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The impact of macroprudential policy
fragmentation on corporate lending –
evidence from a novel indicator

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Abstract

We construct a novel bank-level index that quantifies fragmentation in the capital buffer framework faced by euro area banks. Defined at quarterly frequency, it measures fragmentation by looking at the number of simultaneously active buffers, their geographical dispersion, and the frequency of buffer rate changes within the preceding year. The index is orthogonalised with respect to the level of capital requirements, bank size, and the financial cycle, thus controlling for these factors when measuring fragmentation as defined above. We then show that a one standard deviation increase in the index is associated with about 36 basis points higher capital headroom and around 50 basis points lower corporate lending growth within existing bank-firm relationships. We interpret these results as suggestive evidence that banks facing more fragmented buffer requirements retain extra capital and adjust lending more cautiously to account for higher uncertainty with respect to future adjustments in buffer requirements.

Keywords: credit supply, banking, financial regulation, capital buffers

JEL classification: E5, E51, G18, G21, G28

Non-technical summary

Since the global financial crisis, European authorities have built an increasingly rich toolkit of capital buffer requirements for banks, designed to make the financial system more resilient. The embedded flexibility allows policy makers to target specific risks with precision, but it also means that banks can face several buffers at once, often set by different authorities and revised at different points in time, resulting in a somewhat fragmented policy environment.

In this paper, we construct a novel bank-level indicator of policy fragmentation, capturing how many buffers a bank faces at the same time, how geographically dispersed these requirements are, and how frequently they change, while controlling for the level of capital requirements and other relevant factors. We then match this indicator with granular data from the European corporate credit register, to examine whether fragmentation of capital requirements affects how banks plan their capital and lend to businesses.

Our findings reveal that banks facing a more fragmented policy environment tend to have more capital headroom than their peers, consistent with these banks building an extra cushion as a precaution against added uncertainty. We further find that greater fragmentation is associated with weaker growth in lending to non-financial corporations, with this effect being most pronounced for banks having little spare capital above their requirements, as these banks are more at risk of falling short of future requirements.

Overall, our findings suggest that the effects of macroprudential policy can be dependent on how these requirements are designed, combined, and adjusted over time. A framework that is overly fragmented in its design, frequently revised, or layered with a multitude of instruments may unintentionally restrain credit supply. At the same time, fragmentation also brings benefits, since it allows policy makers to tailor requirements more precisely to the risks they are trying to address. A fully-fledged welfare analysis would have to weigh these costs and benefits against each other and is beyond the scope of this paper. Nevertheless, this apparent trade-off should be considered as macroprudential frameworks continue to evolve.

1 Introduction

Macroprudential policy gained in prominence after the global financial crisis of 2008–09, with the aim to address systemic risks to financial stability ([Brunnermeier et al. 2009](#), [Hanson et al. 2011](#), [Kashyap et al. 2011](#)). Capital buffer requirements are among the key instruments in this respect, enhancing the banking system’s capacity to withstand systemic shocks while continuing to lend to the real sector ([Basel Committee on Banking Supervision 2021, 2022](#)). These buffers generally follow a risk-based approach, relating specific types of systemic risks with individual buffers that are then added up to form the combined buffer requirement. In Europe, this concept from the Basel standard has been further expanded with a range of flexible tools such as (sectoral) systemic risk buffers or macroprudential risk weight measures, with the primary responsibility for setting these tools being in the hands of national macroprudential authorities.¹ While the general design of the buffer framework, the institutional setup and the additional flexibility in Europe have contributed to a resilient financial system and increased authorities’ abilities to target specific sources of systemic risk, they also led to a somewhat fragmented environment for banks and investors, characterised by a multitude of instruments, heterogeneous activation criteria, and frequent adjustments over time.

In this paper, we examine how this fragmentation in euro area macroprudential policy affects banks’ capital planning and their corporate lending behaviour. While the implications of adjustments in the *level* of capital requirements for bank lending have been extensively studied (see, amongst others, [Aiyar et al. 2014b](#), [Behn et al. 2016](#), [Imbierowicz et al. 2018](#), [Gropp et al. 2019](#), [Fraissee et al. 2020](#), [Auer et al. 2022](#), [Couaillier et al. 2025](#)), much less is known about the impact of the *composition* of capital

¹Capital buffer requirements sit on top of minimum capital requirements (Pillar 1 and Pillar 2) and comprise the capital conservation buffer, the countercyclical capital buffer, the buffers for systemically important banks (global and other systemically important institutions), all derived from the Basel standards, and the European (sectoral) systemic risk buffer. In addition, European authorities can adjust risk weights for specific types of exposures. For an overview of the capital stack in the euro area, see Annex D. National authorities are primarily responsible for setting the capital tools enshrined in European legislation, while the ECB has the power to apply more stringent measures than those set nationally (“top-up power”).

requirements. On the one hand, a richer and more granular toolkit may allow authorities to better tailor requirements to the identified risks, bringing benefits in terms of risk coverage and mitigating the potential for policy spillovers or unintended side effects. On the other hand, a more fragmented application of tools can raise uncertainty about the conduct and predictability of macroprudential policy. This, in turn, may complicate banks' capital planning and ultimately also affect their lending behaviour. Against this background, whether, and to what extent, a more fragmented application of regulatory capital buffer requirements ultimately affects bank lending behaviour remains an open question requiring further investigation. To the best of our knowledge, this is the first paper that explicitly examines this question.

Importantly, our paper does not take a stance on whether fragmentation in macroprudential policy is warranted or unwarranted from a welfare perspective. As noted above, fragmentation certainly brings benefits, as it allows authorities to tailor their policies to the prevailing risk situation in their respective countries. For a fully-fledged welfare analysis, such benefits of fragmentation would have to be weighted against possible costs, which is beyond the scope of this paper. Instead, we take the perspective of the bank and contribute to the debate in two main ways: First, we construct a novel macroprudential policy fragmentation index for euro area banks – the first of its kind – and make it available to the public. Second, we use the index to examine whether policy fragmentation exerts a measurable and statistically significant impact on banks' capital planning and their lending behaviour.

Going beyond previous measures, our policy fragmentation index reflects not only the number of active tools for each bank (*breadth*), but also their geographical fragmentation (*dispersion*) and the frequency of regulatory changes (*churn*).² Importantly, the index is

²Existing policy indices such as the ones in [Cerutti et al. \(2017\)](#) and [Budnik and Kleibl \(2018\)](#) typically focus on the stringency of macroprudential policy by counting active tools at country level, effectively treating the combined buffer requirement (CBR) as a single scalar. [Weigert et al. \(2015\)](#) and related analyses have identified the practical shortcomings of decentralised macroprudential policy – limited coherence, reduced transparency, and discretionary deployment across member states – yet lacked a quantitative institution-level measure of the resulting fragmentation. Thus, our paper bridges these different strands of the literature.

orthogonalised with respect to the level of capital requirements, the size of the bank, and the state of the financial cycle, thus isolating a source of policy fragmentation that cannot be attributed to preferences for policy stringency, structural bank characteristics, or the state of the economy. Moreover, it is institution-specific and time-varying, thus creating a precise measure of exposure to policy fragmentation at the level of the individual bank.³

We then proceed by matching the bank-level policy fragmentation index with granular loan-level data from the European corporate credit register (AnaCredit). Our empirical strategy consists of assessing whether changes in the exposure to policy fragmentation of different banks affects their lending decisions for loans to the same firm in the same period. In this assessment, we control for credit demand and other time-varying firm-specific factors, following the identification approach pioneered by [Khwaja and Mian \(2008\)](#) and further extended by [Jiménez et al. \(2014\)](#). This allows us to isolate supply-side effects arising from differences in banks' exposure to policy fragmentation from other factors affecting bank lending. To further strengthen the identification strategy, we also control for a range of bank- and loan-specific variables that may have an impact on lending.

Our analysis yields two main findings. First, we show that banks exposed to a more fragmented macroprudential environment maintain significantly more capital headroom above regulatory requirements. Depending on the specification, a one-standard-deviation increase in the fragmentation index is associated with 26 to 36 basis points of additional capital headroom. This pattern is consistent with precautionary capital retention: in a more uncertain policy environment, banks self insure by maintaining a larger cushion

³We focus on the period after the pandemic, which further limits potential concerns about endogeneity between bank lending and macroprudential policy decisions (and hence their fragmentation). During this period, macroprudential authorities increasingly switched to an approach whereby capital buffers are activated early in the financial cycle (e.g., [European Central Bank and European Systemic Risk Board \(2025\)](#)). This contrasts with previous approaches under which the countercyclical capital buffer was calibrated based on indicators of excessive credit growth ([Drehmann et al. 2011](#), [Lang et al. 2019](#)), which could raise concerns about reverse causality in analyses on the relation between buffer requirements and loan growth. This link was considerably weakened with the widespread adoption of early activation approaches.

on top of regulatory requirements. Second, we find that increases in macroprudential policy fragmentation lead to an economically and statistically significant contraction in bank lending to non-financial corporations. Specifically, a one-standard-deviation increase in the fragmentation index reduces loan growth by about 0.5 to 0.9 percentage points. The effect is most pronounced for banks with little capital headroom. This is intuitive since such banks are more at risk of breaching their regulatory requirements, so that uncertainty about the level of these requirements matters more for them. Importantly, the results are robust to a range of alternative fixed-effects specifications and orthogonalisation procedures for the policy index.

Our paper contributes to a growing empirical literature on the effects of capital-based macroprudential policy on bank lending (for recent surveys, see [Galati and Moessner 2018](#), [Biljanovska et al. 2023](#), or [Škrinjarić 2025](#)). Existing studies mostly examined how the level of requirements or changes in requirements affect bank lending and range from broad-based studies considering aggregate variables (e.g., [Claessens et al. 2013](#), [Vandenbussche et al. 2015](#), [Cerutti et al. 2017](#), [Bergant and Forbes 2021](#)) to papers using more granular data at the bank- and/or loan-level. Within the latter category, studies have examined the effects of increases (e.g., [Basten 2020](#), [Behn and Schramm 2021](#), [Auer et al. 2022](#), [Cappelletti et al. 2022](#), [Degryse et al. 2023](#), [Cabrera et al. 2025](#)) or releases in capital buffer requirements (e.g., [Mathur et al. 2023](#), [Bedayo and Galán 2024](#), [Couaillier et al. 2025](#)), and also considered possible leakage or spillovers of macroprudential policies (e.g., [Aiyar et al. 2014a,b](#), [Reinhardt and Sowerbutts 2015](#)). In contrast to all these papers, we focus on the composition capital requirements, while explicitly controlling for the level of the latter. In doing so, we demonstrate that uncertainty about the future course of action, measured via our policy fragmentation index, exerts an economically and statistically impact on capital planning and bank lending, particularly for banks with low capital headroom.⁴

The remainder of the paper is organised as follows: Section 2 introduces the data

⁴The latter is consistent with findings by [Lang and Menno \(2023\)](#), [Behn et al. \(2024, 2025\)](#), showing that also the impact of changes in capital requirements strongly depends on capital headroom.

set, while Section 3 explains the construction of the policy fragmentation index and its key components. Section 4 lays out the estimation strategy, while Section 5 includes the main results. Further robustness checks are provided in Section 6, before Section 7 concludes.

2 Data

We construct a comprehensive dataset by combining multiple proprietary and public data sources to measure macroprudential policy fragmentation. The sample period used for the construction of the index ranges from Q1-2015 to Q4-2024, while for the empirical analysis we focus on observations from Q1-2021 onward, covering 1,411 institutions operating in the European banking union. Bank-level information is gathered with a quarterly frequency and matched with granular firm-bank relationship data on loan characteristics.

Our analysis relies on four main data sources: the pan-European credit register (AnaCredit), ECB Supervisory Data, notifications of capital-based measures from National Authorities, and publicly available databases on macroprudential policy measures.

AnaCredit. We use loan-level data from AnaCredit, the pan-European credit register, which contains information on all credit instruments pertaining exposures to euro area firms that are larger than €25,000. AnaCredit is collected by the ECB from the National Central Banks of the Eurosystem in a harmonised manner to ensure consistency across euro area countries. For each loan, we observe the lender via a bank identifier and information about the borrower, including a firm identifier, the country location, the postal code and the NACE code. We retrieve the outstanding loan balances, their average interest rate, maturity, impairment and collateral ratios. We retain only instruments that link a single creditor to a single debtor, excluding also reverse repos, deposits other than repos, and technical null instrument categories. We further restrict the sample to observations with strictly positive, non-missing outstanding nominal amounts and agreed annualized interest rates. For each instrument, exposure is defined as the sum

of the outstanding nominal amount and any non-missing off-balance-sheet credit commitment amount. We then collapse the data to the firm-bank-quarter level, summing exposures, impairment measures, protection values, and commitment amounts across all instruments within a given relationship. Interest rates, interest-rate type, and original maturity are aggregated as exposure-weighted averages, where the denominator only includes instruments with non-missing values for the corresponding variable.

ECB Supervisory Data. Bank balance sheet and income statement information as well as regulatory capital requirements are collected from the ECB Supervisory Data submitted by supervised banks according to the Common Reporting (COREP) and Financial Reporting (FINREP) frameworks.⁵ The supervisory data includes detailed information on banks' exposures relevant for the calculation of capital buffers, including sectoral and geographical breakdowns of risk-weighted assets. In addition, we extract key bank-level covariates, including the Total SREP Capital Requirements ratio (TSCR), the logarithm of total assets, the cash-to-asset ratio, the return on assets, the non-performing loans ratio, the deposit-to-asset ratio, the ratio of loan-loss provisions to total assets, and the risk weight density.

National Competent Authorities notifications. Data on capital buffers applied to individual institutions are obtained from notifications made by National Designated Authorities (NDAs) to the ECB. These notifications provide information on institution-specific buffer requirements, including on the countercyclical capital buffer (CCyB), the systemic risk buffer (SyRB), and buffers for systemically important institutions (O-SII and G-SII buffers). The notifications include both the announcement and implementation dates of buffer changes, allowing us to track the evolution of regulatory buffers over time.

BIS and ESRB macroprudential databases. To capture the full scope of banks' buffer exposures, we complement the supervisory data with publicly available infor-

⁵COREP is the standardised reporting framework established by the European Banking Authority to comply with the Capital Requirements Directive. It covers credit risk, market risk, operational risk, own funds and capital adequacy ratios. FINREP encompasses balance sheets, income statements, disclosures of financial assets and liabilities, off-balance sheet activities and non-financial instrument disclosures.

mation on macroprudential policy measures. Data on CCyB rates set worldwide are obtained from the Bank for International Settlements (BIS).⁶ For the reciprocation of the SyRB across jurisdictions, we use data from the European Systemic Risk Board (ESRB).⁷ These data are crucial for computing the institution-specific buffer rates, given that banks must apply buffers based on the geographical location of their exposures.

To ensure data accuracy and consistency, we perform standard data cleaning processes. Bank-specific variables are winsorised at the 1% and 99% levels to reduce the influence of extreme outliers. To avoid double-counting of exposures, balance sheet data are taken at the highest level of consolidation for the euro area, which is either the solo, sub-consolidated or fully consolidated level, depending on the organisational structure of the respective bank. Descriptive statistics for all our variables are reported in Table 1, while a detailed definition of the variables is provided in Appendix Table A1.

3 The Macroprudential Fragmentation Index

We introduce a novel bank-level indicator, the Macroprudential Fragmentation Index (MFI), designed to capture fragmentation in the application of macroprudential capital buffer requirements in the European Banking Union. Specifically, the index aggregates information on the number of distinct instruments simultaneously applied to a bank (*Breadth*), their frequency of adjustment over time (*Churn*), and the extent to which applicable buffer requirements differ across jurisdictions in which the bank operates (*Dispersion*). It is orthogonalised with respect to the level of capital requirements, the size of the bank, and the state of the financial cycle. Thus, it identifies fragmentation going beyond the one that can be attributed to these explanatory factors for variation in buffer requirements.

⁶The data are accessible at <https://www.bis.org/bcbs/ccyb/ccyb.xlsx>

⁷The data are accessible at https://www.esrb.europa.eu/national_policy/shared/pdf/esrb.measures_overview_macroprudential_measures.xlsx

3.1 Index Components

The index is granular and time-varying, computed at the bank level for each quarter. It aggregates information from three distinct sub-indicators.

3.1.1 Breadth

The first dimension, *Breadth*, is defined as the total number of distinct macroprudential capital buffers with a positive rate that are applied to a bank in a given quarter.⁸ Specifically, it counts applications of the following tools: the Countercyclical Capital Buffer (CCyB), the broad or sectoral Systemic Risk Buffer (s/SyRB), the Other Systemically Important Institutions (O-SII) Buffer, and the Global Systemically Important Institutions (G-SII) Buffer.⁹

Conceptually, *Breadth* captures the plurality of different instruments faced by the same institution. A higher count indicates a more multi-layered macroprudential environment. Each of the buffers is characterised by different calibration practices, activation triggers, release conditions, and cross-border reciprocity rules. Moreover, the combination of instruments differs across banks, depending on their size, the jurisdictions in which they operate, and the discretionary decisions of macroprudential authorities. This can create challenges in terms of transparency and impose monitoring costs on banks and investors, thus complicating banks' capital planning. Overall, the multitude of applicable buffers constitutes a meaningful source of fragmentation, varying at the bank level and entering our index accordingly.

The cross-sectional distribution of *Breadth* is shown in Figure 1a, Panel A, and varies across bank-quarter observations. For approximately 83 percent of the bank-quarters in our sample the count of buffers is equal to zero, meaning that banks are not subjected to any macroprudential capital buffer requirements beyond the Capital Conservation

⁸This index component expands on previous measures – such as those proposed by Budnik and Kleibl (2018) or Cerutti et al. (2017) – which capture policy *stringency* by counting active tools at the country level. The *stringency* element of the index component (as opposed to its *fragmentation* element) is controlled for via the orthogonalisation (see Section 3.3).

⁹We do not include the Capital Conservation Buffer (CCoB) in the count of measures, as it is a fixed buffer requirement that applies in an equal manner to all banks within our sample.

Buffer (CCoB) in these quarters. About 9 percent of bank-quarters exhibit a count of one additional capital buffer requirement, while the count is equal to two or three for approximately 8 percent of the observations. As shown in Figure 1b, the distribution of the variable is uneven over time. Specifically, for the average bank the number of applicable buffer requirements tends to increase over time, in particular since 2023. This reflects a shift in macroprudential policy making since the pandemic, as more countries have started to activate releasable capital buffer requirements such as the CCyB or the (s)SyRB, thus following up on one of the key lessons learnt from the pandemic (see, e.g., Behn et al. 2023).

Taken together, these patterns illustrate two salient features. First, macroprudential *Breadth* is particularly relevant for a small group of large international banks that operate in several countries and are subjected to a multitude of different instruments, also on account of their size. Second, *Breadth* has generally increased over time, as more countries have activated additional tools since the pandemic. As these are generally applied to the whole population of banks within a jurisdiction, the share of banks with at least one additional buffer requirement beyond the CCoB has increased markedly.

[Insert Figures 1a and 1b]

3.1.2 Churn

The second dimension, *Churn*, captures the frequency of adjustments in macroprudential capital buffer requirements. For each bank i and quarter t , it is defined as the number of upward adjustments in the rates of the CCyB, the (s)SyRB, the O-SII buffer, and the G-SII buffer over a rolling window of four quarters, ranging from quarter $t - 3$ to quarter t .¹⁰

Conceptually, *Churn* captures volatility in the setting of macroprudential buffer re-

¹⁰The measure counts the number of individual buffer rate increases, meaning that a simultaneous increase of two different buffer rates in the same quarter would be counted as two rather than one increase. For country-level buffers such as the CCyB or the (s)SyRB, it counts the number of changes of the buffer rate in the bank's home country over the rolling four-quarter window.

quirements. More frequent adjustment may create uncertainty with respect to future requirements, increasing monitoring cost and potentially complicating banks' capital planning. It may also induce banks to act in a more conservative manner and keep extra capital buffers on top of their regulatory requirements, to account for the possibility of future increases in buffer rates. Thus, *Churn* captures fragmentation in buffer rates over time and, in this way, complements the more structural dimension of *Breadth*.

As shown in Figure 2a, macroprudential buffer requirements tend to be overall relatively stable, with around 93 percent of the bank-quarter observations exhibiting no change in buffer requirements over the past four quarters. Still, for 7 percent of the observations there was at least one change, for 0.5 percent of the observations there were at least two changes, and there are even observations with three or four changes in buffer rates for the same bank within a single calendar year. Thus, also the *Churn* variable exhibits some variation across banks and also over time (Figure 2b).

[Insert Figures 2a and 2b]

3.1.3 Dispersion

The third dimension, *Dispersion*, captures the geographical fragmentation of banks' regulatory capital buffer requirements, which may also have an impact on monitoring costs and capital planning. Specifically, for exposure-based measures such as the CCyB and the (s)SyRB, banks with cross-border operations are subject to buffer rates set by multiple national authorities.¹¹ Depending on the distribution of their exposures, this implies that the actions of several different authorities can have a substantial impact on banks' capital requirements. For example, banks that are equally active in several countries will have to follow the actions of several macroprudential authorities, whereas banks active in only one country can focus on the actions of the single authority in that country. Dispersion captures this form of fragmentation by measuring the extent

¹¹Macroprudential buffers can generally be distinguished into (i) exposure-based measures, for which institution-specific rates are calculated as weighted averages of country-specific rates; and (ii) institution-specific measures for which the respective rates are directly set by the responsible authority. For this part of the analysis, we focus on exposure-based measures.

to which a bank's capital buffer requirements are determined by multiple jurisdictions rather than by a single national authority.¹²

Concretely, we measure *Dispersion* by means of an inverted Herfindahl–Hirschman Index (HHI) that is constructed in two steps. First, we calculate the share of bank i 's overall exposure-based buffer requirements that can be attributed to country c at time t as:

$$\kappa_{i,c,t} = \frac{CCyB_{c,t} \times exposure_{i,c,t}^{CCyB} + SyRB_{c,t} \times exposure_{i,c,t}^{SyRB}}{\sum_c \left(CCyB_{c,t} \times exposure_{i,c,t}^{CCyB} + SyRB_{c,t} \times exposure_{i,c,t}^{SyRB} \right)}, \quad (1)$$

where $CCyB_{c,t}$ and $SyRB_{c,t}$ are the applicable buffer rates in country c at time t , and $exposure_{i,c,t}^{buffer}$ is the bank's relevant risk-weighted exposure for either buffer. Second, we use these shares to calculate the *Dispersion* component of the fragmentation index as follows:

$$D_{i,t} = 1 - \sum_c (\kappa_{i,c,t})^2 \quad (2)$$

Intuitively speaking, the component indicates the extent to which a bank's overall exposure-based buffer requirement depends on the decisions of multiple authorities. A value of $D_{i,t}$ that is close to 1 indicates a high degree of geographical fragmentation, meaning that the overall buffer requirement depends on the decisions of many authorities in an equal manner, whereas a value of 0 implies that the requirement is driven entirely by a single authority.

The distribution of *Dispersion*, shown in Figure 3, indicates that geographical fragmentation is a salient feature of the macroprudential environment for most euro area banks. Nearly 92% of institutions exhibit a strictly positive level of Dispersion, implying

¹²Prior policy analyses, including Weigert et al. (2015), have highlighted a key limitation of the decentralised euro area macroprudential framework – namely, reduced coherence and transparency arising from a potentially heterogeneous application of capital buffer requirements. These assessments, however, are largely qualitative. The *Dispersion* component of the MFI provides a quantitative, bank-level measure of what practitioners commonly describe as the burden of operating under multiple jurisdictional regimes.

that their capital buffer requirements are determined by more than one macroprudential authority. The distribution is concentrated away from zero, suggesting that for many banks the regulatory requirement arises relatively evenly from several jurisdictions, thereby increasing monitoring and compliance cost.

[Insert Figure 3]

3.2 Aggregation of the Index Components

To aggregate the three components *Breadth*, *Churn*, and *Dispersion* into a single fragmentation index, we first standardise each of the components by computing their Z-scores:

$$Z(X_{b,t}) = \frac{X_{b,t} - \mu^x}{\sigma^x} \quad (3)$$

The standardisation places all components on a common scale and ensures that no single dimension mechanically dominates the index due to differences in units or dispersion. The aggregated fragmentation index ($MFI_{i,t}^{aggr}$) for bank i at quarter t is then calculated as the simple average of the three Z-scores:

$$MFI_{i,t}^{aggr} = \frac{1}{3} (Z(\text{Breadth}_{i,t}) + Z(\text{Churn}_{i,t}) + Z(\text{Dispersion}_{i,t})) \quad (4)$$

By construction, a higher MFI value corresponds to a more fragmented regulatory capital buffer regime for bank i at time t , characterised by a larger number of concurrently applied instruments, more frequent adjustments in buffer requirements in the recent past, and/or greater geographical dispersion in the composition of the capital buffer requirement. The choice of equal weighting scheme ensures transparency, communication ease, and tractability. Alternative weighting schemes are discussed in Appendix B.

Figure 4 plots the evolution of the MFI and the contributions of its standardised components over time. All three dimensions contribute to the marked increase of the raw fragmentation index observed in the post-pandemic period, albeit to varying degrees. *Breadth* rises as additional macroprudential tools are activated; *Dispersion* increases as

CCyB and (s)SyRB measures are applied across a broader set of jurisdictions; and *Churn* intensifies during the tightening wave, reflecting more frequent recalibrations of buffer rates.

[Insert Figure 4]

Figure 5 plots the evolution of the raw fragmentation index for the entire sample of banks and separately for the subset of Global Systemically Important Banks (G-SIBs). Two patterns stand out. First, G-SIBs exhibit substantially higher fragmentation throughout the entire sample period, consistent with their broader cross-border footprint and greater exposure to simultaneously active buffer requirements across multiple jurisdictions. Second, the gap between G-SIBs and the rest of the sample narrows markedly after 2022, as the post-pandemic tightening wave extended the activation of releasable buffers to a much wider set of institutions.

These patterns, however, also illustrate a challenge for any empirical assessment of the effects of fragmentation on lending. G-SIBs differ from other banks not only in their degree of fragmentation, but also in their size and other characteristics. Moreover, some of our index components are likely to be correlated with the overall stringency of capital requirements, or the phase of the financial cycle (e.g. because some buffers are activated in upswing phases of the financial cycle). A raw comparison of lending behaviour across banks with different levels of $MFI_{b,t}^{agg}$ would therefore risk conflating the effect of fragmentation with these confounding factors. Disentangling the two requires isolating the component of fragmentation that varies across banks independently of these characteristics, which motivates the construction of the orthogonalised measure described in the following section.

3.3 Orthogonalisation of the Index

While the MFI is designed to capture fragmentation in banks' macroprudential capital buffer requirements, it naturally co-moves with several other characteristics that may have an impact on bank lending, which poses identification challenges. Specifically, the

fragmentation index is likely to be positively correlated with the level of a bank's combined buffer requirement (CBR), the bank's size, and the state of the financial cycle.¹³ This is because a higher CBR typically implies that more macroprudential instruments are active, larger banks are subjected to additional requirements on account of their systemic importance and are more likely to be active in multiple jurisdictions, and buffer requirements like the CCyB are more likely to be activated during upswing periods of the financial cycle. At the same time, the level of the CBR, bank size and the state of the financial cycle may affect lending also via other channels than fragmentation, so that it is important to control for these variables when measuring the latter.¹⁴

To address this issue econometrically, we orthogonalise the index with respect to the three dimensions mentioned above, thus isolating a component of fragmentation that cannot be attributed to these dimensions. Specifically, we regress the MFI on these covariates in a simple linear model and we estimate it via OLS, obtaining:¹⁵

$$MFI_{i,t}^{aggr} = -1.675 + 0.542 \cdot CBR_{i,t} + 0.142 \cdot \ln(TA_{i,t}) + 0.159 \cdot CCI_t \quad (5)$$

(0.077) (0.012) (0.010) (0.015)

where i indexes banks and t quarters, $CBR_{i,t}$ is the bank's combined buffer requirement in per cent of risk-weighted assets, $\ln(TA_{i,t})$ is the natural logarithm of total assets as a parsimonious measure of bank size, and CCI_t is the ECB's country-level Common

¹³The CBR aggregates the bank's individual buffer requirements, including the CCoB, the CCyB, the (s)SyRB, and the higher of G-SII/O-SII buffers.

¹⁴There is a long literature looking at the relationship between the level of capital requirements and bank lending (e.g., [Aiyar et al. 2014b](#), [Behn et al. 2016](#), [Imbierowicz et al. 2018](#), [Gropp et al. 2019](#), [Fraisie et al. 2020](#), [Auer et al. 2022](#), [Couaillier et al. 2025](#)), or the relationship between bank size and bank lending (e.g., [Kishan and Opiela 2000](#), [Berger et al. 2005](#)). Moreover, tools like the CCyB have been explicitly designed to be activated during times of buoyant credit growth that tend to be associated with a build-up of systemic risk ([Drehmann et al. 2011](#)).

¹⁵Alternative orthogonalisation procedures are discussed in [Appendix C](#).

Composite Indicator (CCI) capturing the state of the financial cycle.¹⁶ Indeed, the coefficients on all three regressors are positive and highly statistically significant. Banks with higher CBRs, larger balance sheets, and operating in more exuberant phases of the financial cycle exhibit higher raw MFI scores. The adjusted R^2 of this regression is around 0.68, indicating that these three variables explain more than two thirds of the cross-sectional and time variation in our fragmentation index. We use the remaining third, captured in the residuals of the regression, to define the orthogonalised MFI that we then employ in the empirical analysis:

$$MFI_{i,t}^{orth} = \hat{\varepsilon}_{i,t} \quad (6)$$

By construction, $MFI_{i,t}^{orth}$ is uncorrelated with the level of the CBR, bank size, and the cyclical risk indicator, thus capturing variation in macroprudential policy fragmentation that cannot be attributed to these three dimensions. To illustrate the outcome of the orthogonalisation, Figure 6 plots the raw fragmentation index, $MFI_{i,t}^{agg}$, and its orthogonalised counterpart, $MFI_{i,t}^{orth}$, against the level of the combined buffer requirement. The left panel illustrates the clear positive correlation between the level of the CBR and the raw fragmentation index, which is then removed via the orthogonalisation as shown in the panel on the right. At the same time, there remains substantial variation in the orthogonalised index for any given level of the CBR, indicating that banks with similar overall capital buffer requirements can face markedly different degrees of macroprudential fragmentation. This residual heterogeneity is the variation that we exploit in the lending analysis below.

[Insert Figure 6]

The average $MFI_{b,t}^{orth}$ is shown in Figure 7, where we compare the evolution of the

¹⁶The ECB's CCI aggregates information from five core indicators (change in bank credit-to-GDP ratio, growth of real total credit, change in debt service ratio, change in RRE price-to-income ratio, current account balance as % of GDP) to arrive at a simple measure of cyclical systemic risk. It is similar to and follows the same methodology as the publicly available Systemic Risk Indicator (SRI), which additionally includes an equity price growth variable (see [Lang et al. 2019](#) for further details on the latter.)

raw fragmentation index with that of its orthogonalised counterpart. While the two indicators display a similar broad pattern over time, the increase in the orthogonalised measure is visibly more muted, especially during the post-pandemic tightening phase. This suggests that part of the rise in the MFI is associated with common factors related to the overall level of capital requirements, bank characteristics, and broader financial conditions, but also that a sizeable residual component of fragmentation remains.¹⁷

[Insert Figure 7]

Figure 8 displays the within-country distribution of $MFI_{i,t}^{orth}$ at the peak of the MFI (2023 Q3) and reveals two patterns that are relevant for the empirical analysis. First, within-country dispersion is considerable in most jurisdictions, confirming that banks operating under the same national authority can face markedly different degrees of residual fragmentation. Second, there is substantial heterogeneity in mean residual fragmentation across countries. Banks in Estonia, Ireland and Lithuania face systematically higher fragmentation than their observable characteristics would predict, while banks in Belgium, Italy, Spain and Portugal exhibit the opposite pattern. Because the index is orthogonalised with respect to the level of capital requirements, bank size and the financial cycle, this cross-country gradient reflects differences in the design and implementation of macroprudential policy that are not captured by the included controls. Importantly, the positive mean residuals observed for countries predominantly populated by comparatively small institutions (Estonia, Lithuania and Croatia) indicate that residual fragmentation is not simply a large-bank phenomenon, but also arises from other policy choices such as the number of tools or the frequency of adjustment. This within- and between-country variation forms the empirical basis for the identification strategy

¹⁷This distinction is important for the analysis that follows. The $MFI_{b,t}^{orth}$ captures the component of fragmentation that is not explained by the included controls at the bank-quarter and country-quarter level and therefore provides a cleaner measure of the independent fragmentation in the macroprudential environment faced by banks. Its continued co-movement with the raw index should not be interpreted as evidence against the orthogonalisation, but rather as a reflection of the fact that the residual remains one sizeable component of the underlying raw series. In this sense, the orthogonalised measure allows us to move from a descriptive indicator of fragmentation to a concept that is more suitable for identification.

in Section 4.

4 Estimation strategy

4.1 Bank-level analysis

To study whether macroprudential capital buffer fragmentation affects banks' capital planning, we estimate a bank-level panel regression with capital headroom as the dependent variable. Capital headroom is defined as the difference between the CET1 ratio and the sum of Pillar 2 Guidance and overall capital requirement (OCR), so that a higher value captures a larger management buffer above binding requirements and supervisory guidance (see Appendix D). We estimate the model on quarterly data from 2021Q1 to 2024Q4, when capital requirements had normalised after the pandemic interventions and cross-country variation in the macroprudential environment again became more informative. Specifically, the regression equation looks as follows:

$$\text{Headroom}_{i,t} = \beta \text{MFI}_{i,t-1}^{\text{orth}} + \mathbf{\Gamma}' \mathbf{X}_{i,t-1} + \mu_i + \lambda_c + \nu_t + \varepsilon_{i,t} \quad (7)$$

where i indexes banks and t quarters. $\text{Headroom}_{i,t}$ is the bank's capital headroom in percentage points, $\text{MFI}_{i,t-1}^{\text{orth}}$ is the orthogonalised Macroprudential Fragmentation Index lagged by one quarter, $\mathbf{X}_{i,t-1}$ is a vector of lagged bank controls, μ_i denotes bank effects, λ_c country, and ν_t quarter fixed effects. The set of control variables includes the level of the CBR, the natural logarithm of total assets, cash balances in percentage of total assets, the return on assets, the share of total assets financed by deposits, provisions over total assets, the ratio of non-performing loans to gross loans, and the average risk weight density.

We use three complementary estimators for equation 7: fixed effects (FE), correlated random effects (CRE), and random effects (RE). FE is more conservative because it differences out all time-invariant bank characteristics and identifies the coefficient only from within-bank changes over time. RE exploits both within-bank and between-bank

variation and is therefore more efficient if unobserved time-invariant bank heterogeneity is not correlated with the orthogonalised fragmentation measure. CRE provides an intermediate specification by augmenting the RE model with bank-specific means of the time-varying regressors, thereby allowing the unobserved bank effect to be correlated with the observables (see [Mundlak \(1978\)](#); [Wooldridge \(2019\)](#))

In our setting, FE is the natural preferred estimator because it is robust to time-invariant bank heterogeneity. At the same time, the comparison between RE, CRE and FE is itself informative. If the coefficient on $\text{MFI}_{i,t-1}^{\text{orth}}$ is robust across the three estimators, then the between-bank variation used by RE does not appear to introduce material bias relative to the within-bank estimate. More intuitively, bank-specific, time-invariant features are not confounding the coefficient on MFI^{orth} , reassuring us on the index plausibly reflecting policy fragmentation rather than a choice made by the bank itself.

4.2 Bank-firm level analysis

To assess how macroprudential fragmentation affects the supply of credit, we exploit quarterly bank-firm level data and estimates a panel regression. Following [Khawaja and Mian 2008](#), identification relies on firm $\times$ time fixed effects to purge the estimates from firm-specific credit demand shocks and isolate the impact of bank-side regulatory capital buffer fragmentation on lending. The main specification at the bank-firm level is:

$$\Delta \ln(\text{loans})_{i,j,t} = \beta \text{MFI}_{i,t-1}^{\text{orth}} + \mathbf{\Gamma}' \mathbf{X}_{i,t-1} + \mathbf{\Theta}' \mathbf{Z}_{i,j,t} + \alpha_{j,t} + \varepsilon_{i,j,t} \quad (8)$$

where $\Delta \ln(\text{loans})_{i,j,t}$ is the quarter-on-quarter change in the logarithm of total credit exposure from bank i to firm j at time t (the intensive margin). $\text{MFI}_{i,t-1}^{\text{orth}}$ is the orthogonalised fragmentation index for bank i , lagged by one quarter. $\mathbf{X}_{i,t-1}$ is a vector of lagged bank-level controls that includes the combined buffer requirement (CBR), the distance to the Pillar 2 Guidance (D2P2G), the Total SREP Capital Requirement (TSCR), the natural logarithm of total assets, the cash-to-asset ratio, the return on assets, the share

of deposits over total assets, the ratio of loan-loss provisions to total assets, the non-performing loans ratio, and the average risk-weighted assets density. $\mathbf{Z}_{i,j,t}$ is a vector of bank-firm level controls including the impairment ratio, the log maturity of the bank-firm relationship and the collateral-to-loan ratio. $\alpha_{j,t}$ are firm $\times$ time fixed effects, controlling for time-varying firm-specific factors such as variation in credit demand, while $\varepsilon_{i,j,t}$ is an idiosyncratic error term, with standard errors clustered at the bank level. The coefficient of interest, β , measures how a change in the bank-specific policy fragmentation index affects the credit that bank i extends to firm j , holding constant all firm-specific factors in that quarter.

The key identification devices are (i) the inclusion of firm $\times$ time fixed effects $\alpha_{j,t}$, and (ii) the choice of the sample period starting in Q1-2021. In relation to (i), the fixed effects absorb any factors that affect the credit demand of firm j in quarter t , including firm-level investment opportunities and cash-flow needs, changes in firm risk, creditworthiness or collateral, and macroeconomic or sectoral shocks that affect all banks lending to that firm. Focusing on firms borrowing from more than one bank, the firm $\times$ time fixed effect implies that the estimated coefficients are identified purely from within-firm variation, by comparing how different banks adjust their lending to the same firm in the same quarter. Demand shocks that are common across all banks lending to firm j at time t are fully captured by $\alpha_{j,t}$ and the remaining variation in the dependent variable across banks for that firm-time cell is attributed to differences in bank characteristics, including $\text{MFI}_{i,t-1}^{\text{orth}}$ and $\mathbf{X}_{i,t-1}$. Under the maintained assumption that firm demand for credit does not differentially favour specific banks within a quarter once $\alpha_{j,t}$ is controlled for, the coefficient β is identified as a credit supply effect of regulatory capital buffers fragmentation. In relation to (ii), the choice of the sample period further helps to limit concerns about reverse causality between bank-level lending and macroprudential capital buffer decisions, and thus their fragmentation. In this period, macroprudential authorities increasingly adopted an approach where buffer requirements were increased also absent signs of elevated cyclical risks or strong credit growth, early in the financial cycle (e.g., [European Central Bank and European Systemic Risk Board 2025](#)). This

timing choice weakens the direct feedback from contemporaneous lending conditions to buffer calibration, so that cross-sectional and time-series variation in our Macroprudential Fragmentation Index is less likely to reflect policy reacting to bank-specific lending shocks and can instead be used as an exogenous driver of credit supply in our regressions.

Because $\text{MFI}_{i,t-1}^{\text{orth}}$ is orthogonalised with respect to the CBR level, bank size and the financial cycle, the estimated coefficient β is not driven by the overall tightness of capital requirements, the structural size of the bank, or the phase of the financial cycle. Instead, β captures how residual macroprudential fragmentation at bank level, arising, for example, from the configuration, timing, and interaction of tools across jurisdictions, translates into differential lending behaviour to otherwise similar firms. A negative estimate of β implies that, for a given firm in a given quarter, banks facing higher unexplained fragmentation contract their lending more than banks facing lower unexplained fragmentation.

We progressively saturate the specification with additional fixed effects. Beyond the borrower $\times$ quarter fixed effects that are present in all columns, we add interest rate type controls or interest rate type $\times$ quarter fixed effects to account for systematic differences in lending behaviour across fixed-rate and variable-rate contracts. We then introduce bank fixed effects, which difference out time-invariant bank heterogeneity such as business model, ownership or structural risk profile. Bank headquarters country $\times$ quarter fixed effects additionally control for time-varying country-level shocks that may affect all banks headquartered in the same jurisdiction. Finally, bank $\times$ country fixed effects absorb all time-invariant bank-country pair heterogeneity. The progressive inclusion of these controls tests the robustness of the estimated coefficient β to increasingly demanding identification assumptions.

5 Results

5.1 Bank-level results: capital headroom

We begin by examining whether banks respond to macroprudential fragmentation by adjusting their voluntary capital buffers above regulatory requirements. Capital headroom is defined as Distance to Pillar 2 Guidance (D2P2G), that is, the difference between the bank's CET1 ratio and the sum of the Overall Capital Requirement (OCR) and the Pillar 2 Guidance (P2G). Table 2 reports the estimates. Columns 1–3 omit country and quarter fixed effects and serve as a specification benchmark. In that block, the CRE and FE estimates are identical by construction: without additional fixed effects, the Mundlak device absorbs all between-bank variation through the bank-level time averages, so the within-bank coefficient is mechanically reproduced under both estimators. The coefficient of 0.35 therefore reflects the raw within-bank correlation between fragmentation and headroom, but conflates it with country-level characteristics and common quarterly shocks that are not absorbed in those columns.

Once separate country and quarter fixed effects are added in columns 4–6, the coefficient falls to approximately 0.23–0.26 and remains statistically significant at conventional levels. The preferred fixed-effects estimate in column 6 implies that a one-standard-deviation increase in $\text{MFI}_{t-1}^{\text{orth}}$ is associated with roughly 26 basis points of additional capital headroom, which is also economically significant. Because the fragmentation measure is orthogonalised with respect to the combined buffer requirement, bank size, and the financial cycle, this result does not capture a mechanical link between the level of requirements and excess capital. Rather, it isolates the residual component of fragmentation that reflects the multitude, adjustment, and cross-jurisdictional interaction of macroprudential measures.

We interpret this as evidence of precautionary capital retention. In a more fragmented environment, banks face greater uncertainty about the future path of their bank-specific combined buffer requirement. A natural response is to retain a larger management buffer, reducing the probability that future policy changes require a costly

balance-sheet adjustment.

The near-equality of the RE and FE coefficients in columns 4 and 6 supports this interpretation and speaks to identification. It implies that the positive association is not affected by a cross-sectional selection bias in which structurally conservative banks both hold more headroom and happen to operate in more fragmented environments. The fixed-effects estimate shows that when the same bank's fragmentation exposure rises over time, its headroom also rises. The CRE estimate, obtained by augmenting the random-effects model with bank-level time averages of the regressors following [Mundlak \(1978\)](#) and [Wooldridge \(2019\)](#), confirms that the result is robust to allowing the unobserved bank effect to be correlated with the regressors; the RE and FE estimates are effectively capturing the same relationship, so unobserved time-invariant bank characteristics are not confounding the estimated effect of fragmentation on headroom.

This headroom result helps rationalise the lending estimates that follow. If fragmentation induces banks to preserve larger management buffers, a contraction in credit supply need not arise because current capital regulation is immediately binding. It can also arise because banks endogenously choose to protect capital space under a more uncertain and operationally more fragmented policy environment.

[Insert Table 2]

5.2 Bank-firm level results: intensive margin

We now turn to analysing how bank-firm lending relationships respond to increases in regulatory capital buffer fragmentation. Table 3 reports the baseline regression results for the intensive margin, measured as the quarter-on-quarter change in the logarithm of total credit exposure from bank i to firm j . All specifications include borrower $\times$ quarter fixed effects, thereby identifying changes in credit supply by banks facing different degrees of policy fragmentation while lending to the same firm in the same quarter.

Column 1 serves as a benchmark and omits the fragmentation index. In this specification, the level of the combined buffer requirement (CBR) is not significantly associated with lending growth, consistent with recent evidence on the limited average effects of

buffer levels on bank lending ([Lang and Menno 2023](#), [Behn et al. 2024, 2025](#)). Column 2 introduces the orthogonalised MFI and shows that higher fragmentation is associated with a statistically significant contraction in credit supply. The estimated coefficient is -0.879 (significant at the 1% level), implying that a one-standard-deviation increase in the fragmentation index reduces lending growth by approximately 0.9 percentage points. Column 3 replaces interest rate type controls with interest rate type $\times$ quarter fixed effects, yielding a slightly larger estimate of -0.961.

Columns 4-6 progressively tighten the specification by adding bank fixed effects, bank headquarter country $\times$ quarter fixed effects, and bank $\times$ country fixed effects. These additional controls absorb time-invariant bank heterogeneity and time-varying country-level shocks affecting all banks headquartered in the same jurisdiction. Across all three saturated specifications, the coefficient on the MFI is approximately -0.51 and remains significant at the 1% level. Quantitatively, a one-standard-deviation increase in fragmentation is associated with a reduction in lending growth of about half a percentage point.

The attenuation of the coefficient between columns 2-3 and columns 4-6 indicates that a portion of the cross-sectional variation in fragmentation co-moves with persistent bank characteristics. The within-bank estimate in columns 4-6, which identifies the effect from changes in fragmentation over time for the same bank, represents the more conservative and preferred estimate. Its stability across the three saturated specifications with bank FE only, with bank FE and country $\times$ quarter FE, and with bank $\times$ country FE, provides reassurance that the result is not sensitive to the particular way in which unobserved heterogeneity is controlled for.

Importantly, the level of the combined buffer requirement is not significantly associated with lending growth in any of the saturated specifications (columns 4-6), consistent with the view that conditional on the degree of fragmentation, marginal adjustments in buffer stringency do not materially affect bank lending behaviour.

[Insert Table 3]

5.3 Interaction between fragmentation and capital headroom

We now ask whether the effect of fragmentation on lending varies with banks' capital position. Table 4 interacts the MFI with the distance to the Pillar 2 Guidance (D2P2G), a measure of banks' capital headroom. The interaction between the MFI and D2P2G is positive and statistically significant, suggesting that the negative effect of fragmentation on lending is less pronounced for banks with more capital headroom. In our most demanding specification, a one-standard-deviation increase in MFI is still associated with a 0.668 percentage point decline in lending growth for a bank with a D2P2G of zero, while a one-percentage-point increase in D2P2G offsets part of this effect by 0.055 percentage points. This is consistent with the precautionary motive discussed above. A bank with ample headroom is more relaxed about future changes in requirements and can absorb an increase in fragmentation without adjusting its loan supply. The direct effect of the MFI remains negative and highly significant across all specifications. The result aligns with previous findings on the effect of changes in the level of capital requirements on lending, which has also been shown to be strongly dependent on capital headroom ([Lang and Menno 2023](#), [Behn et al. 2024](#), [2025](#)).

[Insert Table 4]

6 Robustness

We run a number of robustness checks. First, we check whether more statistically grounded weighting schemes yield a different MFI than the baseline that puts together breadth, churn and dispersion with equal weights. Weights derived from Principal Component Analysis and CRITIC methodologies do not materially affect the overall MFI. Additionally, we make sure that the baseline results are insensitive to the choice of orthogonalisation procedure: the coefficient on the fragmentation index lies in a narrow range across eight alternative residualisation specifications. Details and results of these checks are reported in appendices [B](#) and [C](#).

Finally, we address concerns that the fragmentation index captures variation in the monetary policy pass-through rather than a distinct macroprudential channel. We verify that the estimated macroprudential fragmentation effect does not reflect variation in monetary policy pass-through by augmenting the baseline specification with interactions between all bank-level controls, including MFI^{orth} , and changes in the deposit facility rate (ΔDFR). This interaction specification allows each bank characteristic to have a state-dependent effect conditional on monetary policy tightening, in a similar fashion as [Gómez et al. 2021](#) and [Behn et al. 2025](#)

Results are reported in Table 5. The direct effect of $\text{MFI}_{t-1}^{\text{orth}}$ on lending remains negative and statistically significant (approximately -0.71 in the preferred specification), unchanged from the baseline model. The interaction coefficient between $\text{MFI}_{t-1}^{\text{orth}}$ and ΔDFR is positive and significant, indicating that the negative impact of fragmentation on lending is less pronounced when monetary conditions are tighter.

[Insert Table 5]

7 Conclusion

This paper studies the fragmentation of the regulatory capital buffer framework, and whether it affects bank behaviour beyond the level of capital requirements. While the post-Global Financial Crisis macroprudential architecture has become increasingly sophisticated and differentiated, empirical work has so far focused almost exclusively on the stringency of individual instruments. We provide evidence that the configuration and dynamics of the framework in which these instruments are embedded matter in their own right.

To do so, we construct a novel bank-level Macroprudential Fragmentation Index (MFI) that captures three dimensions of fragmentation for the individual bank: the number of simultaneously applied capital buffers (*breadth*), the frequency of policy changes (*churn*), and the geographical fragmentation of buffer requirements across jurisdictions (*dispersion*). The index is institution-specific, time-varying, and orthogonal to capital

stringency, bank size, and the financial cycle, allowing us to isolate a distinct source of regulatory friction.

We document three main results. First, banks exposed to a more fragmented macroprudential environment exhibit significantly more capital headroom above regulatory requirements, consistent with precautionary capital retention under regulatory uncertainty. In our preferred specification, a one-standard-deviation increase in the fragmentation index is associated with approximately 36 basis points of additional capital headroom. Second, using granular loan-level data from AnaCredit and a borrower $\times$ time fixed-effects design, we show that increases in regulatory capital buffer fragmentation is associated with a contraction in corporate credit supply. A one-standard-deviation increase in fragmentation reduces lending growth by approximately half a percentage point in our most demanding specification. Third, the impact of fragmentation on lending is less pronounced for banks with more capital headroom, consistent with recent literature on state-dependent effects of capital regulation.

From a policy perspective, our results suggest that the effects of macroprudential policy can depend not only on how much capital banks are required to have, but also on how those requirements are designed, combined, and adjusted over time. A framework that is overly fragmented, frequently revised, or layered with a multitude of instruments may unintentionally restrain credit supply. This points to potential downsides of an overly fragmented framework. At the same time, fragmentation also brings benefits, as it allows policymakers to target specific risks with more precision. A fully-fledged welfare analysis would have to weigh these costs and benefits of fragmentation against each other and is beyond the scope of this paper. Nevertheless, as macroprudential frameworks continue to evolve, this apparent trade-off between precision in risk coverage and predictability in policy evolution will require explicit attention in the design of future reforms.

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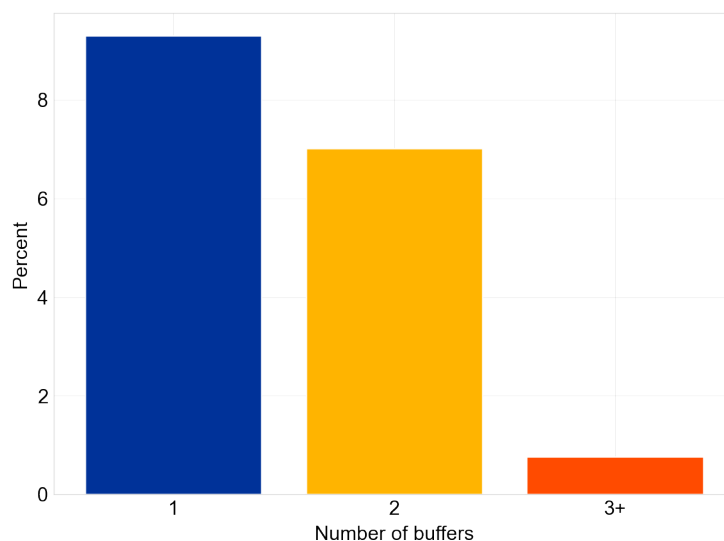
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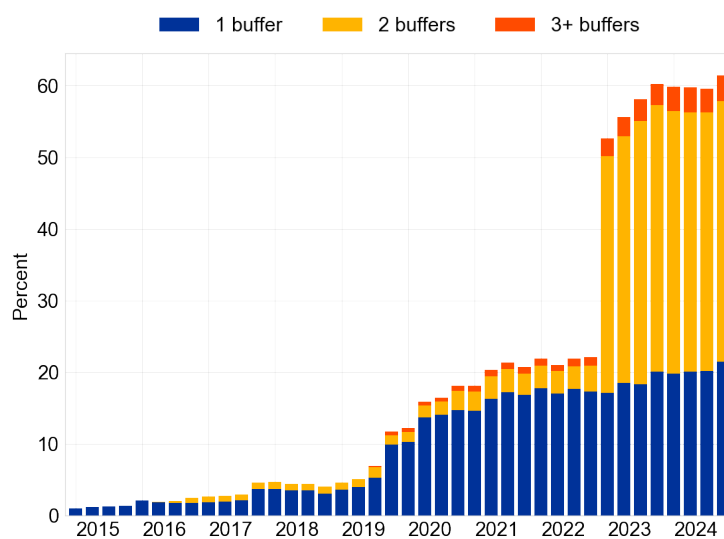
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8 Figures

Figure 1: Distribution and evolution of *Breadth*



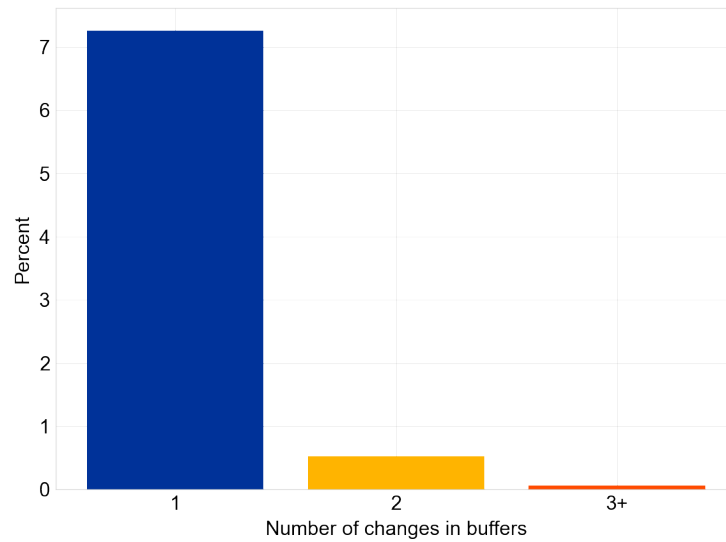
(a) Distribution of *Breadth*



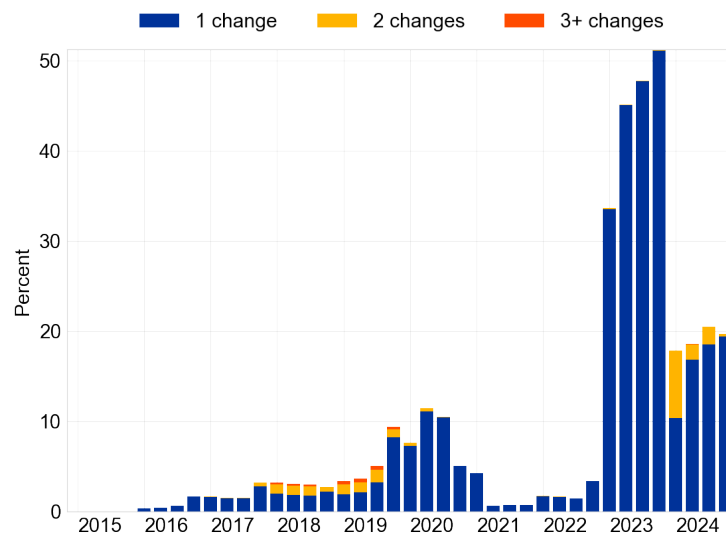
(b) Evolution of *Breadth*

Notes: *Breadth* is computed by counting, for each domain (country or bank), the number of positive-rate macroprudential capital buffers in force at the end of each quarter. The count is based on CCyB and (s)SyRB measures applying to all banks, and G-SII, O-SII and (s)SyRB measures that are institution-specific. For each buffer and domain, we first construct a quarterly time series of implemented values which we carry forward to the period of the next activation. Then we aggregate by quarter using a simple count of buffers with strictly positive values.

Figure 2: Distribution and evolution of *Churn*



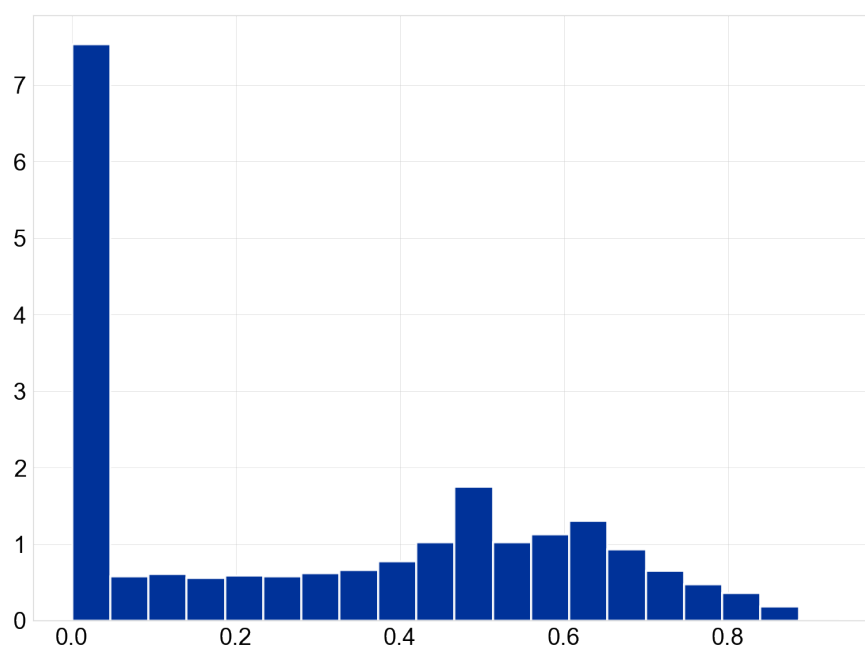
(a) Distribution of *Churn*



(b) Evolution of *Churn*

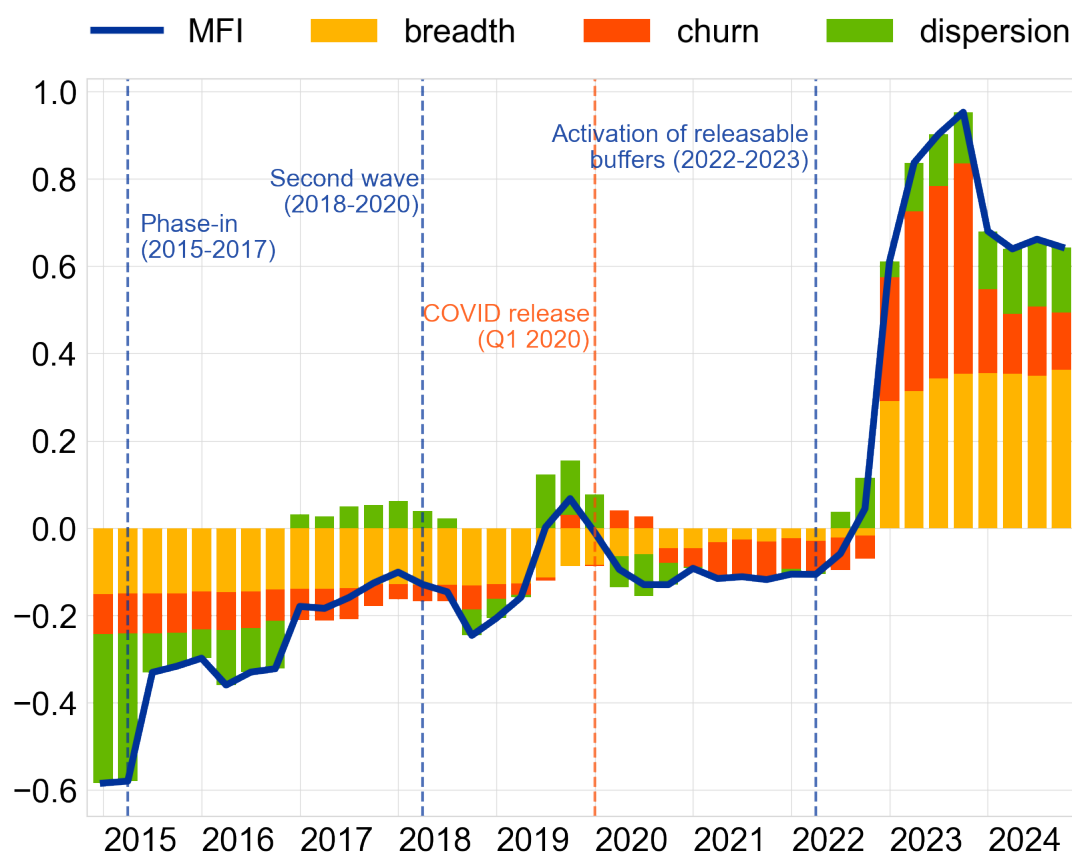
Notes: *Churn* captures the frequency of recent tightening actions in macroprudential capital buffers. For each domain (bank or country) and buffer (G-SII, O-SII, (s)SyRB, CCyB), we build a quarterly panel of buffer values and compute an indicator that takes value one whenever the buffer increases relative to the previous quarter. A rolling four-quarter sum of these indicators is then calculated within each domain–buffer pair and finally aggregated across buffers to obtain, for each domain and quarter, the total number of positive buffer changes experienced over the past year.

Figure 3: *Dispersion*: how much a bank’s capital stack is geographically fragmented



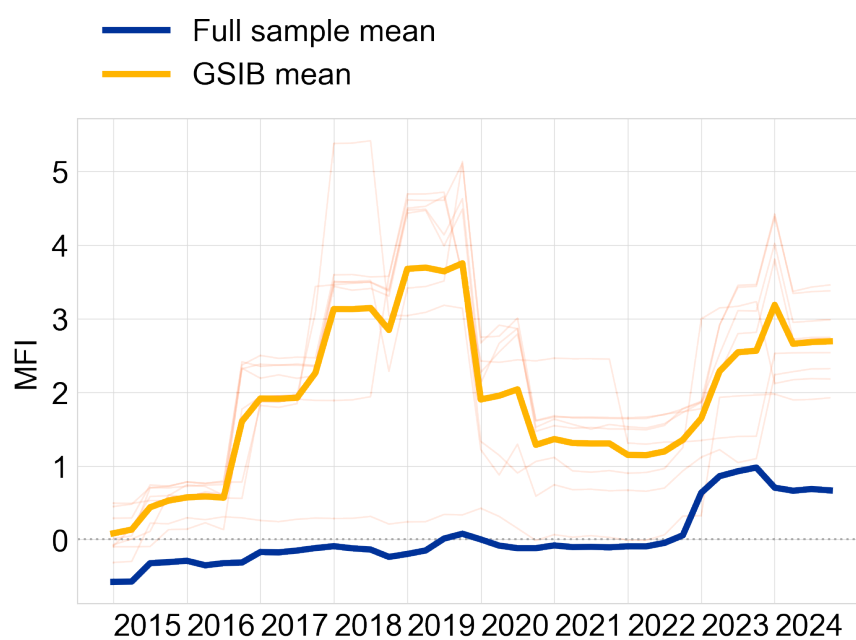
Notes: *Dispersion* is constructed as an inverted Herfindahl–Hirschman index capturing the geographical spread of macroprudential buffers across countries at the bank–quarter level. For the countercyclical capital buffer, we first aggregate IRB and standardised risk-weighted exposures by reporting country and bank and retain only country–bank–quarter cells with strictly positive exposures. These exposures are then merged with the time series of CCyB rates, filled to a quarterly frequency, and forward-filled within each bank–country pair so that the result reflects the applicable CCyB rate for each country in each reporting quarter. For each bank and quarter, we compute the buffer-weighted exposure share of country as in 1 and define the CCyB-based dispersion index as in 2. A value close to zero indicates that buffer-imposed risk-weighted exposures are concentrated in a single jurisdiction, whereas values closer to one indicate that the macroprudential burden is more evenly spread across several countries. For the systemic risk buffer, the dispersion measure is constructed analogously but focuses on the subset of country–bank–quarter observations where the geographical dispersion of the (s)SyRB is effectively relevant i.e. not applied to only domestic exposures. We then incorporate ESRB reciprocity decisions: a country is considered only if it both requested reciprocity and the measure is reciprocated; for other countries, or for domestic-only measures outside the reciprocity set, the complexity flag is set to zero. Hence, only exposures in countries where the (s)SyRB is both domestic and reciprocated enter the dispersion metric; for banks that are not affected by such measures, dispersion is zero. The overall dispersion variable used in the histogram is the sum of the CCyB- and (s)SyRB-based dispersion indices at the bank–quarter level. A large mass at low values indicates that many banks face geographically concentrated macroprudential burdens (for example, purely domestic buffers), while the right tail reflects institutions for which buffers are applied in multiple jurisdictions with comparable weight.

Figure 4: The Macroprudential Fragmentation Index: components and evolution



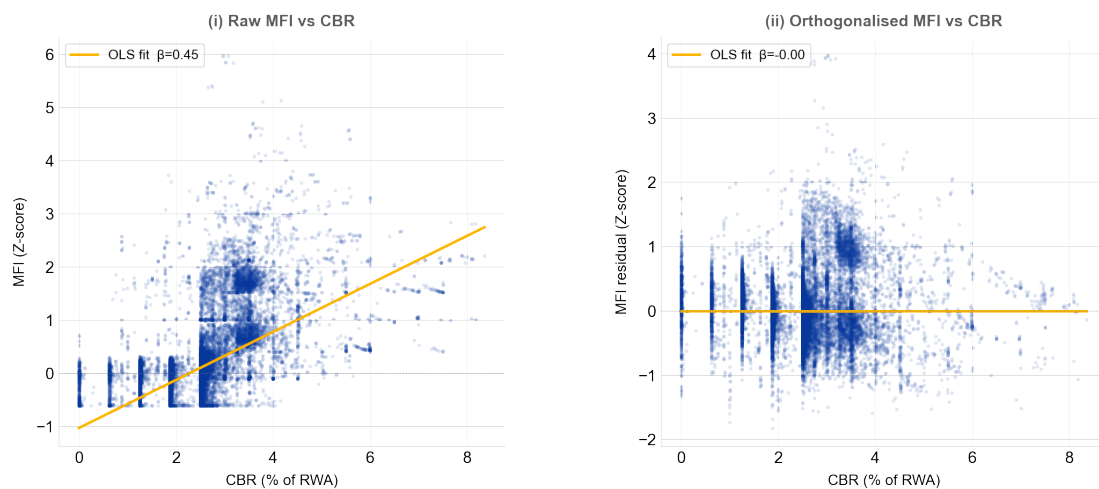
Notes: The stacked bars in the figure show the quarterly mean contributions of geographical dispersion (orange), breadth (blue) and churn (red) to the overall index. The dark blue line plots the quarterly average Macroprudential Policy Fragmentation Index (MFI). It is the sum of the three stacked components: geographical dispersion of buffer burdens (*Dispersion*), count of active tools (*Breadth*), and changes in policy (*Churn*). *Dispersion* is the sum of CCyB- and (s)SyRB-based inverted Herfindahl–Hirschman indices at the bank–quarter level, while *Breadth* counts the number of positive-rate macroprudential capital buffers (CCyB, (s)SyRB, O-SII, G-SII) applicable to each bank and *Churn* measures the rolling four-quarter number of positive buffer increases per bank. For each quarter, we first compute simple Z-scores of the three components across the full panel. The baseline bank-level MFI is then defined as the unweighted average of these Z-scores (see 4). Missing bank-specific Z-scores are set to zero to avoid spuriously excluding banks with incomplete histories. The light blue line is the orthogonalised MFI. It is obtained as a residual of the regression of the raw MFI on the level of the CBR, the log of total assets, the Common Composite Indicator (CCI) and bank fixed effects.

Figure 5: MFI and bank size for GSIBs



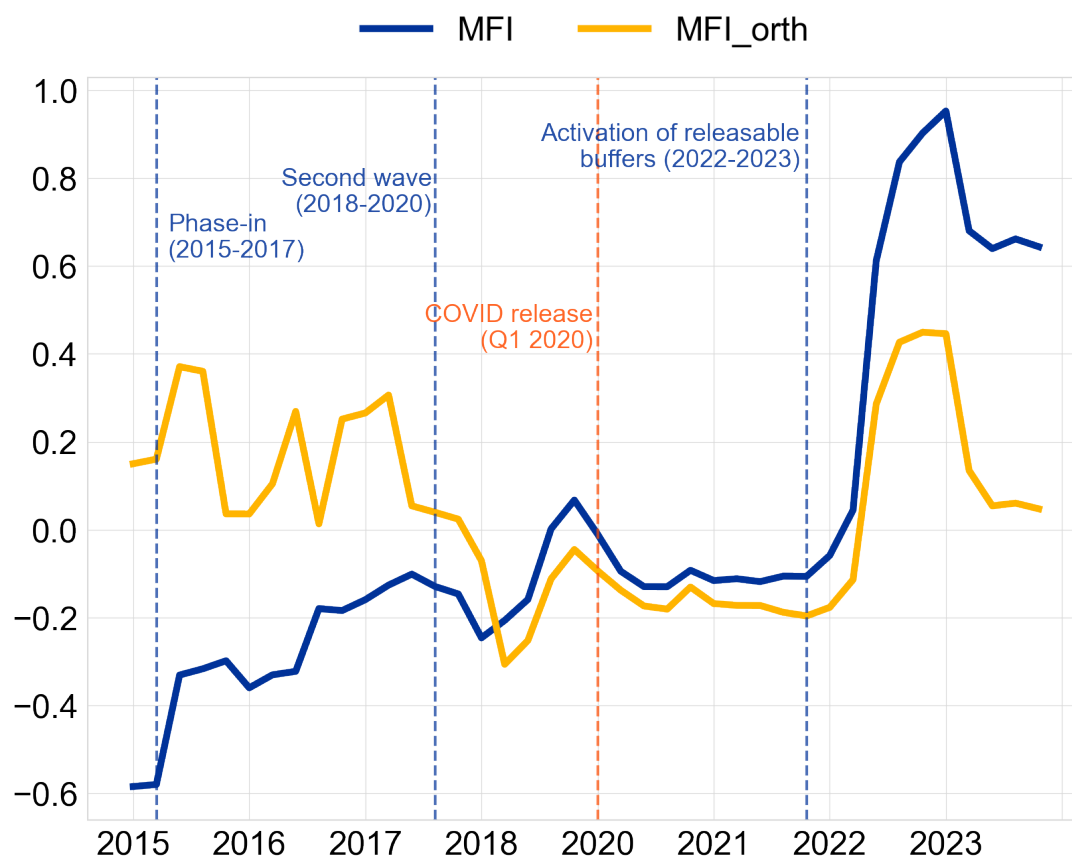
Notes: The blue line plots the cross-sectional mean of the raw $MFI_{i,t}^{agg}$ across all banks in the sample. The yellow line plots the mean across G-SIBs, and the orange lines show individual G-SIB trajectories.

Figure 6: Raw and orthogonalised MFI against the combined buffer requirement



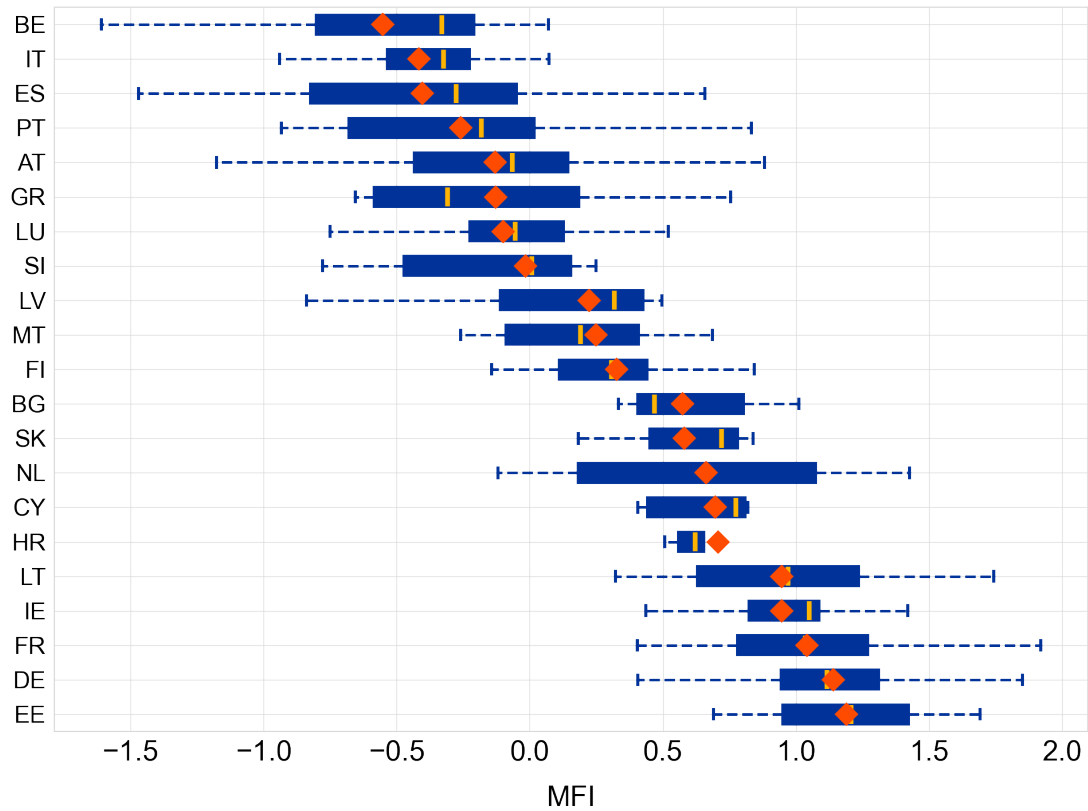
Notes: (Left) Each point represents a bank-quarter observation of the MFI at given levels of the CBR. The yellow line has the slope of the OLS coefficient of the orthogonalisation regression. (Right) Each point represents a bank-quarter value of MFI^{orth} at given levels of the CBR. MFI^{orth} is obtained as a residual of the regression of the raw MFI on the level of the CBR, the log of total assets, the Common Composite Indicator (CCI) and bank fixed effects. The yellow line has the slope of the OLS coefficient of the regression of the residual and the level of the CBR.

Figure 7: Raw and orthogonalised Macprudential Fragmentation Index



Notes: The yellow line is the orthogonalised MFI. It is obtained as a residual of the regression of the raw MFI on the level of the CBR, the log of total assets, the Common Composite Indicator (CCI) and quarter fixed effects. The dark blue line plots the quarterly average Macprudential Policy Fragmentation Index (MFI). It is the sum of the three stacked components: geographical dispersion of buffer burdens (*Dispersion*), count of active tools (*Breadth*), and changes in policy (*Churn*). *Dispersion* is the sum of CCyB- and (s)SyRB-based inverted Herfindahl–Hirschman indices at the bank–quarter level, while *Breadth* counts the number of positive-rate macroprudential capital buffers (CCyB, (s)SyRB, O-SII, G-SII) applicable to each bank and *Churn* measures the rolling four-quarter number of positive buffer increases per bank. For each quarter, we first compute simple Z-scores of the three components across the full panel. The baseline bank-level MFI is then defined as the unweighted average of these Z-scores (see 4). Missing bank-specific Z-scores are set to zero to avoid spuriously excluding banks with incomplete histories.

Figure 8: Within- and between-country variation of MFI^{orth}



Notes: The boxes span the interquartile range (IQR) across all banks in a country, the orange diamonds denote the mean, the yellow vertical lines the median, and the dashed whiskers extend to the approximately 5th-95th percentile range. The distribution refers to 2023 Q3, the peak of the MFI . Because the index is orthogonalised at the bank-quarter level, a country mean of zero indicates that, on average, banks in that country face no more or less fragmentation than predicted by their combined buffer requirement, size, and the state of the financial cycle. Countries are sorted by their mean $MFI_{i,t}^{orth}$. Positive mean residuals indicate that the national macroprudential framework generates a degree of fragmentation that is not explained by these observable characteristics, reflecting country-specific differences in the design and deployment of capital buffer requirements.

9 Tables

Table 1: **Descriptive Statistics**

This table reports descriptive statistics for the main variables used in our empirical analysis at the bank-firm (Panel A) and the bank level (Panel B). A detailed description of all variables is provided in Table A1.

Panel A: Bank-firm variables	N	Mean	SD	p1	p25	p50	p75	p99
$\Delta \ln(\text{loans})$	2,945,006	-4.577	27.331	-125.568	-8.026	-3.361	0.000	121.036
Impairment ratio	2,945,006	0.031	0.099	0.000	0.000	0.002	0.010	0.593
$\ln(\text{Maturity})$	2,945,006	7.655	0.744	5.030	7.455	7.682	7.980	9.302
Collateral ratio	2,945,006	1.707	1.967	0.000	0.800	1.000	1.868	12.803
Panel B: Bank-level variables								
MFI^{agg}	18,889	0.348	0.761	-0.614	-0.130	0.172	0.726	2.526
Breadth	18,889	0.710	0.901	0.000	0.000	0.000	1.000	3.000
Churn	18,889	0.145	0.370	0.000	0.000	0.000	0.000	1.000
Dispersion	18,889	0.379	0.276	0.000	0.118	0.388	0.609	0.876
MFI^{orth}	18,889	0.051	0.640	-0.789	-0.365	-0.039	0.293	1.997
Capital headroom (D2P2G)	18,889	8.942	9.597	0.904	4.134	6.262	9.802	63.099
CBR	18,889	2.910	0.597	2.500	2.503	2.544	3.293	5.078
$\ln(\text{TA})$	18,886	7.083	2.051	3.529	5.691	6.629	8.134	13.429
Cash/TA	18,884	11.276	14.308	0.353	1.222	6.325	14.976	71.810
ROA	18,844	0.557	1.045	-3.896	0.151	0.514	1.001	3.688
DEP/TA	18,883	81.437	15.693	4.634	81.757	86.899	89.273	93.646
Prov/TA	18,579	0.242	0.576	-1.140	-0.004	0.118	0.362	3.375
NPL ratio	18,830	3.246	5.618	0.004	0.919	1.838	3.204	37.963
RWA/TA	18,886	50.843	16.384	13.298	41.076	51.178	59.745	101.614

Table 2: **Capital headroom and macroprudential fragmentation**

This table reports bank-level panel regressions of capital headroom on the lagged orthogonalised Macroprudential Fragmentation Index (MFI_{t-1}^{orth}). Capital headroom is defined as the CET1 ratio minus the overall capital requirement (OCR), expressed in percentage points. Columns (1)–(3) exclude bank HQ country and quarter fixed effects; columns (4)–(6) include them. Within each group the estimators are: random effects (RE), correlated random effects in the Mundlak sense (CRE), and fixed effects (FE). The control set includes lagged bank size, liquidity, profitability, deposit funding, loan-loss provisions, asset quality, and risk density. Standard errors are clustered at bank-level. *, **, *** indicate significance at the 10%, 5% and 1% levels respectively.

	(1)	(2)	(3)	(4)	(5)	(6)
	RE	CRE	FE	RE	CRE	FE
MFI_{t-1}^{orth}	0.351*** (0.098)	0.351*** (0.099)	0.351*** (0.099)	0.234** (0.102)	0.262*** (0.101)	0.261** (0.101)
$\log(TA)_{t-1}$	-2.605*** (0.279)	-4.085*** (0.830)	-4.085*** (0.830)	-3.121*** (0.302)	-5.796*** (0.926)	-5.794*** (0.927)
CBR_{t-1}	0.070 (0.192)	0.201 (0.209)	0.201 (0.209)	-1.245*** (0.214)	-1.317*** (0.223)	-1.328*** (0.224)
$Cash/TA_{t-1}$	0.054*** (0.019)	0.040** (0.020)	0.040** (0.020)	0.055*** (0.020)	0.048** (0.020)	0.047** (0.020)
ROA_{t-1}	0.036 (0.112)	0.094 (0.106)	0.094 (0.106)	-0.158 (0.125)	-0.094 (0.118)	-0.096 (0.118)
DEP/TA_{t-1}	-0.392*** (0.035)	-0.376*** (0.045)	-0.376*** (0.045)	-0.359*** (0.037)	-0.320*** (0.045)	-0.320*** (0.045)
$Prov/TA_{t-1}$	0.710*** (0.133)	0.805*** (0.140)	0.805*** (0.140)	0.267* (0.143)	0.322** (0.145)	0.318** (0.145)
$NPL\ ratio_{t-1}$	0.046 (0.038)	0.043 (0.040)	0.043 (0.040)	0.041 (0.040)	0.031 (0.040)	0.031 (0.040)
RWA/TA_{t-1}	-0.233*** (0.019)	-0.256*** (0.023)	-0.256*** (0.023)	-0.227*** (0.020)	-0.252*** (0.023)	-0.252*** (0.023)
Observations	18,889	18,889	18,889	18,889	18,889	18,889
Banks	1,411	1,411	1,411	1,411	1,411	1,411
R-squared			0.257			0.305
Bank FE			✓			✓
Bank HQ country				✓	✓	
Quarter				✓	✓	✓

Table 3: **Baseline result: intensive margin**

This table reports bank-firm level panel regressions of lending growth ($\Delta \ln(\text{loans})$) on the lagged orthogonalised Macroprudential Fragmentation Index ($\text{MFI}_{t-1}^{\text{orth}}$). Column (1) excludes the MFI. Columns (2)–(3) add the MFI without bank fixed effects. Columns (4)–(6) progressively saturate the specification with bank fixed effects, bank headquarters country $\times$ quarter fixed effects, and bank $\times$ borrowers' country fixed effects. All specifications include borrower $\times$ quarter fixed effects. Bank- and relationship-level controls are lagged one quarter. For a detailed definition of the variables refer to Table A1. Standard errors are clustered at the bank-firm level. *, **, *** indicate significance at the 10%, 5% and 1% levels respectively.

	$\Delta \ln(\text{loans})$					
	(1)	(2)	(3)	(4)	(5)	(6)
$\text{MFI}_{t-1}^{\text{orth}}$		-0.879*** (0.252)	-0.961*** (0.266)	-0.509*** (0.164)	-0.508*** (0.164)	-0.509*** (0.164)
CBR_{t-1}	-0.389 (0.365)	0.237 (0.408)	0.292 (0.402)	0.782 (0.588)	0.703 (0.600)	0.782 (0.588)
D2P2G_{t-1}	0.168*** (0.055)	0.180*** (0.050)	0.163*** (0.050)	0.074 (0.191)	0.091 (0.192)	0.074 (0.191)
TSCR_{t-1}	0.249** (0.109)	0.235** (0.100)	0.295*** (0.095)	-0.113 (0.326)	-0.069 (0.326)	-0.113 (0.326)
$\ln(\text{TA})_{t-1}$	0.074 (0.158)	0.306* (0.168)	0.355** (0.168)	-2.665 (1.848)	-3.180* (1.872)	-2.665 (1.848)
$\text{Cash}/\text{TA}_{t-1}$	0.121*** (0.034)	0.088*** (0.031)	0.074** (0.032)	0.031 (0.024)	0.028 (0.025)	0.031 (0.024)
ROA_{t-1}	-0.612 (0.429)	-0.762* (0.407)	-0.527 (0.408)	0.329 (0.317)	0.400 (0.320)	0.329 (0.317)
$\text{DEP}/\text{TA}_{t-1}$	0.017 (0.021)	0.033 (0.021)	0.037* (0.020)	-0.048 (0.040)	-0.055 (0.045)	-0.048 (0.040)
$\text{Prov}/\text{TA}_{t-1}$	-0.951** (0.389)	-1.338*** (0.322)	-1.279*** (0.343)	-0.660* (0.350)	-0.594* (0.352)	-0.660* (0.350)
NPL ratio_{t-1}	0.101 (0.067)	0.132* (0.071)	0.166** (0.076)	0.177* (0.106)	0.185* (0.110)	0.177* (0.106)
$\text{RWA}/\text{TA}_{t-1}$	-0.002 (0.016)	0.013 (0.017)	0.007 (0.017)	0.117** (0.057)	0.112* (0.058)	0.117** (0.057)
Impairment ratio	-2.066*** (0.703)	-2.142*** (0.716)	-2.177*** (0.752)	-2.173*** (0.814)	-2.173*** (0.814)	-2.173*** (0.814)
Collateral ratio	-1.614*** (0.115)	-1.632*** (0.112)	-1.623*** (0.111)	-1.741*** (0.114)	-1.741*** (0.114)	-1.741*** (0.114)
$\ln(\text{Maturity})$	-1.219*** (0.354)	-1.183*** (0.343)	-1.120*** (0.349)	-1.052*** (0.345)	-1.051*** (0.345)	-1.052*** (0.345)
Observations	2,945,006	2,945,006	2,945,006	2,945,001	2,944,981	2,945,001
R-squared	0.481	0.482	0.482	0.484	0.484	0.484
Borrower $\times$ quarter FE	✓	✓	✓	✓	✓	✓
Interest rate type FE	✓	✓				
Interest rate type $\times$ quarter FE			✓	✓	✓	✓
Bank FE				✓	✓	
Bank HQ country $\times$ quarter					✓	
Bank $\times$ Borrowers' country						✓

Table 4: **Interaction between fragmentation and distance to P2G**

This table reports bank-firm level panel regressions of lending growth ($\Delta \ln(\text{loans})$) on the lagged orthogonalised Macroprudential Fragmentation Index ($\text{MFI}_{t-1}^{\text{orth}}$), interacted with the distance to the Pillar 2 Guidance (D2P2G). All specifications include borrower $\times$ quarter fixed effects. Columns (1)–(2) vary the interest rate type fixed effect (level vs. interacted with quarter). Columns (3)–(5) additionally include bank fixed effects; column (4) augments with bank HQ country $\times$ quarter fixed effects and column (5) with bank $\times$ borrowers' country fixed effects. Bank- and relationship-level controls are lagged one quarter. For a detailed definition of the variables refer to Table A1. Standard errors are clustered at the bank-firm level. *, **, *** indicate significance at the 10%, 5% and 1% levels respectively.

	$\Delta \ln(\text{loans})$				
	(1)	(2)	(3)	(4)	(5)
$\text{MFI}_{t-1}^{\text{orth}}$	-1.259*** (0.234)	-1.282*** (0.263)	-0.668*** (0.171)	-0.664*** (0.175)	-0.668*** (0.171)
D2P2G_{t-1}	0.169*** (0.048)	0.153*** (0.049)	0.067 (0.188)	0.084 (0.189)	0.067 (0.188)
$\text{MFI}_{t-1}^{\text{orth}} \times \text{D2P2G}_{t-1}$	0.127*** (0.038)	0.109*** (0.033)	0.055** (0.023)	0.054** (0.025)	0.055** (0.023)
CBR_{t-1}	0.248 (0.411)	0.301 (0.405)	0.689 (0.596)	0.611 (0.607)	0.689 (0.596)
TSCR_{t-1}	0.230** (0.097)	0.289*** (0.094)	-0.105 (0.325)	-0.062 (0.324)	-0.105 (0.325)
$\ln(\text{TA})_{t-1}$	0.256 (0.167)	0.311* (0.166)	-2.781 (1.831)	-3.309* (1.860)	-2.781 (1.831)
$\text{Cash}/\text{TA}_{t-1}$	0.084*** (0.032)	0.071** (0.032)	0.029 (0.025)	0.025 (0.025)	0.029 (0.025)
ROA_{t-1}	-0.634 (0.419)	-0.418 (0.414)	0.393 (0.320)	0.463 (0.320)	0.393 (0.320)
$\text{DEP}/\text{TA}_{t-1}$	0.037* (0.021)	0.040** (0.020)	-0.031 (0.042)	-0.037 (0.048)	-0.031 (0.042)
$\text{Prov}/\text{TA}_{t-1}$	-1.093*** (0.324)	-1.068*** (0.346)	-0.535 (0.360)	-0.476 (0.359)	-0.535 (0.360)
NPL ratio_{t-1}	0.124* (0.071)	0.158** (0.076)	0.167 (0.108)	0.175 (0.112)	0.167 (0.108)
$\text{RWA}/\text{TA}_{t-1}$	0.005 (0.018)	0.001 (0.018)	0.113* (0.058)	0.108* (0.060)	0.113* (0.058)
Impairment ratio	-2.161*** (0.715)	-2.194*** (0.752)	-2.172*** (0.815)	-2.172*** (0.814)	-2.172*** (0.815)
Collateral ratio	-1.632*** (0.112)	-1.623*** (0.111)	-1.741*** (0.114)	-1.741*** (0.114)	-1.741*** (0.114)
$\ln(\text{Maturity})$	-1.180*** (0.345)	-1.118*** (0.350)	-1.052*** (0.345)	-1.052*** (0.345)	-1.052*** (0.345)
Observations	2,945,006	2,945,006	2,945,001	2,944,981	2,945,001
R-squared	0.482	0.482	0.484	0.484	0.484
Borrower $\times$ quarter FE	✓	✓	✓	✓	✓
Interest rate type FE	✓				
Interest rate type $\times$ quarter FE		✓	✓	✓	✓
Bank FE			✓	✓	✓
Bank HQ country $\times$ quarter				✓	
Bank $\times$ Borrowers' country					✓

Table 5: Monetary policy pass-through and macroprudential fragmentation

This table reports bank-firm level panel regressions of lending growth ($\Delta \ln(\text{loans})$) on bank characteristics interacted with changes in the deposit facility rate (ΔDFR). The lagged orthogonalised Macroprudential Fragmentation Index ($\text{MFI}_{t-1}^{\text{orth}}$) enters both in levels and interacted with ΔDFR . Columns (1)–(2) include the MFI without bank fixed effects, varying the interest rate type fixed effect (level vs. interacted with quarter). Columns (3)–(5) progressively saturate the specification with bank fixed effects, bank headquarters country $\times$ quarter fixed effects, and bank $\times$ borrowers' country fixed effects. All specifications include borrower $\times$ quarter fixed effects. Bank- and relationship-level controls are lagged one quarter, each entering in levels and interacted with ΔDFR . For a detailed definition of the variables refer to Table A1. Standard errors are clustered at the bank-firm level. *, **, *** indicate significance at the 10%, 5% and 1% levels respectively.

	$\Delta \ln(\text{loans})$				
	(1)	(2)	(3)	(4)	(5)
$\text{MFI}_{t-1}^{\text{orth}} \times \Delta DFR$	0.879*** (0.243)	0.919*** (0.249)	0.962*** (0.238)	0.964*** (0.232)	0.962*** (0.238)
$\text{MFI}_{t-1}^{\text{orth}}$	-1.126*** (0.212)	-1.264*** (0.227)	-0.715*** (0.099)	-0.730*** (0.100)	-0.715*** (0.099)
$\text{CBR}_{t-1} \times \Delta DFR$	-0.044 (0.304)	-0.078 (0.333)	0.201 (0.337)	0.099 (0.345)	0.201 (0.337)
CBR_{t-1}	0.269 (0.378)	0.350 (0.382)	0.906 (0.561)	0.828 (0.580)	0.906 (0.561)
Observations	2,945,006	2,945,006	2,945,001	2,944,981	2,945,001
R-squared	0.482	0.483	0.484	0.484	0.484
Borrower $\times$ quarter FE	✓	✓	✓	✓	✓
Interest rate type FE	✓				
Interest rate type $\times$ quarter FE		✓	✓	✓	✓
Bank FE			✓	✓	
Bank HQ country $\times$ quarter				✓	
Bank $\times$ Borrowers' country					✓

Notes: All bank- and relationship-level controls from Table 3 are included in levels and interacted with ΔDFR but not reported.

A Appendix

Table A1: Definitions of variables and their sources

Variable	Label	Definition	Source
<i>Fragmentation index and components</i>			
Fragmentation index (raw)	$MFI_{i,t}^{agg}$	Unweighted average of the Z-scores of <i>Breadth</i> , <i>Churn</i> , and <i>Dispersion</i> . Higher values indicate a more fragmented macroprudential environment.	NCA notifications; BIS; ESRB; ECB Supervisory Data
Fragmentation index (orthogonalised)	$MFI_{i,t}^{orth}$	Residual of a regression of $MFI_{i,t}^{agg}$ on the CBR, $\ln(TA)$, the CCI, and bank and quarter fixed effects. Captures fragmentation orthogonal to capital stringency, bank size, and the financial cycle.	NCA notifications; BIS; ESRB; ECB Supervisory Data
Breadth	<i>Breadth</i>	Count of macroprudential capital buffers with a strictly positive rate applied to bank <i>i</i> in quarter <i>t</i> , covering CCyB, (s)SyRB, O-SII, and G-SII buffers.	NCA notifications
Churn	<i>Churn</i>	Rolling four-quarter count of upward adjustments in the rates of CCyB, (s)SyRB, O-SII, and G-SII buffers applicable to bank <i>i</i> .	NCA notifications
Dispersion	<i>Dispersion</i>	Inverted Herfindahl–Hirschman index measuring the geographical spread of exposure-based buffer requirements (CCyB and (s)SyRB) across jurisdictions. A value of 1 indicates equal distribution across many countries; 0 indicates a single jurisdiction.	NCA notifications; BIS; ESRB
<i>Dependent variables</i>			
Lending growth	$\Delta \ln(\text{loans})$	Quarter-on-quarter change in the natural logarithm of the total credit exposure from bank <i>i</i> to firm <i>j</i>	AnaCredit
Interest rate	IR	Average interest rate (in percentage points) on outstanding exposure from bank <i>i</i> to firm <i>j</i> in quarter <i>t</i> , weighted by outstanding amounts	AnaCredit
Capital headroom (Distance to P2G)	Headroom (D2P2G)	Difference between the bank's CET1 ratio and the sum of the Overall Capital Requirement (OCR) and the Pillar 2 Guidance (P2G), in percentage points	ECB Supervisory Data
<i>Bank-level controls</i>			
Combined Buffer Requirement	CBR	Level of the Combined Buffer Requirement in per cent of risk-weighted assets, comprising CCoB, CCyB, (s)SyRB, and the higher of G-SII/O-SII buffers	ECB Supervisory Data
Capital requirement	TSCR	Total SREP capital requirement ratio, in per cent of risk-weighted assets	ECB Supervisory Data
Bank size	$\ln(TA)$	Natural logarithm of bank total assets	ECB Supervisory Data
Liquidity	Cash/TA	Ratio of cash and central bank balances to total assets	ECB Supervisory Data
Profitability	ROA	Ratio of net income to total assets	ECB Supervisory Data
Funding structure	DEP/TA	Ratio of deposits to total assets	ECB Supervisory Data
Asset quality	Prov/TA	Ratio of loan-loss provisions to total assets	ECB Supervisory Data
Non-performing loans	NPL ratio	Ratio of non-performing loans to gross loans	ECB Supervisory Data
Risk weight density	RWA/TA	Ratio of risk-weighted assets to total assets	ECB Supervisory Data
<i>Bank-firm relationship controls</i>			
Impairment ratio	Impairment ratio	Ratio of accumulated impairments across all loans in the relationship to the total outstanding amount	AnaCredit
Collateral ratio	Collateral ratio	Ratio of total collateral values pledged across all loans in the relationship to the total outstanding amount	AnaCredit
Maturity	$\ln(\text{Maturity})$	Natural logarithm of the exposure-weighted average original maturity (in days) of loans in the bank-firm relationship	AnaCredit
<i>Macro-financial indicator</i>			
Financial cycle	CCI	ECB Common Composite Indicator: a broad-based measure of cyclical systemic risk. See Lang et al. (2019) for details.	ECB Statistical Data Warehouse

B Weighting Schemes for the MFI

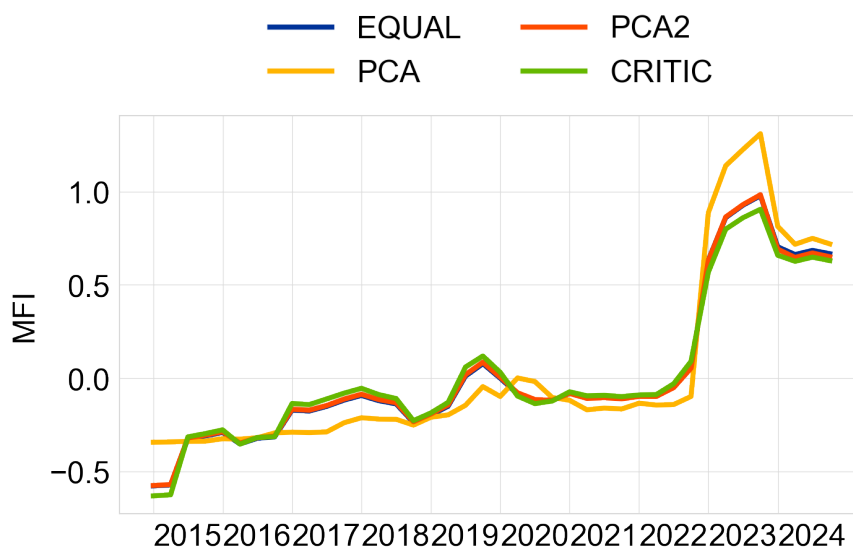
We benchmark the equal-weighting scheme against three outcome-agnostic alternatives. First, we implement a principal component analysis (PCA) on the three standardised components and construct an index based on the first principal component, with weights proportional to the squared loadings on PC1. In our data, PC1 explains only about 53% of the total variance, implying that the three components are on average only weakly correlated ($\bar{r} \approx 0.30$). Pairwise correlations show that Breadth and Churn are moderately correlated ($r \approx 0.60$), while Dispersion is close to orthogonal to both. A single-factor PCA would therefore discard roughly 47% of the joint variation, which is at odds with the aim of capturing several distinct dimensions of fragmentation in one composite measure. Second, we consider a variance-weighted two-component scheme that retains both PC1 and PC2 and recovers around 87% of total variance. While this improves the statistical fit, it yields an index that combines two orthogonal factors and makes the interpretation of regression coefficients less transparent. Third, we experiment with a CRITIC weighting scheme, which assigns weights in proportion to each component's standard deviation, adjusted for its average correlation with the remaining components (Diakoulaki et al., 1995).

Table B1 reports the rank correlation between the equal-weighted MFI and the three alternative composites across the estimation sample. Rank correlations are around 90%, confirming that the main empirical results are not materially sensitive to the choice of weighting scheme.

Table B1: Rank Correlation of MFI Across Weighting Schemes

Weighting scheme	Spearman ρ vs. equal weights	Variance explained
Equal weights (baseline)	1.000	—
PCA – PC1 only	0.8744	53%
PCA – PC1 + PC2 (var. weighted)	0.9996	87%
CRITIC	0.9874	—

Figure B1: MFI_{agg} under alternative weighting schemes



Source: ECB and Authors' Elaboration

C Robustness to alternative orthogonalisation procedures

This appendix shows that the regression results are not an artefact of the particular orthogonalisation used in the main analysis. We consider four alternative residualisation procedures: (i) no fixed effects, (ii) quarter fixed effects, (iii) bank fixed effects, and (iv) bank plus quarter fixed effects. The results are in Table C1.

In all cases, the resulting lagged residualised index is entered into the same headroom and lending regressions with bank fixed effects, country $\times$ quarter fixed effects, borrower $\times$ quarter fixed effects, interest rate type $\times$ quarter fixed effects, and the standard lagged bank controls.

Table C2 reports the results for the capital headroom regressions. The coefficient on the orthogonalised fragmentation measure is positive in all four cases, ranging between 0.348 and 0.362. The consistency across specifications confirms that both the headroom and lending results reflect a genuine policy-environment dimension of fragmentation rather than a by-product of the algebra used to construct the index.

Table C3 reports the same exercise for lending results. The coefficient on the or-

Table C1: **Orthogonalisation results**

This table reports bank-level panel regressions of the raw Macroprudential Fragmentation Index (MFI^{agg}) on its orthogonalisation covariates. $CBR_{b,t}$ is the combined buffer requirement in per cent of risk-weighted assets. $\ln TA_{b,t}$ is the natural logarithm of total assets. $CCI_{c,t}$ is the ECB Common Composite Indicator capturing the state of the financial cycle in bank b 's home country. The orthogonalised index $MFI_{b,t}^{\text{orth}}$ used in the lending analysis is defined as the residual of the preferred specification (column 8). Robust standard errors in parentheses. ***, **, * denote significance at the 1%, 5%, and 10% levels, respectively.

	(1) Pooled	(2) Time FE	(3) Bank FE	(4) Both
$CBR_{b,t}$	0.440*** (0.004)	0.547*** (0.009)	0.400*** (0.004)	0.542*** (0.012)
$\ln TA_{b,t}$	0.101*** (0.002)	0.091*** (0.002)	0.205*** (0.010)	0.142*** (0.010)
$CCI_{c,t}$	-0.272*** (0.007)	0.066*** (0.009)	-0.393*** (0.008)	0.159*** (0.015)
Constant	-1.768*** (0.014)	-1.855*** (0.022)	-2.430*** (0.065)	-1.675*** (0.077)
Observations	45,372	45,372	45,372	45,372
R-squared	0.424	0.531	0.622	0.702

Notes: Equation 5 corresponds to column (4).

thogonalised fragmentation measure is negative and significant at the 1% level in all four cases, lying in a narrow range between -0.509 and -0.511. This stability is notable because the nuisance variation removed from the raw index differs meaningfully across specifications. The negative association between fragmentation and lending is not driven by a specific projection rule, nor by whether the residualisation is performed in pooled, time-demeaned, bank-demeaned, or doubly-demeaned form.

Table C2: **Robustness – capital headroom under alternative orthogonalisation procedures**

This table reports bank-level fixed-effects regressions of capital headroom on alternative orthogonalised versions of the Macroprudential Fragmentation Index. Each column uses a different orthogonalisation: columns (1)–(4) are respectively pooled, quarter FE, bank FE, bank+quarter FE. All specifications include borrower $\times$ quarter FE, interest rate type $\times$ quarter FE, bank FE, and bank HQ country $\times$ quarter FE in the outcome regression. Standard errors are robust. *, **, *** indicate significance at the 10%, 5% and 1% levels respectively.

	(1) Pooled	(2) Time FE	(3) Bank FE	(4) Both
MFI_{t-1}^{orth}	0.353* (0.192)	0.362* (0.193)	0.348* (0.191)	0.361* (0.193)
Observations	18,889	18,889	18,889	18,889
R-squared	0.348	0.348	0.348	0.348
Banks	1,411	1,411	1,411	1,411
Bank FE	✓	✓	✓	✓
Bank HQ country $\times$ quarter	✓	✓	✓	✓
Controls	✓	✓	✓	✓

Notes: Control variables as in Table 2 are included but not reported.

Table C3: **Robustness – baseline lending regressions under alternative orthogonalisation procedures**

This table reports bank-firm level panel regressions of lending growth ($\Delta \ln(\text{loans})$) on alternative orthogonalised versions of the Macroprudential Fragmentation Index. Each column uses a different orthogonalisation: columns (1)–(4) are respectively pooled, quarter FE, bank FE, bank+quarter FE. All specifications include borrower $\times$ quarter FE, interest rate type $\times$ quarter FE, bank FE, and bank HQ country $\times$ quarter FE in the outcome regression. Standard errors are clustered at the bank-firm level. *, **, *** indicate significance at the 10%, 5% and 1% levels respectively.

	(1) Pooled	(2) Time FE	(3) Bank FE	(4) Both
MFI_{t-1}^{orth}	-0.509*** (0.164)	-0.509*** (0.164)	-0.511*** (0.164)	-0.510*** (0.164)
Observations	2,944,981	2,944,981	2,944,981	2,944,981
R-squared	0.484	0.484	0.484	0.484
Borrower $\times$ quarter FE	✓	✓	✓	✓
Interest rate type $\times$ quarter FE	✓	✓	✓	✓
Bank FE	✓	✓	✓	✓
Bank HQ country $\times$ quarter	✓	✓	✓	✓
Controls	✓	✓	✓	✓

Notes: Control variables as in Table 3 are included but not reported.

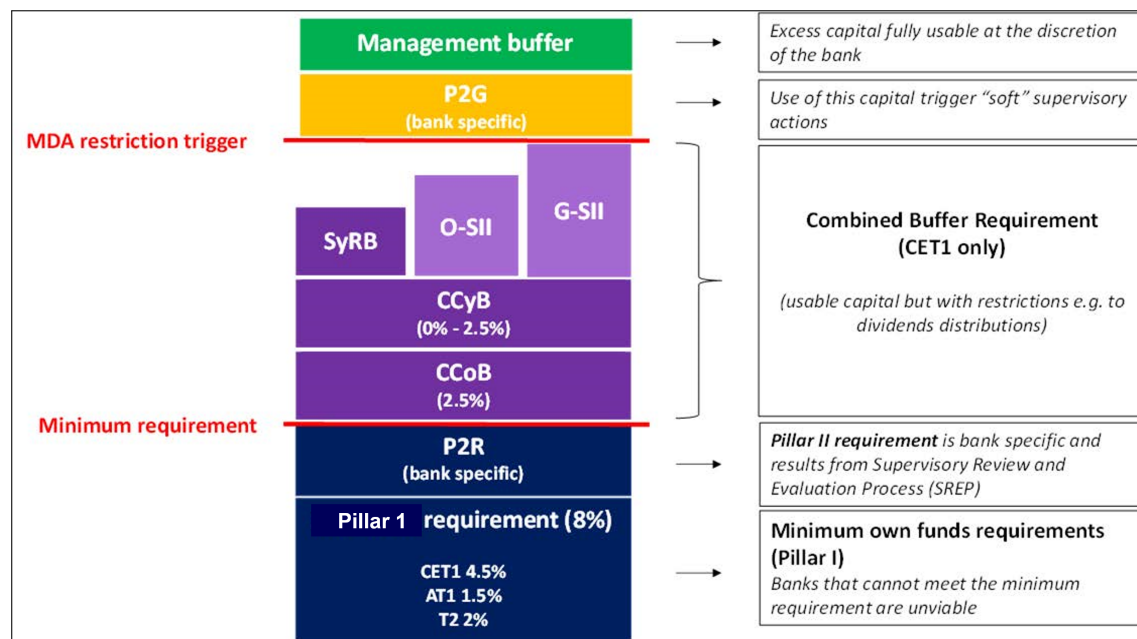
D Euro area banks' capital stack

Figure D1 shows the stacking order of capital requirements for euro area banks. Banks must fulfil *minimum requirements*, composed of a constant Pillar 1 element (8% of risk-weighted assets, with at least 4.5% to be met with CET1) and a bank-specific Pillar 2 requirement determined as part of the Supervisory Review and Evaluation Process (SREP), to be met with a minimum of 56.25% of CET1. The sum of minimum own funds requirements and Pillar 2 requirements identifies the Total SREP Capital Requirement (TSCR).

The CBR sits on top of minimum capital requirements. In the European framework, the CBR consists of the capital conservation buffer (CCoB), the countercyclical buffer (CCyB), the (sectoral) systemic risk buffer (SyRB) and buffers for systemically important banks: other systemically important intermediaries (O-SIIs) and globally systemically important banks (G-SIBs). The sum of TSCR and the CBR forms the Overall Capital Requirement (OCR). Above the CBR, banks are also supposed to fulfil the Pillar 2 Guidance (P2G). This is not strictly speaking a requirement as it is not legally binding.

The distance to the P2G threshold, defined as the difference between a bank's capital ratio and the sum of the OCR and P2G, assumes particular relevance in shaping bank lending behaviour as dipping into the CBR triggers automatic restrictions on dividend distributions, bonuses and coupon payments according to the Maximum Distributable Amount (MDA) mechanism and forces banks to communicate a capital recovery plan to supervisors. It follows that, *ceteris paribus*, an increase in capital buffer requirements reduces capital headroom, pushing banks closer to the threshold and potentially inducing them to deleverage to avoid breaching the CBR.

Figure D1: Stacking Order of Capital Requirements



Source: ECB and Authors' Elaboration

Note: CET1: Common Equity Tier 1. AT1: additional Tier 1. T2: Tier 2. P2R: Pillar 2 requirement. CCoB: capital conservation buffer. CCyB: countercyclical capital buffer. G-SII and O-SII indicate, respectively, the structural buffers required for global systemically important institutions and for other systemically important institutions. SyRB: systemic risk buffer. P2G: Pillar 2 guidance

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The views expressed are those of the authors and do not necessarily reflect those of the European Central Bank or the Eurosystem.

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