefore, it is possible that we do not capture the entire universe of country-specific regulations motivated by macroprudential considerations.

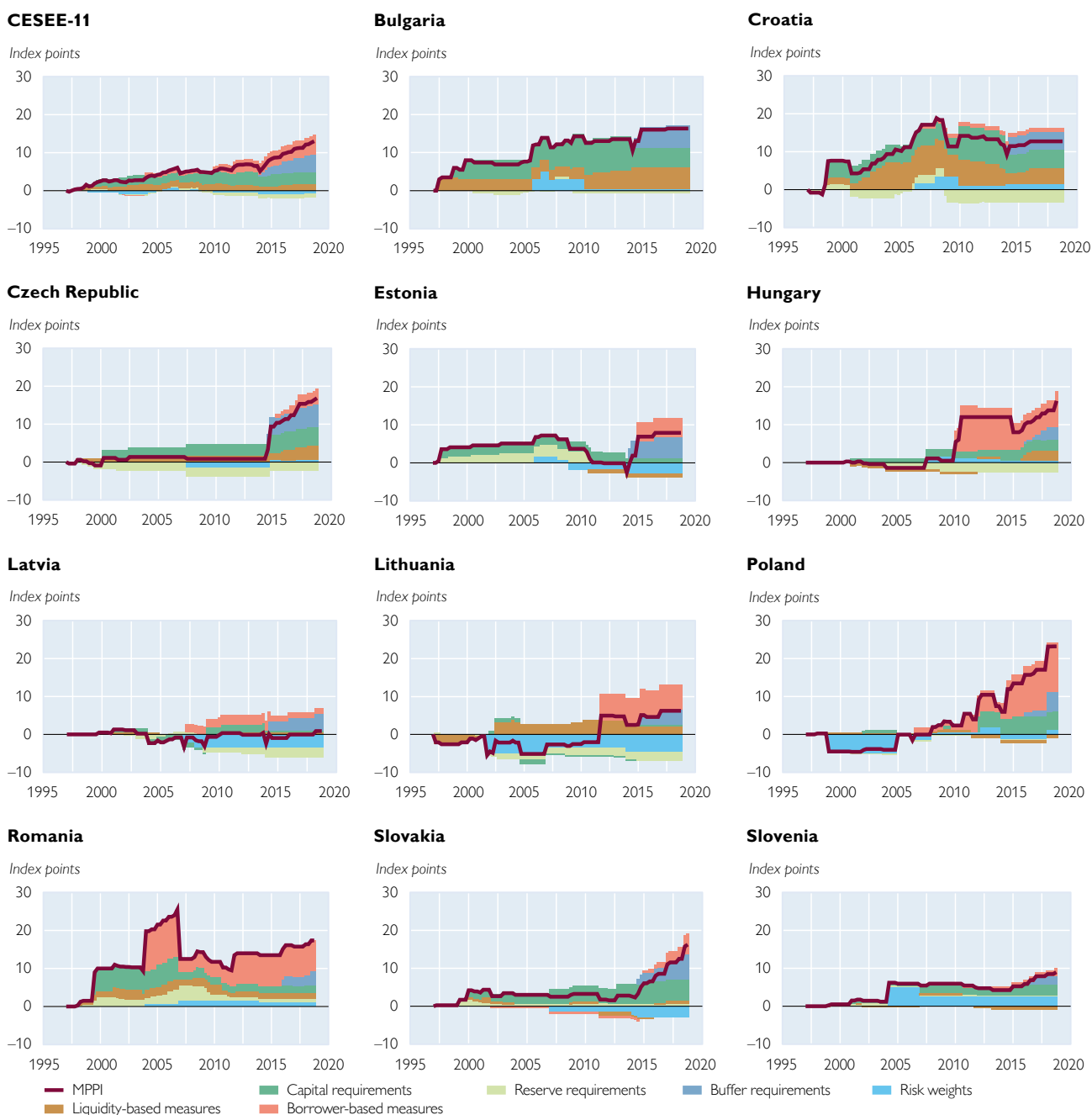
⁷ The data in this chart, as well as all the measures commented on in this section, are based exclusively on implementation dates. By contrast, the charts in the online supplement are based on the differentiated timing used for the econometric investigation in section 3. Any differences between the data shown in chart 2 and in the charts of the online supplement are due to a considerable time lag between the announcement and implementation of tightening measures.

⁸ To show the extent to which classic MPP components contributed to the MPPI over time, the online supplement also contains the corresponding figures for “narrow” macroprudential policies but excludes information on minimum capital requirements and minimum reserve requirements.

aggregate was added by averaging over the 11 countries in order to get an overview of the overall use of macroprudential policy in this region. The aggregate reveals a gradual increase in the intensity of macroprudential policy use in the region. Chart 2 also shows that several CESEE countries had implemented MPP measures to rein in extraordinary strong credit growth already before the 2008–2009 global financial

Chart 2

Intensity-adjusted MPPI and subindex contributions in CESEE-11



Source: Authors' calculations based on Alam et al. (2019), Budnik and Kleibl (2018), Kochanska (2017), Vandenbussche et al. (2015).

Note: Data are based on the implementation dates of macroprudential measures.

crisis (GFC). At that time, such measures were not yet called “macroprudential” but rather “administrative” measures (for an overview, see Hilbers et al., 2005). Bulgaria, Croatia and Romania and, to some extent, Poland, Slovenia and Estonia appear to have been regional “frontrunners” in this respect. Other countries intensified their use of macroprudential instruments toward the end of the observation period.

The tightening in the late 1990s was mainly due to increased minimum capital requirements (shown in dark green in chart 2) and, to a lesser extent, to liquidity-based measures (marked brown). Minimum reserve requirements (shown in light green) were eased countercyclically in many countries in the wake of the GFC and then largely remained at these levels. The tightening evident since 2010 mainly reflects the implementation of borrower-based measures (marked orange) that gained importance after the GFC, but their use stagnated somewhat in recent years. Finally, the accelerated tightening since 2014 was mainly due to the implementation of capital buffers (marked dark blue) with a view to complying with Basel III rules and the respective EU directives. These regulatory changes affected all countries in our sample rather uniformly (and are therefore not discussed further in the subsequent country-specific paragraphs).

Minimum capital adequacy ratios and tier 1 capital ratios were harmonized in 2014–2015, which implied an easing for a few countries (Bulgaria, Croatia, Estonia and Latvia) and a tightening for several others (the Czech Republic, Hungary, Lithuania, Poland, Slovakia and Slovenia). At the same time, all countries activated various capital buffers. Starting in 2014 (or later), positive rates were set (1) for the CCoB in all countries (reaching 2.5% throughout in 2019), (2) for the institution-specific O-SII buffer in all countries but the Czech Republic and (3) for the SyRB in all countries but Latvia, Lithuania and Slovenia. The SyRB was initially often used as a substitute for the O-SII buffer, which became available in 2016; and later to complement the maximum O-SII buffer rate of 2%.⁹ Some of the countries also used the SyRB to compensate for a decrease in Pillar 1 capital requirements, which resulted from the above-mentioned adjustments to EU legislation. Regarding the CCyB, there is more country-specific discretion: until end-2018, positive CCyB rates had been set only in the Czech Republic and in Slovakia (effective since 2017), in Lithuania (effective since end-2018) and Bulgaria (effective since 2019).

The aggregate picture (see the CESEE-11 panel in chart 2) conceals pronounced heterogeneity across countries.¹⁰ Let us focus, first, on countries that tightened macroprudential policy already in the late 1990s or early 2000s and reinforced the use of MPP in the years before the GFC, mostly motivated by extraordinarily strong credit growth at the time, i.e. Bulgaria, Croatia and Romania.

2.1 Bulgaria, Croatia and Romania

Right after its financial crisis in 1997–1998, *Bulgaria* substantially tightened minimum capital requirements (by end-1999, the minimum level of the capital adequacy ratio had increased from 8% to 12% and that of the tier 1 capital ratio from 4% to 6%)

⁹ We calculated a simple average of the individual rates applicable to the SyRB and the O-SII buffers if the rates were differentiated by institutions or if a range was given that covered the individual rates. Moreover, if the SyRB refers to all exposures (and not only to domestic ones), only the larger of the SyRB and the O-SII buffer rates applies. In our sample, this is an issue in Croatia and Romania, which we considered to avoid double counting.

¹⁰ Note that in the description of the various country-specific developments we usually refer to the implementation dates of the respective measures unless stated otherwise.

and liquidity requirements (e.g. limits on banks' single client exposure and qualified holdings outside the financial sector were imposed in 1997). Subsequently, in the years of sizable capital inflows and rapid credit growth prior to the GFC, the Bulgarian National Bank (BNB) imposed comparatively strict regulations for capital, liquidity, risk classifications and provisioning. As a case in point, in 2005–2006, the authorities sharply lowered the LTV threshold for mortgages to which a risk weight of 100% applies, from 100% to 50%, and, in 2007, raised the minimum reserve requirement rate from 8% to 12%. In the years prior to the GFC, some of these measures were bypassed, however, via direct external borrowing, a phenomenon that was also seen in other countries (Vandenbussche et al., 2018). To counteract the strong deceleration in bank lending both during and right after the GFC, minimum reserve requirements were eased again at the end of 2008 and risk weights were reduced in early 2010 (from 100% to 75% for consumer loans, and from 50% to 35% for mortgage loans with an LTV ratio below 70%). By contrast, liquidity requirements were tightened in 2010 to help banks overcome liquidity problems in adverse situations.¹¹

On the back of strong credit growth, mostly denominated in foreign currency, and rising financial and macroeconomic imbalances, *Croatia* started using macroprudential policies in the late 1990s. The minimum capital adequacy ratio was increased from 8% to 10% in 1998, foreign exchange liquidity requirements were introduced in 2001 and maximum limits on banks' open foreign currency claims in 2003. Single client exposure limits were implemented in 1998 and intragroup exposure limits in 2002. With the introduction of marginal and special reserve requirements, the overall minimum reserve requirement rates were gradually increased between 2004 and 2006. In 2006, risk weights for FX mortgage loans to unhedged borrowers were raised from 50% to 75% and, in 2008, to 100%, those for foreign currency-indexed consumer loans from 100% to 150%.¹² When the GFC hit, *Croatia* relaxed its macroprudential policy stance until 2014, e.g. by releasing the system reserves accumulated during the boom phase. Risk weights for currency-induced credit risk were also relaxed in 2010, as part of the adjustment to Basel II, but this easing was offset by an increase in the minimum capital adequacy ratio to 12%. In 2014, the minimum capital adequacy ratio was lowered again to 8% with a view to complying with Basel III but was counterbalanced by implementing several capital buffers.

Romania significantly tightened its macroprudential policy stance already before 2007, mainly by increasing the minimum capital requirements and, to some extent, also the minimum reserve requirements. In 2004, the central bank started to raise reserve requirements on foreign currency deposits while reducing those for local currency. These instruments were complemented with borrower-based measures: an LTV ceiling for housing loans of 75% and DSTI limits (30% on consumer loans, 35% on mortgage loans) were introduced in 2004 already, as well as intragroup exposure limits. However, to harmonize its minimum capital requirements with those of the EU, *Romania* had to loosen its macroprudential stance by reducing the minimum capital adequacy ratio from 12% to 8% in 2007, and by abandoning

¹¹ During the 2014 bank runs on the country's third- and fourth-largest banks, significant liquidity and capital buffers helped contain spillovers to the rest of the banking sector.

¹² The efficiency of those measures was reduced given their circumvention by the less regulated parts of the financial system or via direct borrowing from foreign parent banks (Vujčić and Dumičić, 2016).

explicit ceilings on LTV and DSTI ratios.¹³ When the GFC hit, Romania reversed some of the tightening (especially by loosening reserve requirements) but retightened its macroprudential stance in 2011. The increase in the MPPI at the time mainly reflects the reintroduction of LTV limits and further restrictions for FX loans regarding both the LTV and DSTI ratio. A tightening of the maximum DSTI ratio to 40% was announced in 2018 and implemented in 2019.

2.2 Poland, Slovenia and Estonia

The second group of countries – Poland, Slovenia and Estonia – also tightened their MPP stance before the GFC, but less so than the first group and in part applied a less differentiated toolkit.

Poland escaped the GFC relatively unscathed, and the early use of MPP measures arguably played an important role in preventing banks from suffering large losses during the GFC (Sławiński, 2020). While the MPP stance was loosened between 1999 and 2005, almost exclusively reflecting a reduction of risk weights on local and FX mortgages, it was tightened thereafter. Risk weights for loans with a high LTV ratio were increased starting in 2004. In June 2006, the Polish Commission for Banking Supervision introduced “Recommendation S,” according to which LTV and DSTI limits were tightened and the risk weights for FX mortgage loans were raised from 35% to 75% with effect from 2008. The immediate impact of this regulation was not so much a curbing of the lending boom, but it directed most FX loans toward households that could withstand a sizable depreciation of the złoty (Zettelmeyer et al., 2011). Risk weights for FX mortgage loans were further tightened to 100% in 2012, while, in 2014, the LTV threshold above which a risk weight of 100% applies was raised from 50% to 80% for loans denominated in both foreign and domestic currency, which translated into an easing in this policy area. In another tightening step, the risk weights on FX loans were increased to 150% in 2018. Starting in 2010, borrower-based measures were significantly tightened by introducing a maximum DSTI ratio of 50% for borrowers earning less than the average national wage, and of 65% for other borrowers. Similar DSTI restrictions were applied for FX-denominated loans to unhedged borrowers. Since 2014, LTV limits have been reduced from 100% to 80%. In 2014, FX lending to households without income in the same currency was banned altogether.¹⁴

Slovenia’s MPP stance remained unchanged until 2004, when risk weights on mortgage loans were increased from 50% to 100%. They were relaxed again to 35% in 2007, but, at the same time, the LTV threshold above which a risk weight of 100% applies became more binding, having been set at 60%. Minimum capital reserves were tightened somewhat in 2007, when capital requirements for operational risk were introduced, and in 2015, when the minimum tier 1 capital ratio was increased from 4% to 6%. Capital buffers gained some importance in recent years but not as strongly as in the other CESEE countries. Since 2007, the central bank required banks to assess clients’ creditworthiness based on euro equivalent values of FX loans (Bank of Slovenia, 2008). Borrower-based measures have been

¹³ However, financial institutions using internal models were required to set such limits, and risk weights on high-LTV loans (75% and above) were increased when Romania adopted Basel II in 2007.

¹⁴ If the currency of the loan and the currency in which the borrower obtains his or her highest income is the same, the bank is obliged to account for a fictitious depreciation of 20%.

used more intensively since 2016, when the central bank started issuing several tightening recommendations regarding LTV and DSTI limits.

Like Bulgaria and Croatia, *Estonia* tightened minimum capital and reserve requirements considerably in the late 1990s to improve the resilience of the banking sector in view of speculative attacks against the Estonian kroon in October 1997 and potential spillovers from the Russian financial crisis in 1998. In 2006, in light of very rapid credit growth, the central bank increased the minimum capital requirement further and for the first time raised the risk weights on housing loans (from 50% to 100%). The latter were loosened again considerably (to 35%) during the GFC. Before Estonia joined the euro area, minimum reserve requirements were relaxed significantly in 2010 (from 15%) to gradually approach the rate set by the ECB. Besides the activation of several capital buffers in 2014, borrower-based measures were tightened in 2015, when the LTV cap for new housing loans was decreased to 85% and a DSTI limit of 50% was introduced.

2.3 Czech Republic, Slovakia, Hungary, Lithuania and Latvia

The third group of countries shows a relatively stable overall macroprudential policy stance for a long period before considerably tightening MPPs in the wake of the GFC and especially in the past few years.

The *Czech Republic* left its MPP stance largely unchanged until it raised the minimum tier 1 capital ratio from 2% to 6% and activated various capital buffers in 2014, which it continued to tighten. Notably, the Czech Republic was among the first countries in the EU that applied a positive CCyB rate. In parallel, since 2015, liquidity requirements (i.e. floors for liquidity coverage ratios) and borrower-based measures were tightened gradually. To date, the Czech National Bank (CNB) only has a mandate to issue recommendations for borrower-based measures. It issued tightening recommendations in 2015 and 2016 for gradually reducing the LTV limit from 100% to 90%, and, in 2018, for reducing the maximum DSTI ratio. The pronounced tightening of the overall MPP stance in the Czech Republic in recent years was primarily motivated by an expansionary phase of the credit cycle since 2014 and very dynamic housing loan growth (CNB, 2019).

Slovakia followed a pattern very similar to that of the Czech Republic. Even though a formal LTV cap had already been in place since 1996, it was only applicable to a narrow definition of mortgage loans and could be bypassed by applying for other housing loans (Vandenbussche et al., 2015)¹⁵. In response to an increase in these other housing loans, a new package of LTV limits covering all collateralized mortgages was launched. The central bank, Národná banka Slovenska (NBS), recommended a further tightening in 2014, which became legally binding in 2016. Moreover, in 2014, the LTV threshold above which a risk weight of 100% applies was raised, which resulted in a loosening in this policy area. In light of rising property prices and household indebtedness, borrower-based measures were tightened again in 2018. Among other things, mortgages with an LTV ratio of more than 90% were prohibited and the share of new loans with an LTV ratio

¹⁵ Given that these circumvention possibilities are well documented, we depart from the usual *de jure* coding of macroprudential regulations and apply in this case a *de facto* approach and do not translate this measure into an explicit LTV cap for all collateralized house purchase loans. Instead, we record the measure in the residual group “LTV_other” (subject to a lower aggregation weight), where we capture the 2002 loosening of this narrow LTV cap to 70%, which remained binding until the end of 2017.

between 80% and 90% was restricted (NBS, 2018). Together with the activation and gradual increases of applicable capital buffers, this has substantially tightened the macroprudential environment until end-2018.

Hungary considerably tightened its macroprudential policy stance only after the GFC, having since then put a strong emphasis on borrower-based measures, above all to reduce the high share of FX borrowing. In 2010, Hungary introduced maximum LTV ratios on household mortgage lending (and car loans). Upper limits were set for real estate borrowing, namely 75% for loans denominated in forint (raised to 80% in 2012), 60% for loans in euro, and 45% for loans in other currencies. Maximum DSTI ratios for FX loans differentiated by currency were also set in 2010, and later in that year, FX mortgages were banned altogether. The ban was discontinued in 2015, which contributed to an easing of the macroprudential stance, while the LTV and DSTI limits were tightened further that year (DSTI limit again in 2018). Moreover, more stringent liquidity requirements and the activation and tightening of various buffer rates had a considerable macroprudential tightening impact since 2014.

Lithuania used a comparatively rich macroprudential toolkit. The net easing until mid-2011 was mainly due to reduced risk weights on mortgages (from 100% to 50% in 2001) and gradually relaxed minimum reserve requirements since 1997. By contrast, liquidity-based measures had a counterbalancing tightening impact. The net overall MPP tightening since 2011 was mainly driven by borrower-based measures and the activation of various capital buffers. For mortgage loans, the LTV cap was reduced from 100% to 85% and the DSTI limit from 60% to 40% in 2011.

Latvia is a special case since its overall macroprudential stance remained broadly unchanged during the whole observation period. Tightened minimum capital requirements, buffer requirements and borrower-based measures were outweighed by reduced risk weights and reserve requirements. When we focus only on “narrow” MPPs, there was some net tightening since 2014, which was mainly attributable to the implementation of capital buffers.

3 The impact of macroprudential tightening on macrofinancial variables

Studying the effectiveness of MPPs in dampening domestic financial cycles and/or in increasing financial sector resilience is a rapidly growing area of economic research. In this section, we use the MPPI to assess the impact that macroprudential policy measures had on credit growth and house prices in the CESEE EU countries.

According to several papers, tighter MPPs are associated with slower credit growth, especially if the focus is on household credit and on the impact of borrower-based measures (e.g. Akinci and Olmstead-Rumsey, 2018; Alam et al., 2019; Dumičić, 2018). Using a large panel for the period from 2001 to 2013, Cerutti et al. (2017a) find that, in general, borrower-based measures have a stronger effect on credit growth than other MPPs, in both advanced and emerging economies. Furthermore, their results suggest that while both household and corporate credit have a negative relationship with MPPs, the effect on corporate credit is weaker and often statistically insignificant. They argue that this is the case because MPPs are usually directed at financial institutions or households rather than corporations (while personal loans taken out by firm owners to finance their businesses could still be affected by borrower-based measures).

The empirical evidence regarding the impact of MPPs on house prices is less clear cut, though. Referring to a few of the related papers, Vandenbussche et al.

(2015) found that tighter capital-based MPPs and nonstandard liquidity measures (mostly minimum reserve requirements) have a dampening effect on house price inflation in CESEE. Akinci and Olmstead-Rumsey (2018) concluded that almost exclusively housing-related MPPs, particularly LTV and DSTI caps, constrain housing credit growth and house price appreciation, especially in countries where private sector financing via the banking sector plays an important role. Kuttner and Shim (2016) compared the effectiveness of MPPs with that of fiscal policy measures: while housing credit growth would be mitigated by both tighter borrower-based MPPs and an increase in housing-related taxes, the latter is the only policy tool with a discernible impact on house price appreciation. Finally, there could also be differences across different levels of economic development: Alam et al. (2019), for instance, identified a negative effect of MPPs on house prices only in the case of advanced economies.

3.1 Econometric specification

Following large parts of the literature (for a recent survey, see Galati and Moessner, 2018), we use, as baseline specification, panel regressions with country fixed effects (OLS-FE) to assess the impact of changes in the macroprudential environment on macrofinancial variables, notably house price growth and private sector credit growth (i.e. growth of credit to households and nonfinancial corporates). Our baseline model reads as follows:

$$y_{i,t} = \beta MPPI_{i,t-1} + \mathbf{X}_{i,t} \boldsymbol{\gamma} + \tau_i + \varepsilon_{i,t}, \quad (1)$$

where $y_{i,t}$ denotes the variable of interest, with the superscripts $i=1, \dots, N$ and $t=1, \dots, T$ representing a country and time period, respectively, and $MPPI_{i,t-1}$ denotes the lag of the included macroprudential policy index. $\mathbf{X}_{i,t}$ is the matrix of control variables, τ_i captures country fixed effects and $\varepsilon_{i,t}$ denotes a Gaussian distributed error term with heteroskedastic variance. We analyze short-term effects of changes in the macroprudential environment by including the index lagged by one quarter. To investigate the possibility of more persistent effects, we include, in an alternative specification, a simple moving average of the previous four quarters, similarly to Alam et al. (2019). We use the announcement dates for tightening and the implementation dates for loosening incidents. The matrix $\mathbf{X}_{i,t}$ contains country-specific information about lagged GDP growth and lending rates¹⁶ as well as a dummy for the GFC to control for possible crisis-driven variation. Similarly to Vandebussche et al. (2015) and Alam et al. (2019), we include all other subindices as additional regressors, when focusing on the effects of specific types of MPPs (e.g. borrower-based measures), to ensure that the detected effect of the investigated MPP instruments does not represent the effect of other, correlated MPPs (in econometric terms, this is referred to as an omitted variable bias).

¹⁶ Ideally, we should include a variable representing the price of a loan, i.e. (an average of) the interest rates charged for bank loans in a country. However, for confidentiality reasons, such data are not sufficiently accessible. Hence, we use a proxy, namely the lending rate obtained from the IMF's International Financial Statistics (IFS). It represents the rate of depository corporations usually meeting the short- and medium-term financing needs of the private sector. As a caveat, in this series, several observations would be missing due to definitional changes over time. Such gaps are filled by applying interpolation using the dynamics of long-term interest rates from the same data source.

To mitigate the problem of endogeneity (see Galati and Moessner, 2013), at least to some extent, we include lags of the policy measures and of the other covariates (except for the crisis dummy) instead of using contemporaneous data. Pre-estimation diagnostic tests also supported the inclusion of one lag of each regressor (based on the minimal Schwarz's Bayesian information criterion). Moreover, the dependent variables seemed to be stationary based on the panel unit root test by Pesaran (2007). We conducted robustness checks, including a larger number of control variables, such as inflation, equity prices or the real effective exchange rate, the results of which are available on request.

As pointed out in section 2, the intensity with which macroprudential policies have been used in the CESEE countries under investigation is very heterogeneous, a finding also supported by a pre-estimation panel test for slope homogeneity (Pesaran and Yamagata, 2008). To account for panel heterogeneity, we estimate two other models that allow for heterogeneous slope coefficients, namely the dynamic fixed effects model (DFE) and the mean group estimator model (MG; see Pesaran and Smith, 1995). However, as a caveat, these procedures are mostly applied for panels with large N and T . As our dataset consists of eleven countries, this may lead to results that are driven by outliers, especially for house price growth, where the time series is relatively short. Nonetheless, these additional estimation models are useful complements to our baseline OLS-FE specification. A detailed description of the definitions, data sources and data availability can be found in table A1 in the annex.

3.2 Results

Table 1 summarizes our estimation results. Considering first the impact of macroprudential policies on credit growth, we find that a macroprudential tightening is indeed associated with lower private sector credit growth, both in the short and in the medium run (indicated by the four-quarter moving averages of the respective policy variables). Strikingly, the magnitude of the negative effects increases, when we look at the narrow MPPI, i.e. N-MPPI, and the borrower-based subindex, or BB-MPPI; these two also yield statistically significant results for the baseline OLS-FE specification. The additional DFE and MG specifications confirm a negative sign across all indices. Statistically significant results can, however, only be found in the case of borrower-based measures.

The decline in total credit growth following a tightening of macroprudential policies appears to be primarily driven by a decrease in household credit growth. For this variable, the estimated coefficients are larger in magnitude and statistically significant across the MPPI, N-MPPI and BB-MPPI indices (in the baseline OLS-FE specification). Corporate credit growth also shows a negative relation but is seldom statistically significant. Borrower-based MPPs again seem to have the most significant effect in dampening both household and corporate credit growth.

For house price growth, all estimated coefficients are negative and largest in the case of the borrower-based subindex, for which they are also statistically significant. This provides further evidence for the effectiveness of such measures to dampen house price growth. However, the aforementioned rather short time series for house price growth renders the interpretation of these estimates somewhat less reliable than those for credit growth.

The general observation that the magnitude of coefficients increases for more narrowly defined MPP indices could imply that additional measures included in the

Table 1

Macprudential policy, credit growth and house prices – panel regression results

	MPPI			N-MPPI			BB-MPPI		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	OLS-FE	DFE	MG	OLS-FE	DFE	MG	OLS-FE	DFE	MG
Total nonbank private sector credit growth									
First lag of respective policy index	-0.563	-0.173	-0.987	-0.717*	-0.480	-0.562	-1.586***	-1.387***	-4.560**
Standard error	[0.337]	[0.445]	[0.783]	[0.384]	[0.484]	[0.723]	[0.445]	[0.508]	[2.180]
Moving average of previous four quarters	-0.544	-0.134	-0.944	-0.758*	-0.497	-0.356	-1.734***	-1.513***	-7.694**
Standard error	[0.365]	[0.492]	[0.942]	[0.403]	[0.515]	[0.842]	[0.441]	[0.509]	[3.545]
Number of observations	913	913	913	913	913	913	830	830	830
Household credit growth									
First lag of respective policy index	-1.290*	-0.426	-1.857	-1.217*	-0.546	-1.257	-2.521***	-1.948***	-4.526*
Standard error	[0.582]	[0.679]	[1.286]	[0.554]	[0.667]	[1.257]	[0.544]	[0.624]	[2.428]
Moving average of previous four quarters	-1.432*	-0.558	-2.998	-1.338*	-0.660	-1.999	-2.774***	-2.164***	-7.372*
Standard error	[0.710]	[0.788]	[2.131]	[0.623]	[0.722]	[1.834]	[0.561]	[0.617]	[3.867]
Number of observations	880	880	880	880	880	880	797	797	797
Nonbank corporate credit growth									
First lag of respective policy index	-0.358	-0.120	-0.775	-0.348	-0.202	-0.223	-0.897	-0.783	-2.990*
Standard error	[0.267]	[0.301]	[0.693]	[0.396]	[0.464]	[0.670]	[0.494]	[0.562]	[1.613]
Moving average of previous four quarters	-0.303	-0.043	-0.622	-0.353	-0.180	-0.040	-0.979*	-0.846	-6.358**
Standard error	[0.263]	[0.316]	[0.850]	[0.407]	[0.482]	[0.668]	[0.480]	[0.559]	[2.845]
Number of observations	880	880	880	880	880	880	797	797	797
Housing price growth									
First lag of respective policy index	-0.494	-0.457	-0.483	-0.341	-0.350	0.083	-0.945**	-1.000***	-0.713
Standard error	[0.376]	[0.365]	[0.638]	[0.340]	[0.401]	[0.462]	[0.306]	[0.317]	[0.780]
Moving average of previous four quarters	-0.497	-0.451	-0.468	-0.402	-0.403	0.341	-0.921***	-0.973**	-1.615
Standard error	[0.394]	[0.379]	[0.689]	[0.361]	[0.469]	[0.913]	[0.279]	[0.381]	[1.602]
Number of observations	504	504	504	504	504	504	452	452	452

Source: Authors' estimations.

Note: All models include one lag of GDP growth and the lending rate as additional covariates as well as an unlagged crisis dummy, all at quarterly frequency. Robust standard errors are in brackets below the coefficients. Models (1), (4) and (7) were estimated using OLS with heteroskedasticity-robust standard errors and include country fixed effects (OLS-FE); models (2), (5), (8) were estimated with dynamic fixed effects (DFE), and models (3), (6) and (9) with the mean group estimator (MG). For models (4)–(6), one lag of the index capturing minimum capital requirements and one lag of the index capturing minimum reserve requirements were added as additional controls. For models (7)–(9), additional regressors are the ones for models (4)–(6) as well as one lag of the subindex capturing capital-based MPPs (CB-MPPI) and of the subindex capturing liquidity-based MPPs (LB-MPPI). For models (7)–(9), Bulgaria was excluded due to lacking variation of instruments included in the BB-MPPI. F-tests for joint significance are all highly significant. Robustness checks were conducted with further covariates such as the consumer price inflation rate, equity price growth, and the real effective exchange rate. Results are available on request from the authors. Statistically significant results are given in bold; significance levels: *** –1%, ** –5%, * –10%.

extended MPPI are in fact diluting the impact of the more effective ones, such as borrower-based measures. This is confirmed when we run the same estimations for other MPPI subindices, namely the capital-based (CB-MPPI) and liquidity-based (LB-MPPI) ones. For the sake of brevity, we do not show the results here in detail. The estimated coefficients often exhibited a positive sign and were not statistically significant, except for some specifications looking at house price growth.

In general, the results of this empirical exercise are broadly in line with previous empirical work and suggest that tighter MPPs are associated with lower private sector credit growth. Furthermore, we can confirm key findings of Cerutti et al. (2017a), namely that borrower-based measures seem to be more effective than other MPPs in containing credit growth and that the effect is more pronounced for household than for corporate credit growth. For house price growth, we find that even though broader MPPs tend to have a negative relationship with house prices, again only borrower-based measures seem to have a statistically significant effect (which corroborates the findings of Akinici and Olmstead-Rumsey, 2018).

4 Summary and conclusions

Several countries in the CESEE region have used macroprudential policies for a much longer period than countries in western Europe. Hence, the CESEE region is very suitable for analyzing the effectiveness of macroprudential policies (MPPs). We contribute to this literature by constructing a novel macroprudential policy index that accounts for the intensity with which the eleven CESEE EU countries in our sample used MPP measures over the past two decades. For the CESEE aggregate, our analysis shows a gradual tightening of the overall macroprudential stance from the late 1990s up to the GFC, which mainly reflected the increased use of capital and liquidity requirements. Until 2010, the MPP intensity in the region remained broadly unchanged, but was tightened thereafter, in particular since 2014. Borrower-based measures contributed significantly to the tightening after 2010, whereas the introduction of capital buffers played a big role in the further tightening starting around 2014.

There are considerable heterogeneities across CESEE countries with respect to the composition of instruments and the timing of MPP instrument activation. We identified three clusters of countries. First, Bulgaria, Croatia and Romania implemented macroprudential policy already in the late 1990s or early 2000s and reinforced its use in the years before the GFC – mostly motivated by extraordinarily strong credit growth at the time. Second, Estonia, Poland and Slovenia also used MPP measures before the GFC but to a lesser extent than the first group of countries, and they partly applied a less differentiated instrument toolkit. Third, the Czech Republic, Hungary, Lithuania, Slovakia and partly Latvia initially made only limited use of MPP tools before considerably tightening their MPP stance just after the GFC and especially in the past few years.

Given that the recent MPP tightening in the region was driven more strongly by capital- than borrower-based measures and that it went along with widespread house price increases, the question arises whether there is room to optimize the choice of instruments. To assess the impact of macroprudential policy intensity on the key macrofinancial variables credit and house price growth, we use a set of panel regressions and find that the use of macroprudential policies is effective in lowering credit growth, both in the short and medium term. In line with previous research, we find that borrower-based measures, such as LTV and DSTI limits, tend to have a stronger and more significant impact than other MPP measures that also include capital- and liquidity-based instruments. Broadly confirming previous findings, we conclude that MPPs are more effective in containing household than corporate credit growth. In the same vein, borrower-based measures seem to be relatively more effective in dampening house price growth.

Further research is required to study more closely the role of different transmission channels to better understand the reasons for cross-country heterogeneity and to explore the effectiveness of different sets of macroprudential instruments and their possible interactions with other policy instruments (especially those of monetary policy). The index and its components presented in this paper could serve as an important contribution to the quickly evolving literature in this field of research.

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Annex

This table describes the variables used in the panel regressions, giving the main sources and information on data availability.

Table A1

Description and availability of variables used in the panel regressions

	Description	Main source(s)	Data availability
Total nonbank private sector credit growth	Domestic banks' claims on resident nonmonetary financial institutions, excluding the general government; HICP deflated, seasonally adjusted, in logarithms, year-on-year change	IMF-IFS	Q1 1998–Q4 2018
Household credit growth	Domestic banks' claims on resident household sector, HICP deflated, seasonally adjusted, in logarithms, year-on-year change	IMF-IFS	CZ: Q1 2003–Q4 2018 HU: Q1 2001–Q4 2018 LV: Q1 1999–Q4 2018 rest: Q1 1998–Q4 2018
Nonbank corporate credit growth	Domestic banks' claims on resident nonbank corporate sector, HICP deflated, seasonally adjusted, in logarithms, year-on-year change	IMF-IFS	CZ: Q1 2003–Q4 2018 HU: Q1 2001–Q4 2018 LV: Q1 1999–Q4 2018 rest: Q1 1998–Q4 2018
Housing price growth	House price index and value of housing transactions, 2015=100, no seasonal adjustment, year-on-year change	Eurostat	BG: Q1 2006–Q4 2018 CZ: Q1 2009–Q4 2018 EE: Q1 2006–Q4 2018 HR: Q1 2009–Q4 2018 HU: Q1 2008–Q4 2018 LT: Q1 2007–Q4 2018 LV: Q1 2007–Q4 2018 PL: Q1 2006–Q4 2018 RO: Q1 2010–Q4 2018 SI: Q1 2008–Q4 2018 SK: Q1 2007–Q4 2018
MPPI	Intensity-adjusted macroprudential policy index, no further transformations	authors' calculations	Q1 1997–Q4 2018
N-MPPI	Narrow intensity-adjusted macroprudential policy index, no further transformations	authors' calculations	Q1 1997–Q4 2018
BB-MPPI	Borrower-based intensity-adjusted macroprudential policy subindex, no further transformations	authors' calculations	Q1 1997–Q4 2018
GDP growth	GDP volume, 2005=100, seasonally adjusted, in logarithms, quarter-on-quarter change	IMF-IFS	Q2 1997–Q4 2018
Lending rate	Rate of depository corporations usually meeting the short- and medium-term financing needs of the private sector, no further transformation	IMF-IFS, national central banks	Q1 1997–Q4 2018

Source: Authors' compilation.

Note: This table presents the variables used in the various panel regressions, briefly describes the variables and their transformations, gives the main sources used to obtain the variables and states the periods for which they are available. Seasonal adjustment was based on the Census X12 method. There were a few cases of variables with missing observations, which we interpolated using the dynamics of closely related variables: i.e. we used the long-term interest rate from the IMF's International Financial Statistics (IMF-IFS) for gaps in the lending rate (several countries), domestic banks' loans from the IMF-IFS for gaps in the corresponding claims (Croatia and Estonia) and the CPI from the Vienna Institute for International Economic Studies (wiiw) for gaps in the HICP (Croatia, for the deflation of credit series).