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Macroprudential policy at the ECB: Institutional framework, strategy, analytical tools and policies

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Foreword

A first draft of this paper was circulated at the occasion of the third annual ECB Macroprudential Policy and Research Conference held on 17-18 May 2018.

This occasional paper explains how the financial stability and macroprudential policy functions are organised at the ECB, including a brief description of the analytical tools that have been developed to enable the ECB to effectively fulfil its responsibilities in this regard. Since the launch of the ECB Financial Stability Review in 2004 by my late colleague Tommaso Padoa-Schioppa, it has been clear that the ECB, like other central banks, has to pay close attention to the stability of the financial system in the euro area. Even when central banks do not have an explicit financial stability mandate, which is not the case with the ECB,[1] the markets and general public still consider central banks to be responsible for the overall stability of the financial system. After all, in historical terms, the objective underpinning the establishment of central banks in the 19th century was to stabilise the turbulence created by free private banking. Later, the interrelationship between monetary policy and the stability of the financial system became crucial from the perspective of the transmission channel of monetary policy decisions.

The creation of the banking union and the decision to entrust the ECB with the responsibility for both micro- and macroprudential supervision generated the need for completely new organisational procedures and analytical tools. Following the preparation of the regulation establishing the Single Supervisory Mechanism (SSM)[2], in which the ECB actively participated, the ECB's Governing Council decided on the internal procedures governing the macroprudential policy function in November 2013. Besides the general decision-making rules, which are described in Chapter 3, two informal internal bodies were created, namely the Macroprudential Coordination Group (MPCG) and the Macroprudential Forum (MPF), to facilitate collaboration between ECB Banking Supervision and the Directorate General Macroprudential Policy and Financial Stability (DG/MF). The ECB's Governing Council and Supervisory Board, which constitute the MPF, meet every quarter to discuss issues related to financial stability at the euro area and member country level. The conduct of macroprudential policy is a joint endeavour between the national competent authorities and the ECB. The latter can only further tighten measures decided at the national level, the rationale being that the ECB's role is to counter any possible "inaction bias" on the part of member countries. The MPF meetings allow the Governing Council, as the ultimate decision-making body, to express its view and provide guidance on the use of macroprudential policy.

1 See Article 127(5) of the Treaty on the Functioning of the European Union: "The ESCB shall contribute to the smooth conduct of policies pursued by the competent authorities relating to the prudential supervision of credit institutions and the stability of the financial system."

2 Regulation (EU) No 1075/2013 of the European Central Bank of 18 October 2013 concerning statistics on the assets and liabilities of financial vehicle corporations engaged in securitisation transactions (recast) (ECB/2013/40) (OJ L 297, 7.11.2013, p. 107).

The MPCG informally gathers together experts from the SSM and DG/MF under the chairmanship of the ECB's Vice-President and a member of the Supervisory Board. It prepares the documentation for the MPF meetings, assesses financial stability risks and discusses financial regulation issues in order to coordinate the ECB's positions in international fora where both the ECB, as a central bank, and ECB Banking Supervision are represented. This task is particularly relevant, as financial regulation that creates effective rules for a solid financial system is the front line of macroprudential policy measures.

Measuring systemic risk

The new macroprudential competences of the ECB required the development of new tools for assessing systemic risk, providing the rationale for the use of the new policy instruments and evaluating their impact. At the ECB, systemic risk is defined as the risk that financial instability significantly impairs the provision of the financial products and services required by the financial system to a point where economic growth and welfare may be materially affected.[3] The important factor in this concept is that the materialisation of systemic risk entails significant costs to the real economy, implying the destruction of economic value and leading to losses in terms of economic growth (see Chapter 2).

Whatever its root cause, the primary role of macroprudential authorities is to identify, measure and reduce systemic risk. Identification of risks clearly needs to be probabilistic and attempt to predict the level of overall systemic risk in different scenarios.[4]

Many indicators for measuring systemic risk have been proposed over the last ten years. However, many of them have a "micro-level" dimension aimed at calculating the contribution of significant institutions to systemic risk, e.g. the Marginal Expected Shortfall (MES), CoVar, CoRisk or Conditional Tail Risk (CRT).[5] Taken in isolation, they are not useful for predicting future levels of systemic risk, as they tend to use contemporaneous market prices and do not consider the system as a whole. ECB staff have contributed to the development of some indicators that do cover the entire system and these are now published regularly in the ECB's Financial Stability Review. They include the joint probability of default (JPoD), the Composite Financial Stress Index (CISS) for the euro area, and the Country Level Index of Financial Stress (CLIFS).[6] These indicators usefully capture the extent of disruptions in the financial system. They therefore appropriately track the amount of financial stress and are especially useful for crisis management policies. However, given their reliance on

3 See European Central Bank (2009), *Financial Stability Review*, Special Feature B, for a discussion on the concept of systemic risk.

4 See Constâncio, V. (2016), "Principles of Macroprudential Policy", speech at the ECB-IMF Conference on Macroprudential Policy, Frankfurt am Main, 26 April 2016.

5 For SRISK, see Brownlees and Engle (2017); for CoVaR, see Adrian and Brunnermeier (2016), , for MES, see Acharya et al (2010) For an overview including other indicators, see Bisias et al (2012).

6 For the CISS, see Holló et al (2012), for the CLIFS, see Duprey et al (2015), for the probability of default of two or more large and complex banking groups, see *Financial Stability Review* (2007), box entitled "A market-based indicator of the probability of adverse systemic events involving large and complex banking groups", European Central Bank, Frankfurt am Main, pp. 125-127.

market-based indicators, the indicators provide more limited information for a pre-emptive policy such as macroprudential policy.

For macroprudential policymakers, it is important to use indicators that predict episodes of financial stress. For policymakers, a forward-looking indicator allows policies to be adjusted in good time to act on the economic and financial conditions to contain economic losses from the amplification and contagion of shocks.

To overcome the limitations of existing stress indicators, ECB staff have investigated and developed indicators that anticipate financial crises and severe recessions caused by financial imbalances, with a view to satisfying policymakers' need for indicators that anticipate rather than track financial stress and provide indications on possible countercyclical policy.[7]

Two new indicators of systemic risk

This work led to the development of two new indicators: the financial stability risk index (FSRI) and the cyclical systemic risk indicator (CSRI), which are already in use. These are described in Chapter 3.

The FSRI evaluates near-term risks to the economic outlook. It combines 23 macro-financial stability indicators used to measure cyclical systemic risk, covering pressures on asset price valuation, measures of risk appetite, non-financial imbalances and financial sector vulnerabilities. In addition, the indicator captures the cross-sectional dimension of systemic risk using 16 measures of spillover and contagion risks, including the well-known measures SRISK, CoVaR or Marginal Expected Shortfall (MES). These may contain information on the potential amplification of initial shocks and could provide indications on the severity of economic downturns.

The approach underlying the FSRI combines the time dimension of systemic risk with the cross-section dimension, and the broad range of indicators helps to cover the multifaceted aspects of financial instability. To develop the predictive power for severe recessions and to efficiently aggregate information across indicators, the information contained in the numerous individual indicators is first reduced with the help of four factors to filter out noise.[8] In a second step, the four factors are recursively regressed within a quantile regression set-up on the GDP components that remain unexplained one quarter ahead. The use of the quantile regressions captures non-linearities around systemic crises and makes it possible to focus on the amplification mechanisms during severe recessions. Finally, the forecast performance is evaluated by a goodness-of-fit measure that combines the residuals with the quantile loss function.

The FSRI provides a comprehensive view of the level of near-term financial stability risks that could trigger negative repercussions for the real economy. The indicator

7 See, for example, Alessi, and Detken (2018, 2011); Behn et al (2017).

8 Two alternative data reduction methods were used for robustness: principal component analysis and dynamic factor models with time-varying parameters.

successfully captured well the most important euro area events during the recent crisis episodes. It increased at the outbreak of the financial crisis and reached an all-time high in the fourth quarter of 2008 after the default of Lehmann Brothers; it spiked again at the height of the euro area sovereign debt crisis in 2011 and 2012, when the vicious circle between banks and sovereigns led to speculations about redenomination risks in the euro area. The most recent readings of the index point to a moderate increase in systemic risk on the back of higher risk appetite and higher contagion and spillover risk.

The predictive power for near-term economic activity makes the FSRI a particularly useful tool in the financial stability monitoring toolkit, as it helps assess the costs of a crisis.

The second new indicator is the cyclical systemic risk indicator (CSRI). It builds on early warning models and provides signals in the phase of the build-up of vulnerabilities, well ahead of potential financial crises. The early warning methodology uses the information contained in macro-financial variables to identify common patterns ahead of systemic crises and makes it possible to flexibly adjust the lead time to give policymakers the opportunity to counter the financial cycle and build resilience.

Unlike the FSRI, which focuses on near-term signals, the CSRI is designed to indicate the build-up of cyclical systemic risk with a lead time of one to three years ahead of financial crises. It captures risks stemming from domestic credit, private sector indebtedness, real estate markets, asset prices, external imbalances and cross-country spillovers. These individual indicators are selected based on their overall performance within an early warning system and are further aggregated into a composite indicator using weights that optimise the early warning performance.

Strictly speaking, the CSRI consists of a domestic cyclical systemic risk indicator (d-SRI) that captures the build-up of imbalances in the domestic, non-financial private sector. In addition, an exposure-based systemic risk indicator (e-SRI) uses direct bilateral exposure of the domestic banking system to the foreign countries to weigh each country's d-SRI. The e-SRI thus captures risks from cross-border spillovers. In the final step, the domestic d-SRI and the exposure-based e-SRI are combined into the cyclical CSRI using weights that optimise the early warning performance to predict vulnerable episodes ahead of systemic crises.

The CSRI provides consistent signals of financial crises.In the past it has risen as much as four to five years in advance of a systemic financial crisis. Currently, the median CSRI across euro area countries remains at subdued levels with a high cross-country dispersion. This shows, once more, the need to have country-specific macroprudential policies, and especially so in a monetary union.

The CSRI does not only signal increases in the likelihood of crises well in advance, it also contains information on their severity. The peak value of the domestic SRI ahead of financial crises specifically shows a high correlation with the size of subsequent recessions. The CSRI can therefore be directly used for assessing the impact of

systemic risk build-ups on future declines in real GDP.[9] Given its lead time, it is a useful tool for policymakers to initiate macroprudential policy to limit the pro-cyclicality of the financial system and to adjust resilience to the identified level of systemic risk. The methodology of calculating "GDP at risk" has similarities with Adrian et al (2019) and is drawn from recent academic literature, using factor analysis, quantile regression and distribution forecasting.[10]

The CSRI and the FSRI are two examples of the continued improvements in the ECB's analytical apparatus to monitor changes in systemic risk within its comprehensive macroprudential policy framework.

Measuring the development of systemic risk

These efforts to develop composite indices are complementary to the ongoing research on the concept of a financial cycle as a sort of a generalisation of the old concept of a credit cycle, as distinct from the concept of the economic or business cycle (see Section 4.1). Schüler, Hiebert and Peltonen (2017) build and extend on BIS (2012). The paper shows how credit and asset prices share cyclical similarities, captured in a synthetic financial cycle index that outperforms credit-to-GDP gap measures in predicting systemic banking crises, over a horizon of up to three years. The paper also demonstrates how the financial cycle is different from the business cycle for the euro area and individual countries.

Based on this research, we can conclude that financial variables (credit volumes and asset prices) in EU Member States have historically exhibited higher average volatility than economic variables (volume of activity in goods and labour markets, as well as consumer prices). Financial cycles have also exhibited a longer duration than business cycles on average. Lastly, asymmetries appear to exist, with financial cycles tending to build up slowly and correct more abruptly.

Taken together, these findings have at least two policy implications. First, they establish a rationale for differentiated financial and macroeconomic policies and are thus fundamental to the newly established macroprudential policy area. Policies targeting financial cycles, such as countercyclical macroprudential policies, can powerfully complement policies targeting the business cycle, such as monetary policy. Policy trade-offs may emerge in the short-run, as the propensity for such cyclical divergence seems to be greatest at short frequencies. Second, the results present a strong case for a differentiated national application of macroprudential policies, amid a far-from-complete convergence of country financial cycles. This latter aspect is particularly compelling in a currency union with shared monetary policy, where macroprudential policies represent an additional and potentially powerful element to cushion conditions specific to Member States.

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9 Model estimates suggest that an elevated CSRI value of one standard deviation implies a decline in future real GDP growth of around four percentage points 11-16 quarters down the road. This average drop in real GDP is due to a shift in the entire distribution, but especially due to a shift in its left tail.

10 See also Giglio, S., Kelly, B.T. and Pruit, S. (2016); De Nicolò and Lucchetta (2017).

The calculation of the financial cycle position of each member country as a way of predicting potential vulnerabilities in advance is one of the tools used to report to the MPF meetings. Additionally, early warning systems for banking sectors, random forest methods for probability of crisis, heat maps and dashboards are also used for the same purposes.

Macroprudential stress tests

The financial crisis and its aftermath led to greater use of generalised stress tests aimed at identifying and limiting systemic risk. In 2013 the ECB published an occasional paper describing the framework and its various modules for conducting stress tests with a systemic perspective (see Henry and Kok, 2013). Using earlier versions of that methodology, the ECB supported EU-wide stress tests, conducted first in 2009 by the Committee of European Banking Supervisors, and later by the European Banking Authority (EBA). New modules and tools have been developed since 2013. The traditional bank stress tests suffer from several limitations as they are purely simulations of the impact on the bank capital ratio of selected adverse scenarios. They are solvency tests that are more useful for the micro-supervision of individual banks than the analysis of the system-wide consequences of severe shocks to the economic environment. In particular, the traditional tests adopt the assumption of a static bank balance sheet; they do not include any feedback loop with the macroeconomy; they do not integrate shocks to overall liquidity; and finally, they do not consider the interconnectedness with other financial institutions or economic agents.

It was necessary to expand the scope and stress testing methods to introduce a true macroprudential perspective.[11] ECB staff worked towards this goal and, in the wake of the 2016 EBA stress tests, the first application of such a macroprudential exercise was published in the ECB Macroprudential Bulletin of October 2016.[12] The whole set of models used to conduct top-down macroprudential stress tests was later published in an ECB e-book (see Section 4.4).[13]

The new methodology allows for the inclusion of a dynamic approach, integrating the optimised reaction of banks' balance sheets to the variables being shocked. It also includes feedback to the real economy about the consequences of the scenario for banks, through the use of appropriate macroeconomic models. It considers a system-wide liquidity assessment; analyses the interconnectedness of banks with other financial institutions and the economic behaviour of households; and finally, it can be used to study the impact of some macroprudential instruments.

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11 See Constâncio, V. (2015), "The role of stress-testing in supervision and macroprudential policy", keynote address at the London School of Economics Conference on "Stress Testing and Macroprudential Regulation: a Trans-Atlantic Assessment", London, 29 October 2015. Also available from VoxEU as a CEPR Press e-book edited by Ronald W. Anderson (2016), "Stress Testing and Macroprudential Regulation: a Transatlantic Assessment".

12 European Central Bank (2016), "Macroprudential effects of systemic bank stress", *Macroprudential Bulletin*, Issue 2, Chapter 1, October.

13 Dees, S., Henry, J. and Martin, R. (eds.) (2017), "STAMP€: Stress-Test Analytics for Macroprudential Purposes in the euro area", European Central Bank, Frankfurt am Main, February.

Other developments and policy considerations

Notwithstanding these sizeable efforts made by the ECB and the multiple advances in the analytical toolkits used in the macroprudential community, macroprudential policymaking requires further concerted efforts at all levels.

First, macroprudential policy should extend beyond the banking sector and encompass market-based finance institutions and products in order to overcome the "boundary problem" (see Section 5.3). Letting market-based finance outside of the macroprudential perimeter would not only leave the door wide open for the transfer of credit intermediation outside the banking sector, but would also mean that we turn a blind eye to the inherent liquidity and leverage risks of securities finance transactions and asset management.[14]

Stress-testing methodologies also need to expand on the interaction within the financial sector, particularly with asset managers and their funds, as it continues to grow at a steady pace. These methodologies should help to reveal vulnerabilities in this sector and assess the potential for spillovers to the rest of the financial sector, most notably due to fire sales. Agent-based models, allowing for endogenous asset price determination, can be used to account for such interactions.

Second, given the importance of the real estate component for the financial cycle, instruments on the borrower side such as LTV or debt-(service-)to-income (D(S)TI) ratios pertain to the macroprudential policy toolkit to influence the demand for credit and increase resilience among households and banks. The ECB's Governing Council had called for legislative frameworks for borrower-based measures in all euro area countries to complete the macroprudential toolkit for the real estate sector. For the adequate functioning of the banking union, a harmonised legislative basis for these macroprudential tools is essential. The absence of harmonised legislation invites cross-border arbitrage opportunities to be exploited, undermining the efforts by national authorities to ensure financial stability.

Most of these instruments are not included in the Capital Requirements Directive (CRD IV)[15] and the Capital Requirements Regulation (CRR)[16]. Other missing instruments relate to the broader use of sectoral capital requirements and a temporary add-on to the leverage ratio when the countercyclical capital buffer is used on the side of the risk-weighted capital ratio. I therefore hope that the ongoing review of the two directives will expand the set of macroprudential policy tools and simplify the activation procedure for macroprudential tools provided for in Article 458 of the CRR, which is unnecessarily complex and long. This would allow macroprudential authorities to act in an efficient, effective and timely manner.

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14 See the last section of Constâncio, V. (2017), "The future of finance and the outlook for regulation"; remarks at the Financial Regulatory Outlook Conference organised by the Centre for International Governance Innovation and Oliver Wyman, Rome, 9 November 2017.

15 Directive 2013/36/EU of the European Parliament and of the Council of 26 June 2013 on access to the activity of credit institutions and the prudential supervision of credit institutions and investment firms, amending Directive 2002/87/EC and repealing Directives 2006/48/EC and 2006/49/EC (OJ L 176, 27.6.2013, p. 338).

16 Regulation (EU) No 575/2013 of the European Parliament and of the Council of 26 June 2013 on prudential requirements for credit institutions and investment firms and amending Regulation (EU) No 648/2012 (OJ L 176, 27.6.2013, p. 1).

Macroprudential policy will become increasingly necessary, particularly in a monetary union with a single monetary policy and the possibility of financial imbalances starting to develop in just one or a few member countries. The ECB is prepared to continue to provide analytical support to systemic risk identification and measurement and to the design of appropriate macroprudential policy responses. Hopefully, the legal framework will be appropriately revised at European level and national authorities will have the capacity, and show the necessary determination, to ensure the smooth and efficient functioning of the financial system.

Vítor Constâncio

Abstract

This occasional paper describes how the financial stability and macroprudential policy functions are organised at the ECB. Financial stability has been a key policy function of the ECB since its inception. Macroprudential policy tasks were later conferred on the ECB by the Single Supervisory Mechanism (SSM) Regulation. The paper describes the ECB's macroprudential governance framework in the new institutional set-up. After reviewing the concept and origins of systemic risk, it reflects on the emergence of macroprudential policy in the aftermath of the financial crisis, its objectives and instruments, as well as specific aspects of this policy area in a monetary union such as the euro area. The ECB's responsibilities required new tools to be developed to measure systemic risk at financial institution, country and system-wide level. The paper discusses selected analytical tools supporting financial stability surveillance and assessment work, as well as macroprudential policy analysis at the ECB. The tools are grouped into three broad areas: (i) methods to gauge the state of financial instability or prospects of near-term systemic stress, (ii) measures to capture the build-up of systemic risk focused on country-level financial cycle measurement and early warning methods, and (iii) the ECB stress testing framework for macroprudential purposes.

Keywords: Financial stability, financial imbalances, macroprudential, systemic risk, stress testing, financial regulation, SSM, ESRB, monetary policy

JEL codes: E37, F36, G20, G28, K23

Non-technical summary

This occasional paper describes how financial stability and the macroprudential policy functions are organised at the ECB. Financial stability has been a key policy function of the ECB since its inception. The ECB's responsibilities in this field are enshrined in Article 127(5) of the Treaty on the Functioning of the European Union and Article 25 of the Protocol on the Statute of the European System of Central Banks and of the European Central Bank. The responsibility for decisions on macroprudential measures in the euro area is shared between national authorities and the ECB. Macroprudential policy tasks were conferred on the ECB in 2013 by Article 5 of the Single Supervisory Mechanism (SSM) Regulation[17] with the aim of contributing to the safety and soundness of individual credit institutions and to the stability of the financial system, both at the euro area level and in each Member State. Under that Regulation, the national authorities retain the power to activate and implement macroprudential measures, while the ECB regularly assesses the appropriateness of such measures, to which it can object, and has the power to top them up (i.e. to apply higher requirements) in the case of those macroprudential instruments assigned to it through EU legislation.

After recalling the concept and origins of systemic risk, the paper reflects on the emergence of macroprudential policy at the global level in the aftermath of the financial crisis, its objectives and instruments, and specific aspects of this policy area in a monetary union such as the euro area.

It then describes the ECB's macroprudential policy framework in the new institutional set-up with the establishment of the SSM. The ultimate decision-making body in the SSM is the Governing Council, which is also in charge of macroprudential policy. The Governing Council works closely with the Supervisory Board on macroprudential matters and benefits from the Supervisory Board's detailed knowledge of the banking system. The Macroprudential Forum, composed of the members of the Governing Council and the Supervisory Board, operates as a platform for regular discussion at the highest level, bringing together the micro- and macroprudential perspectives across the SSM. The Financial Stability Committee (FSC) of the European System of Central Banks (ESCB) supports the ECB in the area of macroprudential policy. It includes high-level representatives from the national central banks and supervisory authorities of the SSM Member States. It advises the Governing Council on macroprudential matters and potential policy responses, including draft proposals on the activation of macroprudential tools.

These tasks required the development of new tools to measure systemic risk at financial institution, country and system level. In this vein, growing research on financial stability at the global level aims to gauge systemic risk in its build-up and materialisation phases. This occasional paper describes, in a non-technical manner, the ECB's analytical work supporting financial stability monitoring and assessment, as well as macroprudential policy analysis, which can be grouped into three broad areas.

[17] Council Regulation (EU) No 1024/2013 of 15 October 2013 conferring specific tasks on the European Central Bank concerning policies relating to the prudential supervision of credit institutions (OJ L 287, 29.10.2013, p. 63).

First, methods to gauge the state of financial instability or prospects of near-term systemic stress: from contemporaneous measures of financial market stress to near-term risks to economic growth stemming from systemic risk propagation mechanisms. Coincident indicators (such as the Composite Financial Stress Index or CISS) analyse market data to measure the extent of contemporaneous disruptions in the financial system. For indicators with more predictive information to inform pre-emptive macroprudential policy, the ECB has focused on combining indicators in a standard financial stability monitoring framework to assess the build-up of vulnerabilities with measures of propensity for contagion to gauge risks of large macroeconomic losses. Such measures capture the risk build-up in the time dimension, in addition to shock amplification informed by the cross-sectional or cross-border dimension. To capture such near-term risks of deep recessions, the Financial Stability Risk Index (FSRI) for the euro area incorporates information extracted from a large set of indicators of cyclical and structural vulnerabilities.

Second, measures to capture, in a timely manner, the build-up of systemic risk focused on country-level financial cycle measurement and early warning methods. Oriented towards medium-term risks to financial stability, measures of country financial cycles, or the cyclical systemic risk indicator (CSRI), which is available for all individual euro area countries, seek to measure the cyclical systemic risk (in terms of likelihood and severity) over a longer forecasting horizon of two to three years. The CSRI captures risks stemming from domestic credit, private sector indebtedness, real estate markets, asset prices, external imbalances and cross-country spillovers. These individual indicators are selected based on their overall performance within an early warning system and are further aggregated into a composite indicator using weights that optimise early warning performance.

Third, macro-financial models to assess the potential severity of systemic risk complement this suite of methodologies to support the macroprudential policy function. ECB staff have developed a number of models for systemic risk analysis that have been increasingly used for macroprudential stress-testing purposes. The resulting STAMP€ (Stress Test Analytics for Macroprudential Purposes in the euro area) framework brings together micro bank-level data and macro-financial variables. It is a four-pillar structure combining the macro-financial scenario, satellite models for credit and market risk, a balance sheet tool at individual bank level, and macro and contagion feedback models. With dynamic adjustment features, the model framework can go beyond individual bank solvency stress tests and capture the system-wide dimension by accounting for banks' behaviour and their impact on other banks, other sectors and the real economy.

The analytical apparatus, which is composed of systemic risk identification and assessment tools, also contains tools supporting macroprudential policy calibration. These comprise, notably, the countercyclical capital buffer to address cyclical risks or capital buffers for systemic institutions to address structural risks. Clearly there are still a number of challenges and open issues in a continuously developing macroprudential framework. In particular, the obvious important next steps are to establish a comprehensive monitoring framework for the non-bank sector and develop macroprudential instruments to address market-based finance risks.

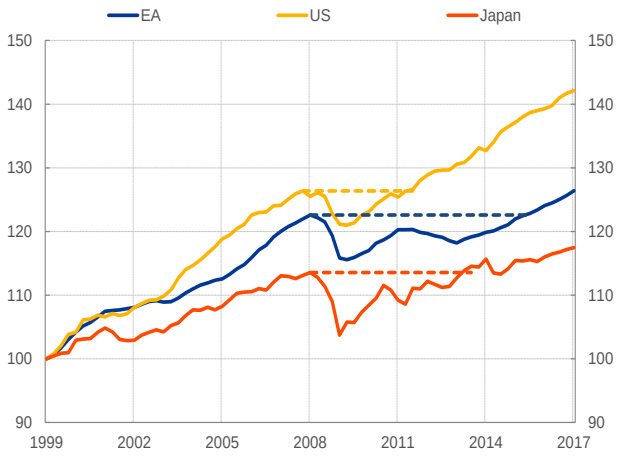
1 The emergence of macroprudential policy

The financial crisis which erupted in 2007-08 imposed enormous costs on the real economy – in terms of the permanent loss in output and the increase in unemployment. The concept of systemic risk gained traction in economic thinking and gradually gave rise to a new policy area at the global level with concrete objectives and dedicated policy instruments. Whereas previous episodes of financial turmoil and instability had caused major disruptions in market functioning and asset price valuations, losses were generally contained, or at least not large enough to have had repercussions on growth and employment conditions. The global financial crisis demonstrated the devastating effect of systemic risk materialisation (see Chart 1) – a situation in which financial instability becomes so widespread that the functioning of the financial system is impaired to the point where economic growth and welfare suffer materially.

Chart 1

Permanent output loss as a result of the financial crisis

(real GDP index, Q1 1999=100)



Sources: Eurostat, BEA, Cabinet Office and ECB calculations.
Notes: EA = euro area, US = United States.

Apart from demonstrating that the costs of instability can be massive, the financial crisis showed that price stability – ensured by monetary policy – is necessary but not sufficient to safeguard financial stability, and that the soundness of individual credit institutions – monitored by microprudential supervision – does not ensure the stability of the financial system as a whole. Macroprudential policy thus progressively gained ground in the aftermath of the crisis, with the focus on the system as a whole, and the ultimate goal of limiting systemic risk.

A foundational aim of macroprudential policy is to increase the resilience of individual financial institutions and of the financial system as a whole. A more ambitious objective is that of smoothing out the financial cycle, determined by fluctuations in

credit, leverage and asset prices, which might otherwise result in patterns of unstable boom and bust.

1.1 Systemic risk and its origins

Systemic risk can originate from various types of source. It can be exogenous to the financial system, originating from severe macroeconomic shocks. It can also be endogenous to the financial system, such as risks emerging from financial imbalances or via contagion effects. Financial imbalances notably comprise excessive credit growth, leverage and maturity mismatches, while contagion can derive from the interconnectedness across financial firms or herd behaviour.

Endogenous or exogenous sources of systemic risk can be of a cyclical or time-varying nature or can relate to structural or cross-sectional sources of risk. The *time- varying dimension* derives from the accumulation of risks over the financial cycle and pro-cyclicality. There is a tendency for financial firms, companies and households to take on more risk in the upswing of a financial cycle and to become overly risk-averse in a downswing. Such behaviour has a variety of underlying causes, such as myopia about risk and herding in financial markets. In line with the stylised fact that credit booms sow the seeds of subsequent credit crunches, Schularick and Taylor (2012) have provided robust econometric support for a clear link between credit and financial crisis.

However, although the financial cycle is an important predictor of financial crisis, it has different properties from the better understood business cycle. Relative to the typical business cycle, the financial cycle is usually longer and its amplitude is higher than that of GDP fluctuations in regular business cycle frequencies (see Chapter 3). These empirical findings are fundamental for the establishment of an additional countercyclical financial policy function that complements its macroeconomic stabilisation policy counterparts. If the cycles were broadly aligned, macroeconomic and monetary policies could also regulate systemic stability. The same set of policy instruments could address both monetary and macroprudential policy objectives.

The *cross-sectional dimension* of systemic risk relates to the distribution of risks across the financial system, notably deriving from direct and indirect interconnectedness. This comprises financial institutions' cross holdings of each other's assets, engaging in similar investment strategies or herding behaviour, for example.

In the run-up to the 2007-08 financial crisis, as credit expanded and assets grew, the financial sector's share of overall economic activity increased exponentially. This was the product of two developments: increased leverage in the banking sector and the expansion of the non-bank financial sector. Macroprudential instruments, while focused primarily on the banking sector, need therefore to extend to the entire financial system, comprising financial institutions (banks and non-banks), the financial markets and the financial market infrastructure.

1.2 Macroprudential policy instruments

Macroprudential policy applied effectively is an intrinsically pre-emptive and countercyclical policy. In the aftermath of the crisis, it became clear that the way to contain risks to system-wide stability would be to curb the excessive accumulation of risk over time and increase the resilience of the financial sector, in conjunction with microprudential supervision. It would furthermore require a system-wide perspective to be embedded in financial regulation, notably for tool calibration and to create the right set of incentives for market participants.

Regulation in place before the crisis could be described as static, targeting primarily bank capital and focused on individual institutions. In the aftermath of the crisis, financial regulation needed to be adjusted considerably to account for the systemic dimension. New tools were designed and calibrated to increase the resilience of the financial system and address systemic risk. Time-varying tools addressing cyclical developments have been established in an attempt to moderate the financial cycle.

In fact, the comprehensive regulatory overhaul in response to the financial crisis was conceived from a macroprudential perspective.

Most of the regulatory reforms focused on making banks safer by bolstering bank capital, limiting leverage and enhancing their liquidity position. Policy instruments addressing fragilities in the banking sector can be broadly classified into three main categories: capital-based, liquidity-based and borrower- (or asset)-based measures. Instruments may have a structural (static) or a time-varying dimension.

Reforms were also introduced to deal with risks stemming from non-bank institutions or the shadow banking sector. To name a few, broker-dealers in the United States have become more strongly consolidated into banking structures. Stricter requirements for capital market activities, such as market-making and trading in derivatives and repos have helped constrain some investment banking activities. There have also been important regulatory changes in market infrastructures, such as the use of central counterparties and disclosure requirements in OTC derivatives or in the introduction of margins and haircuts in collateralised in financial market transactions.

1.3 Special considerations in a monetary union

One element of the euro area that makes it considerably different from national constituencies is the potential for asynchronous financial and business cycles within the monetary union. As illustrated in Charts 7 and 8 in Chapter 3 of this paper, country financial cycles within the euro area have tended to be quite heterogeneous across the main countries. This indicates that an additional policy lever would be required at the national level to contain any unwarranted build-up of systemic risk at the country level.

Apart from the potential for stark divergence of national financial cycles, specific to a monetary union, there is the more general issue of potentially divergent business and

financial cycles. In such circumstances, monetary policy must remain anchored to its primary goal of ensuring price stability for the euro area as a whole. While other goals, such as euro area financial stability are important, a supranational policy instrument cannot address instability in national asset markets. This is the task of macroprudential policy.

Even outside a currency union arrangement, there are various reasons why monetary policy should not be the first policy instrument to deal with financial instability in asset markets. First, the monetary policy objective may require an expansionary stance when asset markets require restrictive measures, reflecting different positions in the business and financial cycle. Second, there is the question of whether monetary policy, through its main policy instrument – the short-term interest rates – can effectively target asset market prices. Finally, monetary policy affects all sectors simultaneously. The tool is therefore too blunt, or even ineffective, to cope with specific imbalances in the financial sector.

The effective conduct of macroprudential policy can therefore help monetary policy to remain focused on fulfilling its price stability mandate. Monetary policy alone cannot address the heterogeneity in financial conditions among the countries in a monetary union, since changes in policy rates are the same for all members.

The role of macroprudential policy is all the more relevant in a monetary union where economic and financial conditions may significantly differ across the member countries. With its granular and targeted instruments, macroprudential policy provides the most appropriate tool for staving off financial stability risks in the specific areas where they arise, be it at the level of a country, sector or financial institution.

By dealing with imbalances specific to a group of countries or to a given sector of the euro area economy, macroprudential policies can effectively take into account heterogeneities among its members and contribute to reducing segmentation, thus enhancing the effectiveness of monetary policy.

Furthermore, interest rates are too blunt a tool to address imbalances specific to a certain region or sector. Macroprudential policies, however, can be designed and calibrated to deal with the specific structural, cyclical and institutional issues of the member countries.

2 The ECB's macroprudential policy framework

In 2013 the Single Supervisory Mechanism (SSM) Regulation[18] conferred specific tasks on the ECB specific tasks concerning policies relating to the prudential supervision of credit institutions. These were intended to contribute to the safety and soundness of individual credit institutions, as well as to the stability of the financial system both within the Union and in each Member State.

In terms of macroprudential policy in the euro area, the power to initiate and implement macroprudential measures, as provided for in the SSM Regulation, remains primarily with the national authorities, subject to a notification and coordination mechanism vis-à-vis the ECB. However, any national supervisory or macroprudential authority may propose to the ECB that it acts on their behalf in order to address the specific situation of the financial system and the economy in its Member State.

Moreover, Article 5 of the SSM Regulation stipulates that the ECB can apply additional capital buffers, including a capital conservation buffer, a countercyclical capital buffer and capital buffers for global and other systemically important institutions, to ensure that credit institutions accumulate a sufficient capital base to absorb losses when they materialise. Furthermore, the ECB can also apply other measures set out in EU law that are intended to address systemic or macroprudential risk. Section 2.2.2 provides an overview of the various instruments.

In order to ensure full coordination, where national competent authorities (NCAs) or national designated authorities (NDAs) impose such measures, the ECB should be duly notified. Similarly, when the ECB applies higher buffer requirements and more stringent macroprudential measures, it should follow the same coordination procedure with national authorities. In addition, as a second step, authorities should also comply with the coordination procedures provided for in the Capital Requirements Regulation (CRR)[19] and Capital Requirements Directive (CRD)[20]. These procedures concern the coordination with European bodies, such as the European Systemic Risk Board (ESRB), the European Banking Authority (EBA), the European Commission, the EU Council and the European Parliament.

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18 Council Regulation (EU) No 1024/2013 of 15 October 2013 conferring specific tasks on the European Central Bank concerning policies relating to the prudential supervision of credit institutions (OJ L 287, 29.10.2013, p. 63).

19 Regulation (EU) No 575/2013 of the European Parliament and of the Council of 26 June 2013 on prudential requirements for credit institutions and investment firms and amending Regulation (EU) No 648/2012 (OJ L 176, 27.6.2013, p. 1).

20 Directive 2013/36/EU of the European Parliament and of the Council of 26 June 2013 on access to the activity of credit institutions and the prudential supervision of credit institutions and investment firms, amending Directive 2002/87/EC and repealing Directives 2006/48/EC and 2006/49/EC (OJ L 176, 27.6.2013, p. 338).

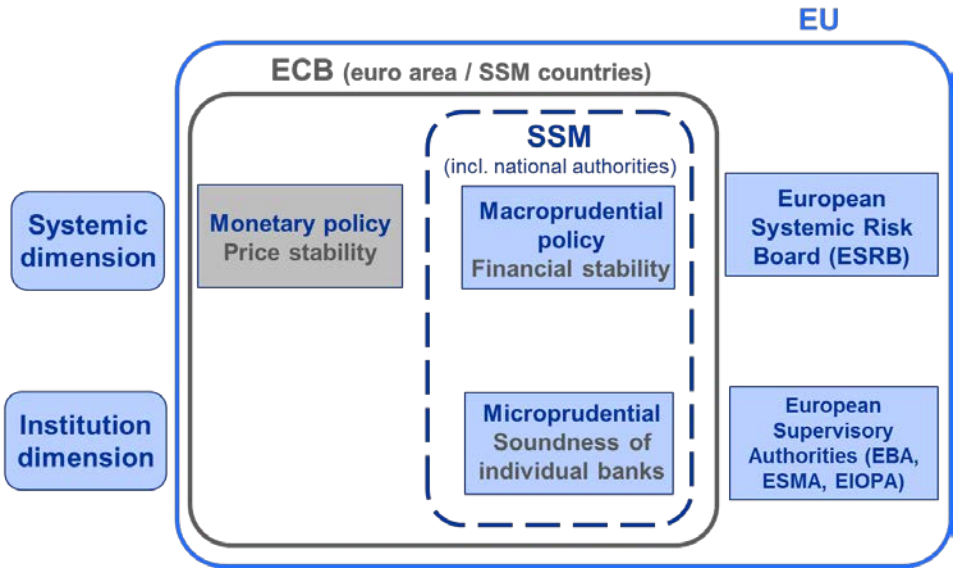
2.1 The institutional set-up and role of the ECB

2.1.1 SSM level

As mentioned above, when the SSM was established, both macro- and microprudential powers were conferred on the ECB. The ECB's tasks cover two distinct, though closely interrelated, dimensions of risks: systemic and institution-specific. The ECB's powers are exercised in coordination with other EU institutions, notably the ESRB for macroprudential issues, and the European Supervisory Authorities (EBA, European Insurance and Occupational Pensions Authority and the European Securities and Markets Authority) for microprudential issues (see Section 2.1.2. below).

The Figure 1 illustrates the relationship between monetary policy and the two dimensions of prudential policies in the EU.

Figure 1
Monetary and prudential policies at the ECB



With regard to microprudential supervision, at present, the ECB directly supervises the 118 significant banks of the participating countries. These banks hold almost 82% of the banking assets in the euro area. The decision on whether a bank is deemed "significant" is based on a number of criteria, including size, importance for the economy of the Union or any participating Member State, and cross-border activities. Banks that are not considered "significant" are known as "less significant" institutions and they are still supervised by their national supervisors in close cooperation with the ECB. Importantly, the ECB can decide at any time to directly supervise any one of these banks to ensure that high supervisory standards are applied consistently.

The ECB carries out banking supervision from a European perspective, *inter alia*, by (i) establishing a common approach to day-to-day supervision, (ii) taking harmonised supervisory actions and corrective measures, and (iii) ensuring the consistent application of regulations and supervisory policies. The ECB, in cooperation with the national supervisors, is responsible for ensuring that European banking supervision is effective and consistent.

With regard to macroprudential policies, national authorities and the ECB are jointly responsible for addressing systemic risk and, as highlighted above, the SSM Regulation gives the ECB the power to tighten certain measures implemented by national authorities. However, the ECB has no power to "scale down" national measures. The asymmetric nature of the powers assigned to the ECB aims at ensuring that systemic risk is properly addressed at the SSM level in case the national authorities do not take adequate action to implement macroprudential measures. This set-up also reflects the expectation that the NCAs and NDAs will be proactive in responding to the specific conditions experienced in their country at any particular time. In view of its specific role in ensuring that action is taken at the SSM level, the ECB focuses on identifying cross-border risk and contagion effects, analysing cross-border implications of policy measures, and reciprocating national macroprudential policies.

2.1.2 EU level

At EU level, the institutional framework mirrors the micro- and macroprudential split mentioned above. With regard to macroprudential oversight, the European Systemic Risk Board is placed at the centre of the EU institutional architecture. The ESRB was established in 2010 and is composed of the ECB, national central banks, representatives of the European Supervisory Authorities and the European Commission (as voting members), as well as national supervisory authorities and the president of the Economic and Financial Committee (as non-voting members). The ESRB is chaired by the ECB President. Furthermore, the ECB provides analytical, statistical, financial and administrative support to the ESRB.

Under the ESRB Regulation, the ESRB is responsible for the macroprudential oversight of the financial system within the Union. It contributes to the prevention or mitigation of systemic risk to financial stability in the EU which may arise from developments within the financial system, taking into account macroeconomic changes, so as to avoid periods of widespread financial distress. Furthermore, it contributes to the smooth functioning of the internal market, thereby ensuring a sustainable contribution of the financial sector to economic growth.

The main powers of the ESRB include issuing warnings and recommendations, which are legally non-binding instruments, but addressees are expected to act on them or explain why they do not. The framework is based on "moral suasion", which is underpinned by the credibility of the ESRB. The addressees of the warnings and recommendations can be the Union as a whole or one or more of its Member States, ESAs or national supervisory authorities. The ESRB should set a specified timeline for

the relevant policy response. Depending on the risks identified, the warnings and recommendations can be public or confidential, and general or specific in nature.

2.2 Objectives and instruments

2.2.1 Objectives

The ultimate objective of macroprudential policy is to contain systemic risk and thus ensure financial stability. As part of the ECB's strategy for containing systemic risk, its macroprudential policy includes the following operational objectives:

- Avoiding excessive accumulation of risk over time, in order to smooth the financial cycle. This involves addressing externalities related to strategic complementarities, e.g. externalities resulting from financial institutions' tendency to take on common exposures to credit and liquidity risk, including maturity mismatches, during upturn phases of the financial cycle, or to shrink their balance sheets by selling off similar assets during the downturn phases of the financial cycle.
- Contributing, alongside microprudential supervision, to increasing the resilience of the financial sector and limiting contagion effects. This involves addressing externalities related to interconnectedness, e.g. externalities resulting from financial institutions' direct and indirect relationships, such as holdings of each other's assets or mutual liquidity funding.
- Encouraging a system-wide perspective in financial regulation to create the right set of incentives for market participants.

2.2.2 Instruments for the banking sector

The macroprudential instruments for the banking sector can be classified as (i) capital-based measures, (ii) liquidity-based measures, (iii) borrower-based measures, and (iv) other instruments. Table 1 below provides a general overview of these measures, categorised according to the legal basis of their implementation.

Table 1

Classification of macroprudential instruments for the banking sector

	CRD IV Tools	CRR Tools	Other Tools
Capital-based measures	• **Countercyclical capital buffer** (CCB) • **Systemic risk buffer** (SRB) • **G-SII** & **O-SII** capital buffer	• **Risk weights** for real estate sector and intra-financial sector exposures • **Capital conserv. buffer** • **Own funds** level	• **Leverage ratio**
Liquidity-based measures		• **Liquidity requirements** • **Large exposure** limits (incl. intra-financial sector)	• **Non-stable funding levy** • **LTD ratio caps**
Borrower-based measures			• **LTV ratio caps** • **LTI ratio caps** • **DSTI ratio caps** • **DTI ratio caps**
Other measures		• **Large exposure** limits (incl. intra-financial sector) • **Disclosure requirements**	• **Margin and haircuts requirements**
	Can be used by national authorities and the ECB (for SSM countries)		**Can only be used by national authorities**

Capital-based measures aim primarily at increasing the resilience of the institutions so that they have sufficient loss-absorbing capacity on a “going concern” basis. These measures can be classified as (i) “hard requirements”, which are expected to be met at all times (such as minimum own funds requirements) or (ii) “buffers”, which institutions can use in stress periods, subject to certain restrictions on distribution (such as restrictions on dividends, bonuses or coupon payments on hybrid capital instruments). Buffers can address cyclical or structural risks (such as the countercyclical capital buffer and the systemic risk buffer, respectively), as well as the “too-big-to-fail” problem posed by large, complex, highly interconnected institutions (such as the capital buffers for global or other systemically important institutions).

Liquidity-based measures aim at addressing risks originating from maturity mismatches in institutions’ balance sheets. The EU legal framework currently includes the liquidity coverage ratio (LCR) as a short-term liquidity measure, and it is expected that the net stable funding ratio (NSFR), which addresses longer-term liquidity risks, will be added to the framework in the context of the ongoing revision of the CRR/CRD IV. Other measures, such as the levy on non-stable funding or loan-to-deposit ratio, are currently outside the EU legal framework and can therefore be applied only by national authorities that have included them in their national frameworks.

Similarly, borrower-based measures aimed at addressing the vulnerabilities of banks’ clients directly, which have proven to be effective in mitigating the financial cycle in several jurisdictions, are available to certain national authorities at the current juncture.

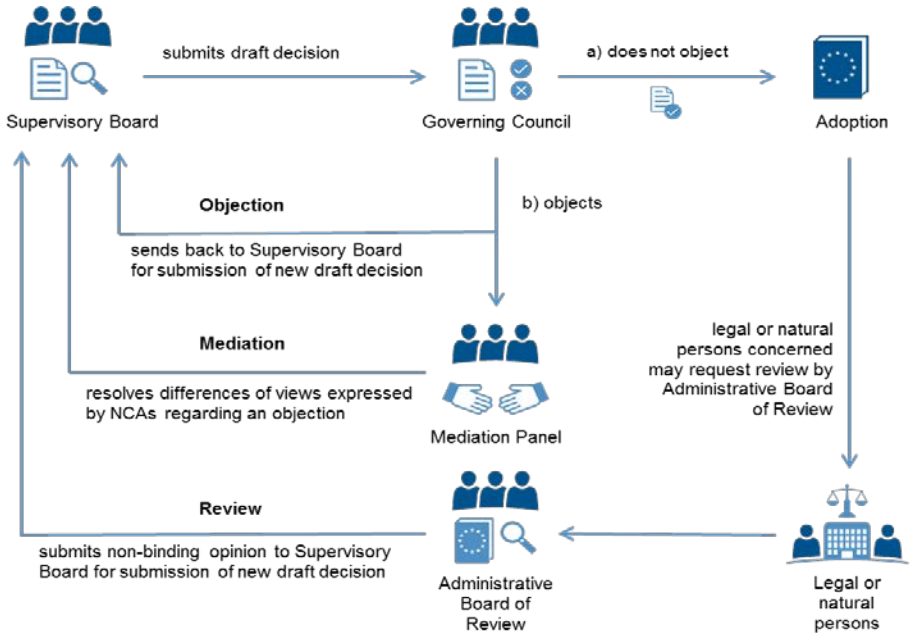
Finally, large exposure limit and disclosure requirements complement the EU macroprudential toolkit.

2.3 Decision-making and governance

With regard to the implementation of macroprudential measures by the ECB, the ultimate decision-making body is the Governing Council. Decisions are made by the Governing Council on a "non-objection" basis following the submission of draft decisions by the Supervisory Board. Decisions on macroprudential matters thus benefit from the Supervisory Board's detailed knowledge of the banking system and are procedurally separate from monetary policy decisions. Figure 2 below illustrates the decision-making process.

Figure 2

Decision-making process in the SSM



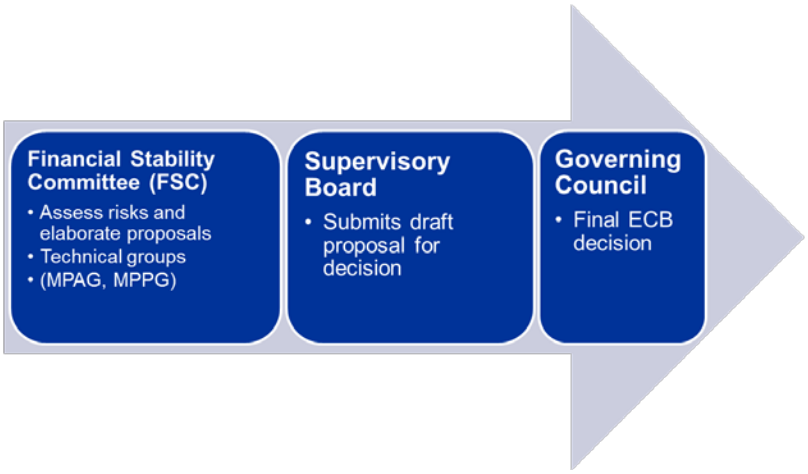
If a draft decision by the Supervisory Board is not objected to by the Governing Council, it should be considered as adopted. However, should the Governing Council express its objection to a draft decision, it can send it back to the Supervisory Board and request that a new draft decision be submitted. This procedure applies to both micro- and macroprudential decisions, the only difference being that the Governing Council can also amend the macroprudential draft decisions.[21] A mediation panel is set up to resolve differences of opinion expressed by the competent authorities of the participating Member States concerned regarding an objection by the Governing Council to a draft decision by the Supervisory Board. Once a decision is adopted, the legal and natural persons concerned may request a review by the Administrative Board of Review. This body can submit a non-binding opinion to the Supervisory Board, which can then reconsider the issue and may submit a new draft decision on the matter to the Governing Council.

[21] See Decision of the European Central Bank of 22 January 2014 amending Decision ECB/2004/2 adopting the Rules of Procedure of the European Central Bank (ECB/2014/1) (OJ L 95, 29.3.2014, p. 56).

In the preparatory phase of the macroprudential policy decisions, various macroprudential issues are discussed within the Macroprudential Forum, which is composed of the members of the Governing Council and the Supervisory Board. The Macroprudential Forum operates as a platform for regular discussion at the highest level, bringing together micro- and macroprudential perspectives from across the SSM.

Analytical and policy issues are discussed within the Financial Stability Committee (FSC), which is the main technical committee of the European System of Central Bank supporting the ECB in the area of macroprudential policy (see Figure 3). It includes high-level representatives from the national central banks and supervisory authorities of the SSM Member States. They meet to discuss macroprudential measures and advise the Governing Council on macroprudential concerns and potential policy responses, including the preparation of draft proposals for the activation of macroprudential tools.

Figure 3
Preparation of macroprudential policy decisions at the ECB



2.4 Macro- and microprudential policy at the ECB

Similarly to the interaction between monetary policy and financial stability, micro- and macroprudential policy also complement each other over a medium-term horizon. While microprudential measures are designed to increase the resilience of individual financial institutions, they also help moderate the emergence of vulnerabilities at the systemic level. Similarly, macroprudential instruments, by mitigating the accumulation of imbalances, also help make financial institutions more resilient.

Furthermore, there is a significant overlap between the instruments used in microprudential supervision and those used in macroprudential policy. Consequently, it is essential not only to ensure that information is shared between the two areas, but also to ensure a high degree of consistency in the actions taken. In the euro area, the clear governance structure set out in the SSM Regulation allows the ECB to benefit

from common access to information, to exploit synergies between the policy areas and to work within a consistent analytical framework. This framework also ensures that potential trade-offs and unintended consequences of micro- and macroprudential measures are properly accounted for in the decision-making process.

Potential conflicts of interest between micro- and macroprudential policy may arise not only from the overlaps between the toolkits, but also from differences in the optimal timing of the implementation of policy measures. Notably, in good times or periods of excessive credit growth, microprudential requirements may decrease (e.g. falling risk weights as probability of defaults and loss given defaults decrease), while macroprudential requirements may increase (e.g. activation of the countercyclical capital buffer). Conversely, in bad times/stress periods, microprudential authorities typically become stricter (e.g. increasing capital add-ons to protect depositors), while macroprudential authorities may aim to relax requirements (e.g. releasing the buffers to support lending). Finally, the fallacy of composition suggests that what is optimal for addressing risk at the institutional level may not always be optimal for addressing risks at the systemic level. Therefore, if implemented independently, micro- and macroprudential measures may offset each other. Since prudential requirements at the institutional and systemic levels are determined jointly by the actions of micro- and macroprudential authorities, the coordination of policy actions is of key importance.

These considerations are also reflected in the ECB's views on the revision of the macroprudential framework. In its contribution to the European Commission's consultation on the review of the EU macroprudential policy framework, the ECB highlighted that the review should clarify the roles of macro- and microprudential authorities in the regulatory framework by clearly aligning the responsibilities and powers relating to the available tools, on condition that both have a sufficient and effective toolkit to deliver on their objectives. Furthermore, it suggested that a proper definition of competent and designated authorities should be introduced to the framework, including their interaction and cooperation, where necessary. The goal of a review should be to address overlaps and eliminate blurred responsibilities, thus creating a transparent and predictable macroprudential policy framework. A case in point would be to clearly define Pillar 2 as a microprudential instrument used by competent authorities to address idiosyncratic risks relating to the individual risk profile of a given institution, provided that the macroprudential toolkit is extended and the framework is made more operational.

2.5 An incomplete institutional set-up and toolkit

While the establishment of the current institutional set-up and a corresponding macroprudential toolkit have been major steps forward, a number of lessons can be drawn at this stage from the experience thus far gained from the functioning of the framework. The ECB provided its contribution to the European Commission consultation on the review of the EU macroprudential policy framework in December 2016, in which it defined the main areas where it had identified shortcomings and where regulatory action was needed.

With regard to the institutional set-up, the Commission published a proposal in 2017 for targeted changes to the governance of the ESRB intended to increase its visibility and effectiveness. The ECB supports these objectives and considers it important to maintain the close link between the ECB and the ESRB. In this context, the ECB will continue to support the ESRB to avoid duplicating work, thus taking advantage of the benefits arising from the ECB's risk assessment role and analysis of the banking sector in the SSM Member States.

In terms of the macroprudential toolkit, the ECB would see benefits in conducting a comprehensive review of the macroprudential policy framework, with the primary objective of enhancing its effectiveness and reach.

In this regard, the ECB considers it important to eliminate the overlaps between various instruments and to increase flexibility in the capital buffer framework. Specifically, this would include work to better delineate the policy objectives of capital buffers (in particular the systemic risk buffer and the G/O-SII buffers) and to enhance authorities' flexibility in calibrating the O-SII buffers at a higher level commensurate with the underlying risks.

It would also be important for the toolkit to include instruments that can be used in a more targeted manner, including their application at a sectoral level, such as sectoral capital buffers, risk weights and exposure limits. In addition, the ECB would see merit in harmonising the definitions of borrower-based measures and in making them available to all macroprudential authorities by integrating them into the European legislation.

Furthermore, to enhance the framework's efficiency, activation procedures should be streamlined where these do not add value in terms of safeguarding the Single Market. A case in point would be the removal of the so-called "pecking order" from the legislation, which currently sets a mandatory sequencing requirement for the activation of certain instruments, ignoring the underlying aim of the measure and the relative effectiveness of the instrument in addressing the risk.

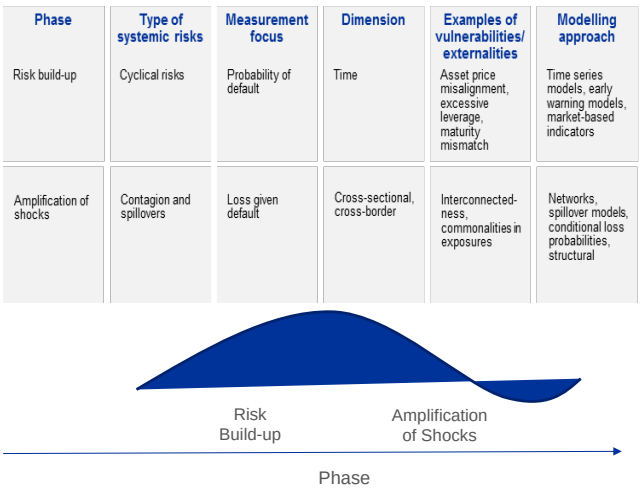
Finally, it is important to ensure that the regulatory framework is revised at regular intervals in the future and amended to include new instruments. Specifically, instruments addressing risks in the rapidly growing non-bank sector should in the future be included in the macroprudential authorities' toolkit.

3 The analytical apparatus

The ECB has actively contributed to expanding the range of systemic risk measures that are appropriate for informing macroprudential policy at the financial institution, country and system levels. This has encompassed measures to inform timely monitoring (probability) and assessment (severity) of systemic risk. Measuring systemic risk is inherently complex – methods are needed not only to support mitigation policies in the risk materialisation phase of a financial cycle, but also to play a timely pre-emptive role during the phase in which there is a build-up of vulnerabilities (see Chart 2). To cover the full spectrum of these phases, analytical work at the ECB has concentrated on three areas. First, empirical methods designed to process a wide range of information have been developed that gauge the prospect of near-term systemic stress. These include coincident indicators of financial market stress and methods to gauge near-term risks to economic growth stemming from mechanisms that propagate systemic risk. Second, measures have been developed to capture timely readings needed to understand the build-up of systemic risk, which, in light of the monetary union in the euro area, is focused on country-level financial cycle measurement and early warning. Third, considerable resources have been devoted to developing state-of-the-art macro-financial models to gauge the potential severity of systemic risk. Each of these approaches is examined below.

Chart 2

Critical phases of a financial cycle



Sources: ECB, ECB calculations.

3.1 Taking stock of measures of the state of financial (in)stability

Research on financial stability metrics has flourished in the last decade. This research can be broken down into three aspects of systemic risk: amplification, contagion and

systemic risk build-up (see, for instance, Benoit et al., 2017, similar to the taxonomy of systemic risk outlined by the ECB Macroprudential Research Network (MaRS)).[22]

In parallel with work on theoretically grounded notions of systemic risk in these three areas, it has become commonplace to use certain empirical measures, involving market-based indicators, to measure the impairment of the financial system. ECB staff has actively contributed to the development of various systemic risk indicators, regularly publishing findings in the ECB's Financial Stability Review. One of the longest reported metrics has been the probability of default of large and complex banking groups (JPoD), which has been complemented by advances in systemic risk measurement at the euro area level via the Composite Financial Stress Index (CISS), and at the country level using the Country Level Index of Financial Stress (CLIFS).[23] These coincident indicators usefully analyse market data to measure the extent of contemporaneous disruptions in the financial system. Thus, they appropriately track the amount of financial stress and are especially useful for crisis management policies. Notwithstanding their value in this respect, they provide limited predictive information and require a broader sweep of balance sheet vulnerabilities to inform pre-emptive macroprudential policy.

While no single measure can fully capture the complex set of market failures underlying systemic risk, a combination of complementary perspectives can provide a systematic synthesised reading on the state of financial stability – from a *near-term* perspective of imminent euro area level stress to a *medium-term* one relating to a build-up of vulnerabilities in euro area countries.[24]

An evaluation of near-term risks to financial stability needs to bring in the complex mechanics underlying a risk materialisation phase – in which accumulated vulnerabilities and system resilience come together. The ECB's work has focused on generating a reading across such measures and measuring their impacts in terms of the risk of a deep recession (consistent with definitions of systemic risk). It has also focused on combining indicators in a standard financial stability monitoring framework to assess the build-up of vulnerabilities with measures of propensity for contagion in the cross-section to ascertain risks of large macroeconomic losses. Such measures capture the risk build-up in the time dimension, in addition to shock amplification, which is informed by the cross-sectional or cross-border dimension. The latter set of indicators encompasses overall systemic risk and can also be broken down into the contributions of individual financial institutions: (i) interconnectedness or amplification measures, which are standard network indicators that assess the importance of the nodes or network concentration; (ii) contagion measures based on simulation of

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22 For more on the Macroprudential Research Network (MaRS), see https://www.ecb.europa.eu/pub/economic-research/research-networks/html/researcher_mars.en.html

23 For the CISS, see Holló et al (2012), for the CLIFS, see Duprey et al (2015), f or the probability of default of two or more large and complex banking groups, see *Financial Stability Review* (2007), box entitled "A market-based indicator of the probability of adverse systemic events involving large and complex banking groups", European Central Bank, Frankfurt am Main, December, pp. 125-127.

24 The work resulted in two new indicators: the financial stability risk index (FSRI) and the cyclical systemic risk indicator (CSRI) published in the *Financial Stability Review (2018) European Central Bank, Frankfurt am Main, May*, see Deghi, A., Welz, P. and Żochowski, D., Special Feature A: "A new Financial Stability Risk Index (FSRI) to predict near term risks of recessions", and Detken, C., Fahr S., and Lang. J.H., Special Feature B: "Predicting the likelihood and severity of financial crises over the medium term with a Cyclical Systemic Risk Indicator (CSRI)".

default cascades in the networks; and (iii) systemic risk-taking indicators relating to systemic liquidity in the financial system.

The main value of systemic risk indicators lies in whether they predict severe recessions. The effects of materialising systemic risk concern the left tail of the real economic growth distribution when an initial shock is endogenously aggravated by the activation of multiple vicious spirals, such as the bank-sovereign nexus, macro-financial negative feedback loops and liquidity spirals and fire sales. Vulnerability indicators that are good predictors of the materialisation of systemic crises are well-documented in the literature. However, the extent to which systemic risk measures are useful in gauging the magnitude of the crises has been less studied. Yardsticks of spillovers and contagion risks could be useful in assessing the potential magnification effect of an initial shock. Measures of spillovers and contagion may contain information on the strength at which the risks could be amplified when they materialise. As such, they could be helpful in assessing the costs of the crises, in the form of the size of economic downturns.

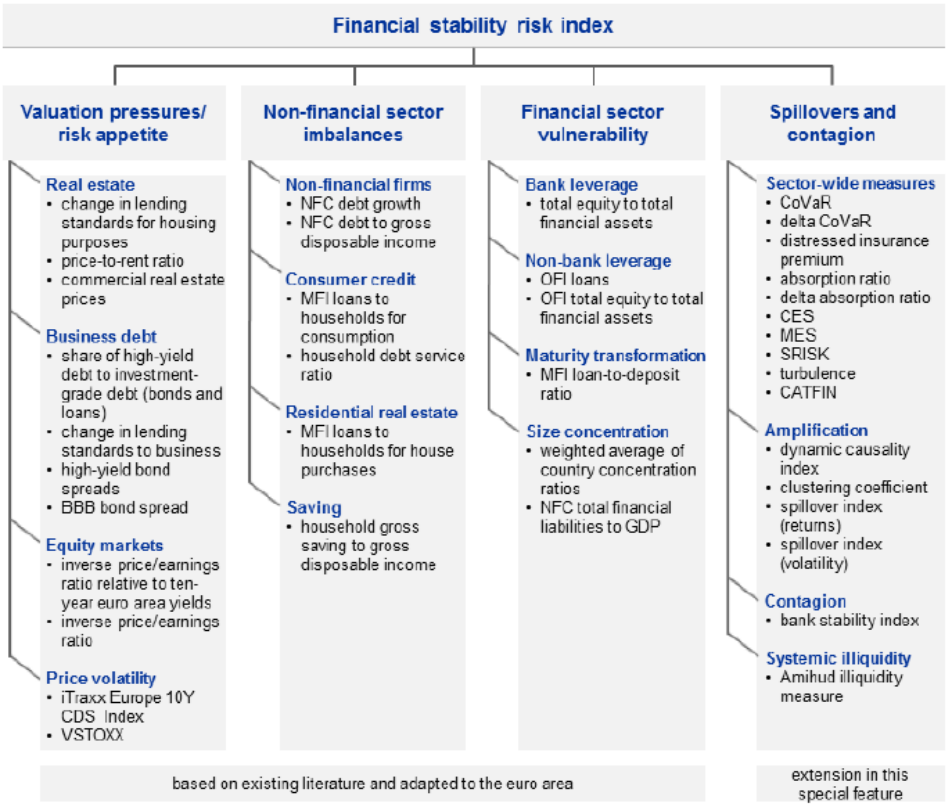
To capture such near-term risks of deep recessions, a financial stability index for the euro area incorporates relevant information extracted from the large set of indicators of cyclical and structural vulnerabilities. Specifically, data dimension reduction, which is useful for predicting large economic downturns, is applied to efficiently aggregate information across indicators.

The financial stability risk index (FSRI) for the euro area as a whole evaluates near-term risks to the economic outlook (see Figure 4). It combines 23 macro-financial indicators used to measure the time dimension of systemic risk, covering pressures on asset price valuation, measures of risk appetite, non-financial imbalances and financial sector vulnerabilities. In addition, the indicator captures the cross-sectional dimension of systemic risk by taking into account 16 measures of spillover and contagion risks, including the well-known measures, SRISK, CoVaR and Marginal Expected Shortfall (MES).[25] These may contain information on the potential amplification of initial shocks and could provide indications about the severity of economic downturns.

[25] For SRISK, see Brownlees and Engle (2017), for CoVaR, see Adrian and Brunnermeier (2016), for MES, see Acharyaet al (2010).

Figure 4

A taxonomy of indicators for monitoring systemic risk



Source: ECB Financial Stability Review (May 2018).

The approach underlying the FSRI combines the time dimension of systemic risk with the cross-sectional dimension, while the broad range of indicators helps to cover the multifaceted aspects of financial instability. To develop the near-term predictive power for severe recessions and to efficiently aggregate information across indicators, the information contained in the numerous individual indicators is first reduced with the help of four factors to filter out noise. [26] In a second step, the four factors are recursively regressed within a quantile regression set-up on the GDP components that remain unexplained one quarter ahead. The use of quantile regressions captures non-linearities around systemic crises and makes it possible to focus on the amplification mechanisms during severe recessions. Finally, the forecast performance is evaluated using a goodness-of-fit measure, combining the residuals with the quantile loss function.

The FSRI provides a comprehensive view of the level of near-term financial stability risks that could lead to negative repercussions for the real economy. The indicator successfully captured the most important euro area events during the recent crisis episodes. It increased at the outbreak of the financial crisis and reached an all-time high in the fourth quarter of 2008 after the default of Lehmann Brothers; it spiked again at the height of the euro area sovereign debt crisis in 2011 and 2012, when the vicious

[26] Two alternative data reduction methods were used for robustness: the principal component analysis and a dynamic factor model with time-varying parameters.

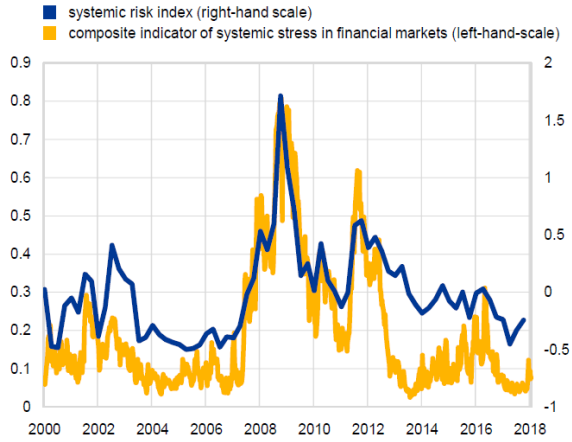
circle between banks and sovereigns led to speculation about redenomination risks in the euro area. The most recent readings of the index point to a moderate increase in systemic risk on the back of higher risk appetite and higher contagion and spillover risk.

The FSRI has similar features to the CISS, but unlike the CISS, it does not tend to fall as abruptly after policy interventions thanks to the incorporation of non-financial variables. The FSRI thus complements the CISS and provides a risk narrative via its grouping into four factors (see Chart 3). The predictive power for near-term economic activity makes the FSRI particularly useful in the financial stability monitoring toolkit, as it helps assess the costs of a crisis.

Chart 3

Systemic risk index and the CISS

(January 2000 to March 2018; Q1 2000 to Q4 2017)

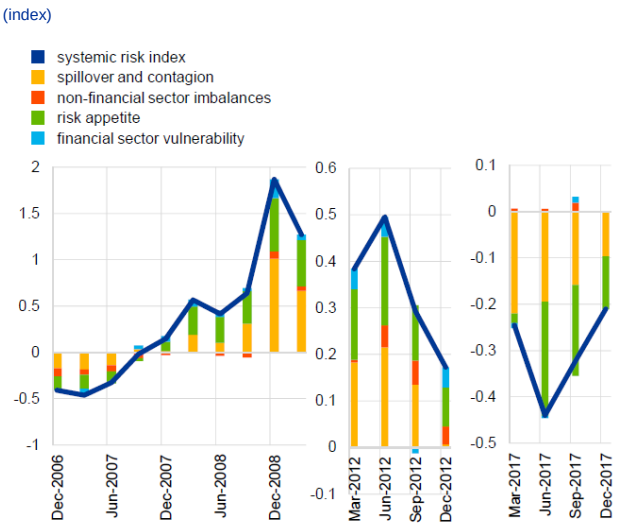


Sources: ECB, ECB calculations.
Notes: The composite indicator of systemic stress in financial markets (CISS) is normalised to lie between 0 and 1. Systemic risk index: quarterly frequency; CISS weekly frequency, two-week moving average.

Contribution analysis of its development suggests that the most recent pick-up in the value of the systemic risk index is driven primarily by higher risk appetite and an increased contribution from spillover and contagion risks (see Chart 4). While these two categories are still a drag on the overall level of the index from a historical perspective, their negative contributions have declined in the second half of 2017. Similarly, these categories were also the major contributors to systemic risk in the period 2007-09 and during the sovereign debt crisis.

Chart 4

Breakdown of the systemic risk index into its major components for selected periods



Sources: ECB, ECB calculations.

3.2 Measuring the build-up of systemic vulnerabilities

An essential feature of macroprudential policy that distinguishes it from its microprudential counterpart is its clear countercyclical orientation. One of the main values of macroprudential policy is its pre-emptive focus on tempering the financial cycle, in addition to enhancing the resilience of the financial sector ahead of crises. In the euro area context, the relative effectiveness of macroprudential policy in tackling the build-up of financial stability risks is even more pronounced owing to the fact that, in a monetary union, a single monetary policy is ill-suited to deal with financial imbalances emerging at national level. Such imbalances are better tackled with targeted national macroprudential measures.

A complementary perspective that is more directly focused on medium-term risks to financial stability seeks to measure the cyclical systemic risk of a financial crisis over a longer forecasting horizon of two to three years. In monitoring cyclical systemic risk, the focus is on assessing the probability that a systemic crisis will materialise, while in monitoring structural risk, the focus is on assessing the overall damage that a shock to the financial system could create, taking account of possible amplification mechanisms.

3.2.1 Measures of country financial cycles

Financial cycles are not directly observable. Their elusive nature belies their powerful potential to destabilise financial equilibrium. The systemic risk build-up inherent in a bullish cycle has been at the heart of historic crises (going back centuries, as described in Reinhart and Rogoff (2008) and Schularick and Taylor (2012)). Although

the move to curb financial cycles, as one of the main macroprudential policy objectives, has come to the fore in the last few years, the research literature on empirical measurement of financial cycles remains in its infancy – particularly when compared with its business cycle counterparts. To support its policy mandate, work at the ECB has continued to try to fill this knowledge gap in financial cycle measurement and understanding, focusing on euro area countries (see Schüler, Hiebert and Peltonen, 2015 and 2017).

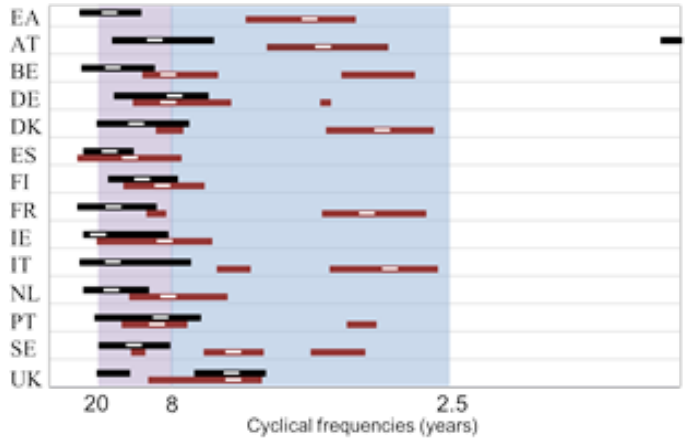
At the ECB, we have broadened the credit cycle concept prevalent in much of the literature to include asset prices and therefore bring it more in line, on an empirical basis, with the concept of leverage cycles (see Geanakoplos, 2009). The methodological aim is to extract variation at a cyclical frequency common to asset prices and credit. To this end, we construct a *narrow* measure of the financial cycle – including credit and house prices – as well as a *broad* measure – also expanding narrow cycles to encompass equity and bond prices.

We show that composite financial cycles, emphasising expansions and contractions common to credit and asset prices, are lengthy for most euro area countries. Estimates from a frequency domain-based perspective suggest the average financial cycle length is around 15 years, about twice the length of business cycles. As shown in Chart 5, there is considerable heterogeneity across countries; in the case of some countries, important medium-term frequencies characterise economic growth as the economy moves between lengthy periods of relative stagnation and expansion (see also Comin and Gertler, 2008). Lastly, financial cycles tend to have a higher amplitude than their business cycle counterparts – almost twice the size.

Chart 5

Country financial cycle length (applying spectral methods in the *frequency* domain)

(cyclical frequencies, years)



Source: ECB calculations based on Schuler et al. (2017).

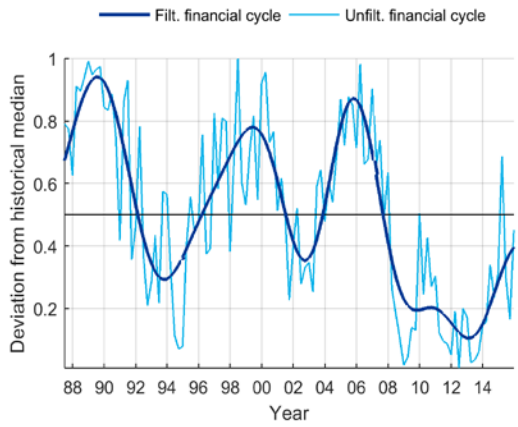
Moving to the time domain, which is important for policymaking, the ECB's findings suggest that, despite the strongly idiosyncratic nature of the credit market and main asset price markets, the consistency of their joint dynamics is striking. The strong short-term volatility of equity markets, in particular, is eliminated when their movements are combined with bond prices, property prices and total credit using a

simple aggregation scheme that emphasises positive movement – prior to any filtering (see Chart 6 for an illustration of this phenomenon using an aggregate euro area index).

Chart 6

Euro area composite cycle (applying time-varying aggregation and filtering in the *time* domain)

(standardised units, 0.5 = historic median)



Source: ECB calculations based on Schuler et al. (2017).

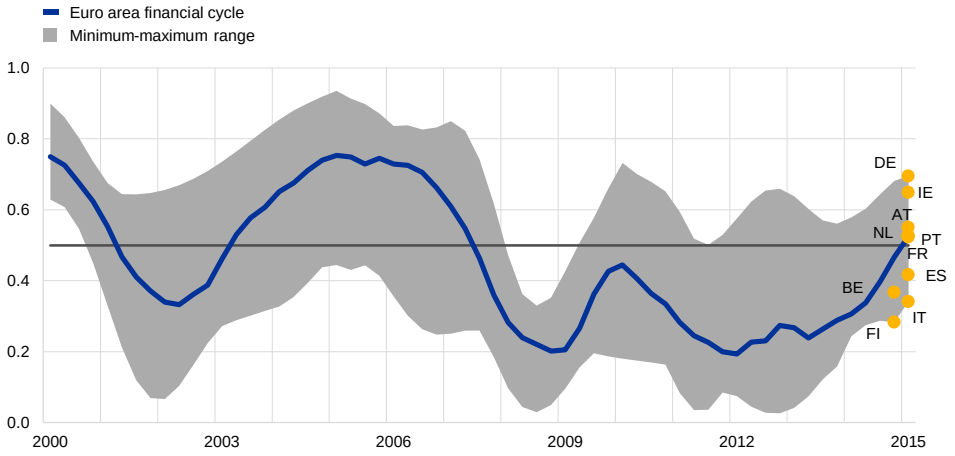
Financial cycles also powerfully predict systemic banking crises. In terms of signalling, equity prices tend to precede credit. In terms of performance, out-of-sample signalling results suggest that composite financial cycle indices, which exploit the co-movement of credit and asset prices, are the best indicators for predicting the start of systemic banking crises and periods of vulnerability. In predicting the start of crises, a broad index, which considers the interaction of credit, housing, equity and bond prices, has an AUROC (area under the receiver operating characteristic) curve that is significantly higher than any individual indicator or, for that matter, the credit gap. This performance is the same as that of the narrow index, mirroring the co-movement of credit and house prices only, albeit to a somewhat lesser extent given the noisiness of asset markets.

Across countries, financial cycle synchronisation is strong for most, but not all, countries. In contrast, business cycles show a homogeneous relationship.

Chart 7

Historical analysis of country financial cycles in the euro area

(correlation of financial variable with financial cycle)

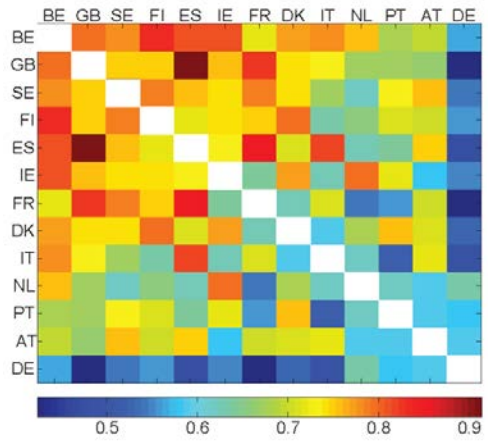


Source: ECB calculations based on Schuler et al. (2017).
Notes: (Q1 2000 – Q2 2015; normalised deviation from historical median). The shaded area marks the locations of financial cycles of ten euro area countries (AT, BE, DE, ES, FI, FR, IE, IT, NL and PT). Figures for BE and FI refer to Q4 2014, while figures for PT refer to Q1 2015.

Chart 8

Concordance of financial cycles across countries

(concordance measure, [0,1] normalised scale)



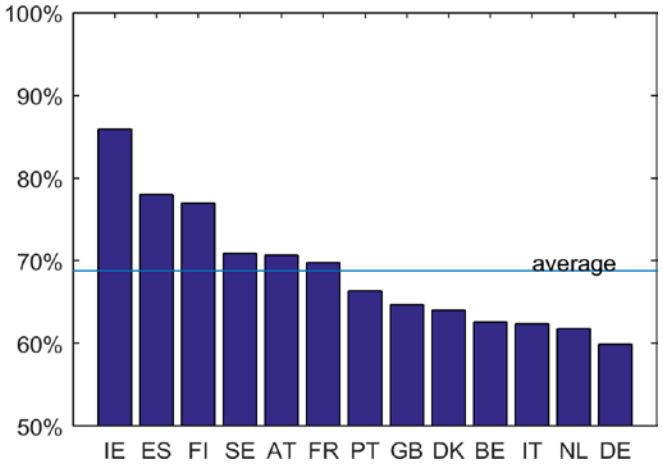
Source: ECB calculations based on Schuler et al. (2017).
Note: Results shown are derived from a standard turning point analysis on the smoothed financial and business cycle indicators.

Compared with business cycles, financial cycles differ in amplitude and persistence, although the degree of difference varies across countries. Relative to their business cycle counterparts, we find that financial cycles have a longer duration, higher amplitude, and exhibit far higher symmetry. Furthermore, we show that financial and business cycles synchronise, on average, only two-thirds of the time. Our results indicate that countries with very persistent financial cycle downturns synchronise the least with their business cycle counterparts (see Hiebert, Jaccard, Schüler, 2018).

Chart 9

Heterogeneous concordance of national financial and business cycles

(concordance measure, [0,1] normalised scale)

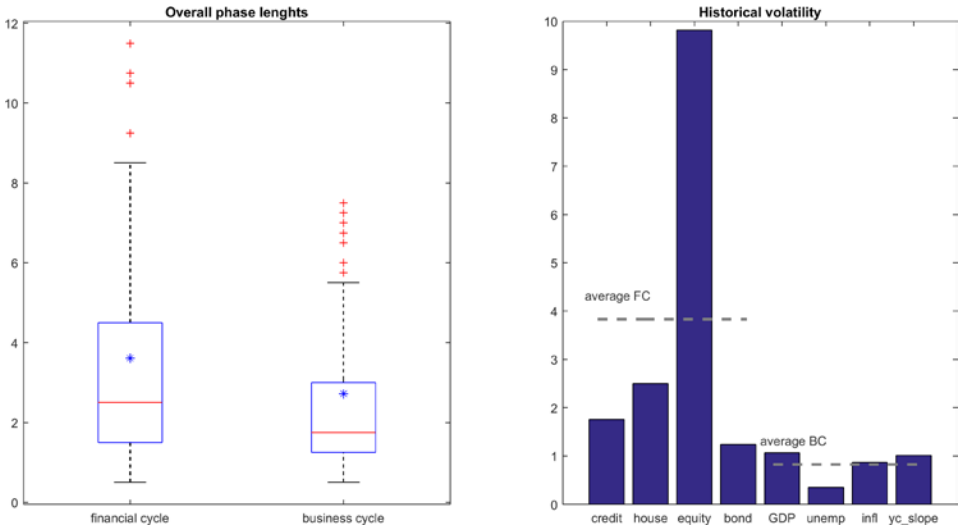


Source: ECB calculations based on Schuler et al. (2017).
Note: The results shown are derived from a standard turning point analysis on the smoothed financial and business cycle indicators.

Chart 10

Higher volatility and persistence of financial cycles compared with business cycles

(standardised units, 0.5 = historic median)



Source: ECB calculations based on Schuler et al. (2017).
Notes: The results shown are derived from a turning point analysis on the smoothed financial and business cycle indicators. LHS chart: Boxplots show the distribution of length in years of the filtered series. RHS chart: Historical standard deviation, bars reflect average across countries for specific indicators, dotted line represents average across indicators.

Several possible economic mechanisms could underlie this difference between financial and business cycles. First, debt overhang effects are likely to be a contributing factor, as periods of debt build-up give way to a lengthy period of debt deleveraging. Other competing mechanisms outlined in the theoretical literature could also play a role – including financial shocks embedding accelerator-like properties, expectational errors and market failures stemming from the scope for strategic complementarities, structural features of national housing markets and credit booms.

3.2.2 Early warning models

Early warning models are a key element of the analytical apparatus supporting macroprudential policy decision-making. Their purpose is to provide warning signals well before risks materialise, i.e. in the build-up of vulnerabilities phase, to allow the policymaking authority to take measures to increase resilience and counter the financial cycle in a timely manner. Predicting financial crises is a difficult, some would say impossible, undertaking. This scepticism stems from the mistaken application of the efficient market hypothesis to financial crises so that all information on future developments should be reflected in current market prices. And indeed, one stylised fact is that there is little information on major forthcoming market corrections in financial asset price warnings over any useful horizon. However, the efficient market hypothesis has lost followers in the wake of the great financial crisis. Furthermore, the early warning literature shows that there is indeed useful information to be obtained from lower frequency changes in fundamental variables covering private sector indebtedness, financial sector leverage, real estate price changes and indicators measuring a general risk-taking attitude. A rise in these variables has historically indicated the build-up of financial stability vulnerabilities. Nevertheless, it is futile to try to predict the exact timing of a crisis. However, identifying the build-up of vulnerabilities, which have a high probability of leading to a crisis at some future point in time, is to some degree possible. Early warning models might not appeal to short-term speculators in financial markets but could prove useful for macroprudential policymakers.

Nevertheless, several caveats apply to the use of such models for policymaking, especially in the context of the ECB's macroprudential policy mandate. Early warning models exploit historical patterns in the periods leading up to financial crises. If the next crisis has very different characteristics from those observed historically, early warning models will not issue a timely signal. Even if the underlying pattern remains the same – and there is some historical evidence that some key patterns are indeed surprisingly similar across countries and centuries – relevant structural breaks may invalidate the signal. A high debt ratio might have a different relevance in a fixed or a flexible exchange rate regime. A world with tighter financial regulation is likely to be able to cope with higher levels of vulnerabilities without triggering a crisis. Another complication arises from Goodhart's law, which claims that "any observed statistical regularity will tend to collapse once pressure is placed upon it for control purposes". Thus, the more early warning models are used for successful macroprudential policy decisions, the fewer analysts are able to confirm the appropriateness of the underlying models in the future, as the statistical relationship between a risk indicator and subsequent crisis may no longer be found in the data. Finally, in the context of the euro area, countries' financial sectors differ structurally, which should lead to a more prudent interpretation of the model-based results. A pooled crisis database covering several countries allows for a more efficient identification of relevant early warning models and robust thresholds for issuing signals, but this large sample of crises also increases the heterogeneity of historical experiences. A common threshold for all countries derived from such a pooled exercise would certainly not always lead to appropriate warning signals if there are significant national specificities in a country's financial sector. A last caveat refers to the often-expressed accusation that early

warning modelling is a classic attempt at data mining and sample overfitting. The temptation to explain crises with the benefit of hindsight instead of predicting them certainly exists, but a lot of progress has been made in significantly reducing this fallacy. The variables are often selected using automated selection methods (e.g. Lasso), out-of-sample validation (i.e. validating the performance of individual indicators with a subset of the overall sample, which is not used for the identification of or threshold generation for that indicator) or with recourse to economic theory. Early warning models for financial crises are evaluated at the ECB using out-of-sample exercises. In this way, the policymaker is given a fair assessment of the potential past performance of the selected early warning models and indicators in terms of type one and type two errors made in quasi-real time.[27]

In the following section, we briefly describe the early warning models developed and used at the ECB. Five types of approach are computed to derive early signals that vulnerabilities are building up in the SSM Member States. These approaches are a) univariate and bivariate signalling models, b) a multivariate logit early warning model at the country level, c) a multivariate logit early warning model using individual bank level data,[28] d) a machine-learning algorithm known as random forest,[29] and e) aggregate risk indicators derived from risk scoreboards.

Table 2 gives an example of how the early warning information is presented in a policy document. The columns show the latest value of the indicator or estimated crisis probability per country. As the technical experts producing the report do not know the policy preferences of the decision-making bodies in terms of type 1 and type 2 errors with certainty at each point in time, which might also vary across individuals, it is not advisable to compute one single signalling threshold, reflecting one policy preference. Instead, the colour code is selected out of six buckets and depicts the conditional crisis probability for the current value based on historical experience. The darker the colour, the higher the conditional crisis probability, varying between zero and 40%. The colour code visually shows the probability with which this particular value has led to a crisis in the following five to 12 quarters based on euro area countries' past experiences of crises.

27 See also Alessi, L., Detken, C. and Oprica, S. (2015), "On the evaluation of early warning models for financial crises" in "Financial and banking crisis prediction through early warning systems", IGI Global, Hershey, PA.

28 See Lang, J.H. (2016), "A bank-level early warning model and its uses in macroprudential policy", *Macroprudential Bulletin*, Vol.1., European Central Bank, Frankfurt am Main.

29 See Alessi, L. and Detken, C. (2018), "Identifying excessive credit growth and leverage", *Journal of Financial Stability*, Vol. 35, pp. 215-225.

Table 2

Identified vulnerabilities based on selected univariate signalling models with asset price indicators

	Residential property price overvaluation measure	Residential property price-to-income ratio	Real residential property price average 3-year growth rate	Real equity price average 3-year growth rate
Latest observations	Q3 2017 [1]	Q3 2017 [1]	Q3 2017 [2]	Q4 2017
Country 1	-8.0	-6.0	10.8	11.4
Country 2	6.0	15.0	1.0	3.1
Country 3	4.0	5.0	5.1	7.5
Country 4	4.5	7.0	0.5	6.7
Country 5	-6.5	-8.0	-0.5	-8.4
Country 6	-5.5	-3.0	-1.8	7.0
Country 7	1.0	5.0	5.1	0.7
Country 8	-13.0	-17.0	-2.7	-15.6
Country 9	-4.5	2.0	6.4	18.3
Country 10	22.0	27.0	3.9	16.6
Country 11	13.0	16.0	0.3	10.1
AUROC	0.83	0.72	0.69	0.66
High threshold: theta = 0.3	17.44 (CP: 0.45 / T1: 0.54 / T2: 0.07)	9.92 (CP: 0.29 / T1: 0.49 / T2: 0.16)	9.34 (CP: 0.31 / T1: 0.56 / T2: 0.12)	300.65 (CP: . / T1: 1.00 / T2: 0.00)
Med-high threshold: theta = 0.4	13.96 (CP: 0.40 / T1: 0.49 / T2: 0.10)	9.92 (CP: 0.29 / T1: 0.49 / T2: 0.16)	9.27 (CP: 0.31 / T1: 0.56 / T2: 0.13)	11.87 (CP: 0.16 / T1: 0.31 / T2: 0.35)
Medium threshold: theta = 0.5	2.46 (CP: 0.26 / T1: 0.23 / T2: 0.28)	3.77 (CP: 0.25 / T1: 0.40 / T2: 0.22)	7.11 (CP: 0.25 / T1: 0.45 / T2: 0.21)	8.28 (CP: 0.15 / T1: 0.26 / T2: 0.40)
Med-low threshold: theta = 0.6	-6.67 (CP: 0.19 / T1: 0.01 / T2: 0.54)	-16.38 (CP: 0.16 / T1: 0.14 / T2: 0.57)	-2.72 (CP: 0.13 / T1: 0.01 / T2: 0.85)	5.04 (CP: 0.14 / T1: 0.21 / T2: 0.45)
Low threshold: theta = 0.7	-6.67 (CP: 0.19 / T1: 0.01 / T2: 0.54)	-22.37 (CP: 0.14 / T1: 0.08 / T2: 0.70)	-2.72 (CP: 0.13 / T1: 0.01 / T2: 0.85)	-2.84 (CP: 0.12 / T1: 0.11 / T2: 0.64)
Conditional crisis probability > 40%			Conditional crisis probability > 25%	
Conditional crisis probability > 35%			Conditional crisis probability > 20%	
Conditional crisis probability > 30%			Conditional crisis probability > 15%	

Source: ECB calculations.
Notes: The colour coding is based on the conditional probability that a banking crisis could materialise within the next 12 to 5 quarters upon a crisis signal being issued. This conditional probability depends on the specific signalling threshold that is being breached. In general, a higher preference for not missing vulnerable states leads to a lower signalling threshold and more false alarms being issued, which is usually associated with a lower conditional distress probability. For each indicator or model, five different signalling thresholds are applied based on preference parameters ranging between 0.7 (strong preference for not missing vulnerable states) and 0.3 (strong preference for not issuing false alarms). T1 refers to the type 1 error rate, T2 to the type 2 error rate and CP to the conditional probability associated with each threshold. Footnotes 1) and 2) Countries 1 and 5 as of Q2 2017.

Univariate and bivariate signalling models mainly use real estate and/or credit-related variables. As an example, Table 2 depicts four univariate indicators focusing on real and financial asset prices. Bivariate models only produce a signal when both indicators breach their respective thresholds simultaneously. Experience shows that combining a real estate and a credit indicator delivers the best-performing bivariate signalling models.

A multivariate logit model is a regression-based approach allowing a non-linear combination of several variables to generate a crisis probability. The ECB model toolkit contains one logit model estimated with aggregate country data and one model estimated with bank-level data and, where derived, individual bank distress probabilities are later aggregated at the country level. The country-level model uses four indicators, i.e. (i) the bank credit to GDP gap, (ii) the residential property price to

income ratio, (iii) the three-year real equity price growth, and (iv) the debt service to income ratio. The bank-level model contains 11 risk drivers, some referring to the individual bank (e.g. leverage and interest expenses), some to the banking sector of the country as a whole (e.g. assets to GDP, loans to deposits), and others to the macroeconomic environment the bank is operating in (e.g. the ten-year government bond yield and total credit over GDP of the country of residence). The non-linear combination of these three sets of variables provides the value added and – compared with the literature – the favourable prediction statistics of this model.

Another interesting class of models is based on machine-learning algorithms. The latter can process and cluster a large variety of data. The ECB uses a random forest, a method that bootstraps and aggregates a large number of individual decision trees, using only a subset of the variables and time periods available. The latest quarterly data for each country are run through the multitude of decision trees, and the share of trees predicting a pre-crisis state for this country is taken as the prevailing crisis probability. Experience with this type of models is still in its infancy and its robustness compared with other modelling choices is currently being explored.

Table 3 shows examples of how the results of multivariate models are presented in the ECB's policy report. Again, the cell colours depict the conditional crisis probabilities, while the numbers show the estimated crisis probabilities. It is evident that different models, focusing on different vulnerabilities, provide different intensities of warning signals. Understanding the strengths and weaknesses of each model makes it possible to derive useful input for the experts' risk identification task.

Table 3

Identified vulnerabilities based on selected multivariate early warning models

	Bank Early Warning Model [1]	Logit Model [2]	Random Forest [3]	Bivariate Signalling [4]		Markov Switching Model [5]
				Bank credit/GDP gap	Real equity price growth (3 years)	
Latest observations	Q1 2018	Q4 2017		Q4 2017		
Country 1	9.2	0.1	13.3	-51.9	11.4	0.5
Country 2	5.5	17.2	24.8	5.5	3.1	3.8
Country 3	4.5	5.2	6.7	-2.4	7.5	2.0
Country 4		6.2	4.5	-5.4	6.7	1.5
Country 5	27.7	0.2	7.1	-54.7	-8.4	1.6
Country 6	15.9	2.1	3.0	-13.8	7.0	1.0
Country 7	4.0	0.2	2.2	-42.1	0.7	0.7
Country 8	7.7	0.6	2.0	-22.5	-15.6	1.0
Country 9		10.3	34.5	3.6	18.3	
Country 10	5.6	7.8	5.9	-7.5	16.6	2.2
Country 11	9.8	12.6	18.2	0.8	10.1	2.7
AUROC	0.85	0.83	0.94	0.84		
High threshold: theta = 0.3	18.08 (CP: 0.46 / T1: 0.44 / T2: 0.07)	15.91 (CP: 0.38 / T1: 0.33 / T2: 0.16)	17.15 (CP: 0.71 / T1: 0.30 / T2: 0.02)	6.12 / 7.93 (CP: 0.49 / T1: 0.42 / T2: 0.06)		
Med-high threshold: theta = 0.4	12.73 (CP: 0.32 / T1: 0.31 / T2: 0.15)	12.46 (CP: 0.33 / T1: 0.23 / T2: 0.22)	12.77 (CP: 0.42 / T1: 0.18 / T2: 0.07)	6.12 / 7.93 (CP: 0.49 / T1: 0.42 / T2: 0.06)		
Medium threshold: theta = 0.5	8.24 (CP: 0.23 / T1: 0.18 / T2: 0.27)	11.99 (CP: 0.32 / T1: 0.20 / T2: 0.24)	12.62 (CP: 0.41 / T1: 0.18 / T2: 0.07)	0.27 / 6.91 (CP: 0.26 / T1: 0.24 / T2: 0.24)		
Med-low threshold: theta = 0.6	7.03 (CP: 0.21 / T1: 0.14 / T2: 0.32)	11.28 (CP: 0.30 / T1: 0.18 / T2: 0.27)	11.09 (CP: 0.29 / T1: 0.13 / T2: 0.13)	0.1 / 7.07 (CP: 0.25 / T1: 0.22 / T2: 0.25)		
Low threshold: theta = 0.7	6.44 (CP: 0.20 / T1: 0.12 / T2: 0.35)	11.28 (CP: 0.30 / T1: 0.18 / T2: 0.27)	10.08 (CP: 0.17 / T1: 0.07 / T2: 0.28)	-0.44 / -10.87 (CP: 0.2 / T1: 0.15 / T2: 0.38)		

Conditional crisis probability > 40%	Conditional crisis probability > 25%
Conditional crisis probability > 35%	Conditional crisis probability > 20%
Conditional crisis probability > 30%	Conditional crisis probability > 15%

Sources: ECB and ECB calculations.
Notes: The colour coding is based on the conditional probability that a banking crisis could materialise within the next 12 to 5 quarters (8 to 1 quarters for the bank early warning model) upon a crisis signal being issued. This conditional probability depends on the specific signalling threshold that is being breached. In general, a higher preference for not missing vulnerable states leads to a lower signalling threshold and more false alarms being issued, which is usually associated with a lower conditional distress probability. For each model, five different signalling thresholds are applied based on preference parameters ranging between 0.7 (strong preference for not missing vulnerable states) and 0.3 (strong preference for not issuing false alarms). T1 refers to the type 1 error rate, T2 to the type 2 error rate and CP to the conditional probability associated with each threshold.
1) Aggregation at the country-level of a logit bank early warning model comprising bank-specific, aggregate banking sector and macro-financial variables.
2) Logit model with bank credit-to-GDP gap; residential property price-to-income ratio; three-year real equity price growth; debt service to income ratio (country 5 as of Q3 2017).
3) Random forest comprising 100,000 trees which are grown on six indicators per tree from a total set of 34 indicators.
4) Bivariate signalling model with 1) bank credit-to-GDP gap and 2) two-year real equity price growth.
5) Markov Switching model with total credit-to-GDP gap, debt service to income ratio, residential property price-to-rent ratio, annual growth of real residential property prices and annual inflation rate.

A final approach consists of deriving summary indicators of cyclical, real estate or structural risks based on a scoreboard approach. Early warning properties or expert judgement are used to select six to ten indicators per risk category, ideally covering different types of vulnerability. The individual indictors are then aggregated into one summary systemic risk indicator where the weights are determined to optimise the in-sample and out-of-sample early warning performance. The advantage of such an approach is its simplicity and transparency. Each individual indicator has an economic

rationale, and its contribution to the aggregate assessment can easily be derived by breaking down the overall risk indicator. For example, the aggregate systemic risk indicator derived from the cyclical risk scoreboard has properties which clearly surpass the standard reference guide, i.e. the Basel credit gap, in terms of predicting financial crises and large recessions.

The cyclical systemic risk indicator (CSRI) is available for all individual euro area countries and provides information on the medium-term likelihood and the severity of financial crises. The CSRI builds on early warning models and provides signals in the build-up of vulnerabilities phase well ahead of potential financial crises. The early warning methodology exploits the information contained in macro-financial variables to identify common patterns ahead of systemic crises and makes it possible to flexibly adjust the lead time to give policymakers the opportunity to counter the financial cycle and to build up resilience.

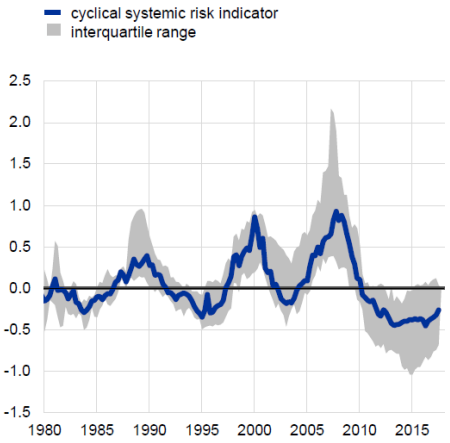
Unlike the FSRI, which focuses on near-term signals, the CSRI is designed to indicate the build-up of cyclical systemic risk with a medium-term lead time of one to three years before a financial crisis.

Strictly speaking, the CSRI consists of a domestic cyclical systemic risk indicator (d-SRI) that captures the build-up of imbalances in the domestic non-financial private sector. In addition, an exposure-based systemic risk indicator (e-SRI) weighs each country's d-SRI against the direct bilateral exposure of the domestic banking system to the foreign countries. The e-SRI thus captures risks from cross-border spillovers. In the final step, the domestic d-SRI and the exposure-based e-SRI are combined into the composite CSRI using weights that optimise the early warning performance to predict vulnerable episodes ahead of systemic crises.

The CSRI provides consistent signals ahead of financial crises; in the past, it has risen as much as four to five years in advance of a systemic financial crisis. Currently, the median CSRI across the euro area countries remains at subdued levels with a high cross-country dispersion (see Chart 11). This shows once more the need to have country-specific macroprudential policies, and especially so in a monetary union.

Chart 11

Median cyclical systemic risk indicator across euro area countries



Sources: ECB, ECB calculations.
Notes: The cyclical systemic risk indicator is a leading indicator of the build-up of systemic risk designed to indicate vulnerable states of the economy and the financial system leading historical crisis in EU Member States by 5-12 quarters. It is compiled using the two-year change in the bank credit-to-GDP ratio, the two-year growth rate of real total credit, the two-year change in the Debt Service Ratio, the three-year change in the residential real estate price, price-to-income ratio, the three-year growth rate of real equity prices, and the current account-to-GDP ratio. The line indicates the median of the SRI across euro area countries.

The CSRI not only signals the likelihood of systemic financial crises, it also contains information on their severity. The peak value of the domestic d-SRI before financial crises, in particular, shows a high correlation with the size of subsequent recessions. The CSRI can therefore be directly used to assess the impact of systemic risk build-ups on future declines in real GDP.[30] Given its lead time, it is a useful tool for policymakers to pre-emptively initiate macroprudential policy to limit the pro-cyclicality of the financial system and to adjust resilience to the identified level of systemic risk.

To summarise, the ECB has invested heavily in a suite of early warning models to assist with the identification of vulnerable states that require the special attention of macroprudential policymakers. So far, these models have been used mainly to support cyclical and real estate risk identification but extensions to structural risk and liquidity risk are possible. The analysis confirms that credit and leverage are cornerstones of any macroprudential risk identification system. However, much can be gained not only by focusing on credit developments, but also by conditioning credit developments on other risk indicators such as asset prices by means of non-linear multivariate regression analysis, decision tree analysis or simple and targeted aggregation.

Interpretation of such model-based results has to be done carefully, especially as the analysis draws on the pooled set of different countries' experiences of crises. Precise thresholds underlying the derivation of the signal depend on the crisis definition, the forecasting horizon and policymakers' relative aversion to type 1 and type 2 errors. The rationale for the unavoidable choices to be made needs to be clearly explained to policymakers for such models to play an effective role.

30 Two alternative data reduction methods were used for robustness.

3.3 Assessment with macro-financial models

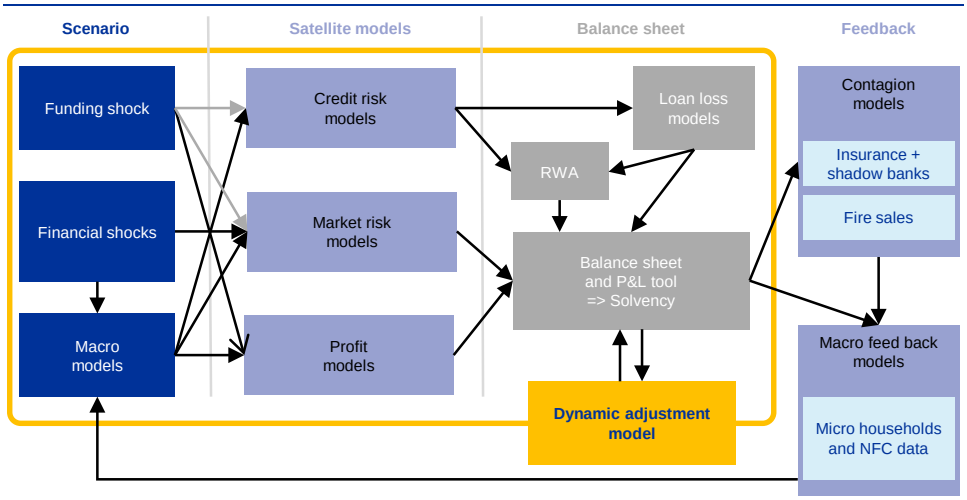
Over the years, and especially over the last post-crisis decade, ECB staff has developed a number of models for systemic risk analysis that have increasingly been used for macroprudential stress testing purposes. Bringing together micro bank-level data and macro-financial variables, the resulting STAMP€ (Stress Test Analytics for Macroprudential Purposes in the euro area) framework has been documented in an ECB e-book, STAMP€ (Dees et al., eds, 2017). Initially, the primary purpose of these tools was to assess the impact of a set of given (pre-identified) risks on banking sectors (Kok and Henry eds, 2013). A supplementary and equally key function of the toolkit emerged after the creation of the SSM and the allocation to the ECB of macroprudential responsibilities. In the corresponding new institutional landscape, these tools can also be employed to assess the impact of policy measures. Policy-related simulations can be conducted both with the macro stress testing infrastructure (e.g. to model banks and others' reactions to new capital requirements) and with specific structural models. Simulations can be run in two ways: either integrated with the macro stress testing infrastructure or on a stand-alone basis. This section first presents the stress testing framework and related tools and then turns to policy applications that go beyond stress testing *per se*, and which can therefore also use another class of models that connect to the macro stress testing apparatus.

3.3.1 A macroprudential stress testing apparatus: STAMP€

A number of steps are required to move from a microprudential to a macroprudential stress test, all of which relate to the need to take a system-wide rather than an isolated entity view (Constâncio, 2015b). This implies accounting for single banks' reactions (in other words, not imposing a static balance sheet), which impact on other banks and other sectors (via a number of externalities). Banks' behaviour matters crucially for assessing the effects of financial stress on or via the real economy, which is key for macroprudential purposes. The STAMP€ framework aims at covering these aspects, considering both the micro and macro dimensions of stress transmissions and based accordingly on both types of dataset and model. It can best be described as a four-pillar workhorse (see Figure 5), which comprises granular risk-specific models, allows for dynamic balance sheets, and captures the credit channel. It also involves contagion and spillover building blocks via financial networks.

Figure 5

The four-pillar structure of the ECB staff solvency analysis framework



Source: Adapted from Henry and Kok (2013) and Constancio (2015a).

Accordingly, in any simulation involving STAMP€, the first step is to design a scenario based on identified risks, mapped to pre-defined shocks that feed into macro models for the real side, while statistical models (parametric and non-parametric) are employed for financial asset prices (see Henry, 2015, for a description of the scenario process). Then a translation block, the "satellite" models, generates bank-specific risk parameters conditional on a given scenario (a baseline and a stressed one). A quasi-accounting block wraps up the overall impact on each individual bank's balance sheet, for the P&L as well as capital account (the latter designed to reflect regulations and accounting rules).

Up to that point, i.e. inside the yellow line (see Figure 5), the set-up mimics a supervisory stress test by concentrating on the first-round impacts of shocks (see Mirza and Zochowski, 2017, for its use in a microprudential context). The required macro ingredients then kick in, first with the introduction of a dynamic balance sheet module, whereby banks individually or collectively adjust their asset and liabilities. Their reaction affects their own balance sheet and P&L. Furthermore, the banks' changed behaviour sets in motion a range of feedback, first and foremost via the credit channel to the macroeconomy at large. Moreover, other banks as well as, more broadly, other parts of the financial sector, can be impacted by stress in the banking system, e.g. via financial asset prices that react to banks' decisions (such as shedding securities) or their market valuation (dented by stress). This is the contagion and spillover component of the framework. These reactions triggered by stress or crises are not reflected in standard macro models, which are estimated over longer periods and do not capture such specific agent behaviour.

Finally, these externalities within the banking sector and towards other sectors, not least the real economy, result in a new macro-financial picture or updated scenario, which, in turn, leads to updated results for the stress test. The latter now includes the second-round effects. This iterative process repeats until stabilisation. In practice, further rounds of effects on activity and solvency generally appear marginal, unless large enough liquidity shocks are triggered that destabilise the system.

Focusing more in detail on the translation block, the first-round impact of macro-financial variables on banks can be assessed along the lines of a standard microprudential stress test, whereby various risk parameters reflect the assumptions made in a differentiated manner. The ECB top-down modelling framework considers the following areas: credit risk, net interest income, market risk, fees and commission, and operational risk. These areas cover most items in the P&L in a simplified manner, albeit with sufficient granularity.

Credit risk is modelled at the banking sector level (28 EU Member States and 20 areas for the rest of the world, see Gross et al., 2017a) for various loan segments (consumption, mortgages, large non-financial corporations and small and medium-sized enterprises (SMEs)).The resulting set of granular risk parameter equations relate, for example, the probability of default on mortgages in a given country to corresponding activity and interest rate variables. The estimation method is the Bayesian Model Averaging (BMA), which combines a number of possible explanatory variables and selects a large set of relevant and significant models (see Gross and Poblacion, 2015, for the specific econometric methodology employed). Their average is used to derive the response of risk parameters to scenario components. The method also provides a distribution for all estimated elasticities instead of only their point estimate. The severity of the scenario impact can thus be strengthened by using response parameters that are stronger than the estimated median one. Such equations have been used to compute European Banking Authority (EBA) benchmarks and are being updated to account for IFRS 9 features.

Net interest income (see Gross et al., 2017b) is split into two components, income and expenditure, with a focus on interest rates, broken down into reference rates and product-specific spreads. Lending rates cover different sectors for each country (SMEs, large corporates, households for consumption and mortgages) and funding costs, different types of instruments (sight and term deposits, wholesale, bonds). Links to macro-financial assumptions can be estimated, again via BMA, based on banking sector data. Alternative estimates directly compute net interest margins, obtained from panel bank-level data, related to scenario inputs. Regardless of the modelling retained for interest rates, the simulation results for net interest income are also affected by the rollover and repricing assumptions that may be exercise-specific.

Market risk parameters (see Laliotis and Mehta, 2017) cover a range of areas, such as credit valuation adjustment, fair valuation or counterparty risk. While mark-to-market computations, such as those employed for Available-For-Sale / Full-Value-Option, are straightforward – basically translating scenario financial asset yield shocks into a price movement, more complex models are needed for other risk parameters. The models use bank-level information on exposures (using the notional for derivatives) and banks' stress test results for market risk shocks. In broad terms, the models have been calibrated by regressing banks' results for a given entry on relevant bank-level balance sheet data. Simulations must also account for hedging, on which information is partially available, again from previous stress test results.

Apart from the above three main and standard contributors to losses under stress, a few more items need to be modelled to complete the required picture for each bank in the sample to be analysed. Fees and commission are derived from panel estimations

linking such bank-level outcomes to macro-financial scenario variables and bank-specific indicators (Mirza et al., 2017). Finally, for operational risk (Bousquet and Dubiel-Teleszynski, 2017), past loss events have been used to fit and project probability distributions for conduct or non-conduct risk losses, grouping events by amount buckets. A particular feature of this item is that it is based on a purely statistical approach, i.e. with no structural driving role for scenario macro-financial variables.

In addition to the impact of macro-financial variables on bank-specific risk parameters, for any given scenario, credit supply should be aligned with the rest of the macro-financial picture. This contradicts the assumption that banks keep a static balance sheet over the stress period, i.e. do not amend their asset or liability mix over a protracted period of stress. Credit is not included in the EBA/SSM stress test scenario input, which, in turn, is consistent with the static balance approach taken. This is, however, clearly counterintuitive and cannot be retained for a macroprudential exercise. As a first step in the set-up, credit flows are therefore modelled and adjusted for all banking sectors conditional on the scenario (Gross and Venditti, 2017). This consistency step already alters the stress test results, to the extent that, mechanically, with a new path for loans, all other things being equal, both impairments and net interest income in particular would change.

A further reaction affecting credit supply can occur when, for example, banks are requested by a regulator or the market to reach a specific new capital target – once again an event that is not considered when designing the scenario itself. How banks achieve this, be it by raising equity or deleveraging loans or other assets, then becomes a key simulation parameter. This notwithstanding, such further changes in loan supply would then again impact the real economy. The impact can be evaluated using either reduced-form models (Global Vector Auto-Regressive models with banks or banking sector equations) or structural models (Dynamic Stochastic General Equilibrium models with financial frictions) – the first approach is followed in Gross et al. (2017) or Gross and Zochowski (2017) while the second is taken in Darracq-Pariès et al. (2010) or Rancoita and Hilberg (2017).

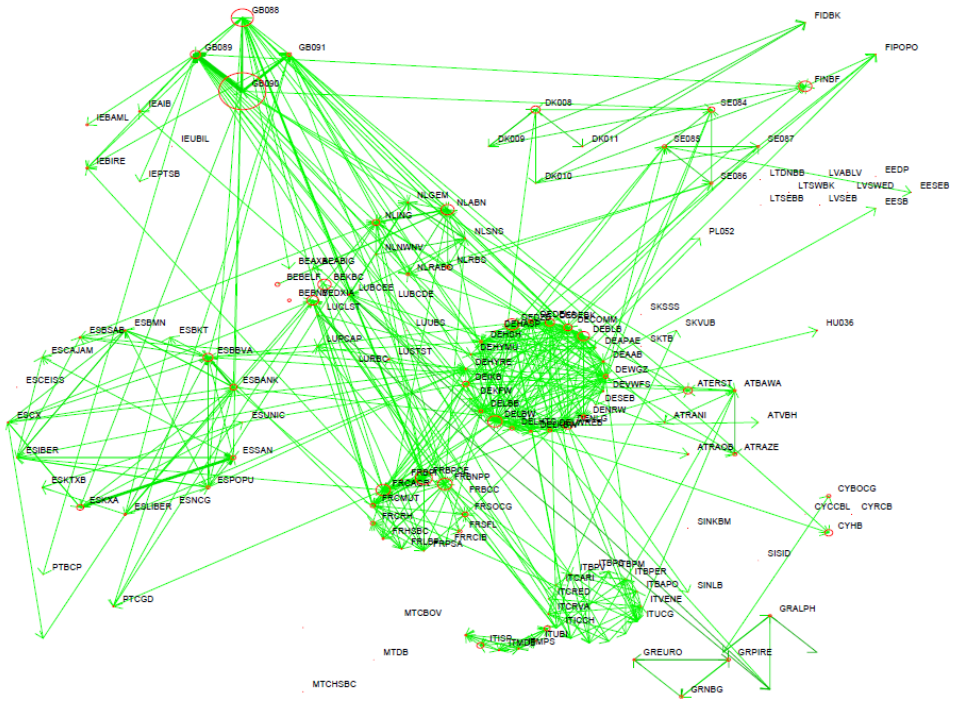
Above and beyond the real financial feedback loop via credit, the framework also caters for two types of network externalities within the financial system. First, a given bank, when under excessive stress from a solvency ratio perspective, for example, could either default on its obligations or sell assets at a “fire” price – i.e. far lower than the purchase price. In both cases, there will be contagion to other banks, via the quantity or price channel respectively. Contagion is termed “direct” if the banks are creditors to the defaulting bank, or “indirect”, if they hold precisely those assets the bank in distress is shedding, the price of which falls as a result of fire sales. Second, under stress, expected losses lead to a decline in the value of the affected banks and banking systems. This then spills over to those sectors holding bank equity, thereby potentially creating further solvency problems in other areas of the broader financial system.

Under the assumption that those banks that experience the largest capital shortfall under stress cannot issue equity or obtain sufficient market or central bank funding, they would have to default on their interbank claims (see Halaj, 2017). This would trigger the well-documented cascade of defaults in the interbank payment system in

line with the observed network of interbank unsecured lending. The network (see Chart 12) shows connections that are both dense in a given country – e.g. Germany – but also across systems, e.g. between France and Belgium. The possible initial defaults can then spread through the system in various ways.

Chart 12

Simulated interbank network structure among the largest EU banks



Source: Halaj and Kok (2013).
Notes: Based on the data from the 2014 comprehensive assessment. Thickness of a link proportional to the log (size of exposures); red circle proportional to log (total assets), arrows indicate direction of payment obligations of interbank exposures.

The network shown is a simulated one (Halaj and Kok, 2013). This is largely due to insufficiently frequent and comprehensive data sources for exposures. At the same time, the approach taken is akin to a risk management one, namely to simulate a large number of networks around the infrequently observed ones. The impact of the triggered cascade of defaults is then computed for each of them. Finally, the network topologies that create a more adverse impact are selected for reporting purposes (e.g. the 10% most damaging), thus focusing on the “tail of the tail” of such contagion risks. If only unsecured interbank lending is considered, cascades of defaults do not appear to have a major impact.

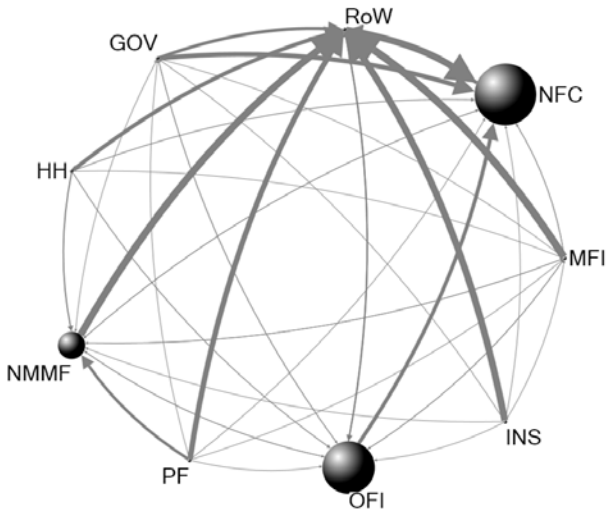
The above-mentioned plain vanilla Eisenberg and Noe (2001) scheme can be enhanced in a number of ways so that more transmission channels and amplification mechanisms are covered in the interbank network, thus coming closer to a system-wide liquidity stress test (as described in Halaj and Henry, 2017, and Halaj and Laliotis, 2017). Additional mechanisms are at play on both sides of the balance sheet. First of all, solvent but weak banks can sell liquid assets instead of defaulting, thereby exerting downward pressure on prices, which, in turn, affects all entities holding the same class of assets as those sold. In addition, connections across banks extend

beyond interbank unsecured lending, which multilayer networks can capture (see Kok and Montagna, 2016). Banks can also dynamically revise their portfolio allocation across assets (see Halaj, 2016) in response to price changes – changing counterparties, but also triggering further price adjustments. On the liability side, funding costs may depend on solvency ratios, which further deplete profits and capital, and thus further increase banks' likelihood of defaulting. Finally, funding dry-out or deposit attrition can occur. Moreover, rationing and cost push can both spread within the system via herding behaviour, whereby a given bank's weakness contaminates that of its peers owing to unfavourable market perceptions.

A last feature of the framework (in Grodzicki and Silva, 2017, extending Castren and Kavonius, 2009) relates to spillovers across sectors, which are captured via the equity holding network, traced from sectoral financial accounts, as available for each country (see Charts 13 and 14). Once banks – monetary financial institutions (MFIs) in the case at hand – experience capital depletion under the stress scenario, it can be assumed (in a simplified manner) that their equity value would immediately fall one-to-one by the expected stress impact over the scenario horizon. If this valuation shock is then transmitted, also one-to-one, to those sectors holding banks' equities, their own market value would also suffer in line with the weight of bank equities held on their asset side. This sets an iterative process in motion, since, for example, insurers (INS) or pension funds (PF) holding banks' equities are also partially owned by banks or other financial institutions (OFIs). The process can be repeated until the final impacts across all sectors converge (or can be derived from a closed-form solution, based on the inverted flow-of-fund matrix). While market value shocks transmit promptly, the timescale over which the whole chain of transmission operates, as described above, is however uncertain. In country B, the sector that appears central to the network and likely to be most affected by this channel would be non-money market funds (NMMF), while for country A it would be the rest of the world (RoW) – i.e. such value contagion would be exported, without sizeable second-round effects in the country itself.

Chart 13

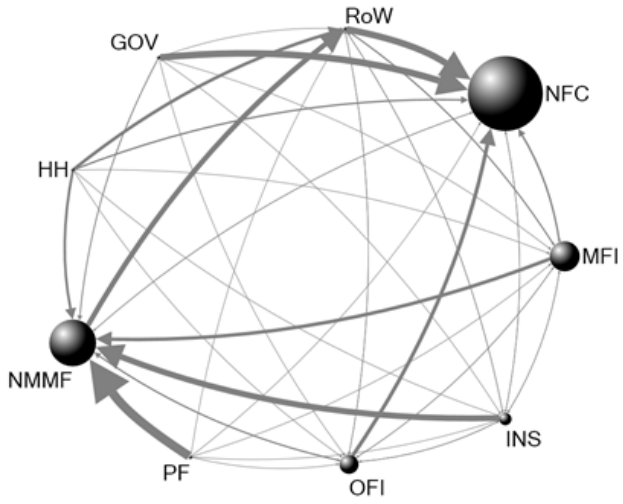
Equity holdings in country A, Q4 2015



Sources: ECB and authors' calculations.
Notes: The direction of the arcs reflects the equity holdings of one sector by another sector, while the thickness of the arcs reflects the relative size of those holdings. The nodes reflect intra-sectoral equity holdings. GOV Government; RoW Rest of the World, NFC Non-financial corporates, MFI Monetary and financial institutions, INS Insurers, OFI Other financial institutions, PF Pension funds, NMMF Non-money market funds, HH Households.

Chart 14

Equity holdings in country B, Q4 2015



Sources: ECB and authors' calculations.
Notes: The direction of the arcs reflects the equity holdings of one sector by another sector, while the thickness of the arcs reflects the relative size of those holdings. The nodes reflect intra-sectoral equity holdings. another sector, while the thickness of the arcs reflects the relative size of those holdings. The nodes reflect intra-sectoral equity holdings. GOV Government; RoW Rest of the World, NFC Non-financial corporates, MFI Monetary and financial institutions, INS Insurers, OFI Other financial institutions, PF Pension funds, NMMF Non-money market funds, HH Households.

4 Policy implementation

4.1 Cyclical risks and the countercyclical capital buffer

In its regular cyclical risk analysis , the ECB starts by reviewing the Basel gaps, i.e. the deviations of each country's total credit to GDP ratio from its one-sided Hodrick Prescott filtered trend. However, in addition, a scoreboard approach consisting of six indicators, as depicted in Table 4, has been developed. The indicators have been chosen to represent five of the six risk categories mentioned in ESRB Recommendation 2014/1 relating to credit developments, property prices, external imbalances, the private sector debt burden and the mispricing of risk. The sixth one, bank balance sheet strength, is only excluded owing to the lack of time series of a sufficient length for all euro area countries. In each category, the variable and transformation with the best early warning properties for predicting banking crises has been selected. This has led to transformations which feature two- or three-year rates of change or growth rates. This suggests that there is more information on financial stability in longer-term changes rather than in yearly changes, which might include a significant amount of noise. The variables considered in the scoreboard are the two-year change in bank credit to the non-financial private sector to GDP ratio, the two-year real growth rate of unconsolidated total credit, the two-year change in the household debt service ratio, the three-year change in the house price to income ratio, the current account balance to GDP ratio, and the three-year real growth rate of equity prices.

Table 4

Cyclical risk scoreboard

	Early warning indicators						Reference SRI	Supplementary SRIs	
Country	Bank credit-to-GDP ratio, 2-year av. change	Real total credit, 2-year av. growth	RRE price-to-income ratio, 3-year av. change	Real equity price growth, 3-year av., %	Debt service ratio, 2-year av. change	Currrent account balance, % of GDP	SRI benchmark	SRI (ex. Equity)	SRI (ex. CA)
Country 1	-6.30	-0.95	6.33	11.35	-5.28	8.38	-0.81	-0.97	-0.65
Country 2	0.94	1.29	-0.33	3.13	-0.21	-0.83	-0.03	-0.03	-0.05
Country 3	-0.34	2.55	3.33	7.46	-0.08	7.79	-0.30	-0.36	0.00
Country 4	-0.11	-0.31	0.33	6.65	-0.62	0.44	-0.13	-0.18	-0.13
Country 5	-22.26	0.49	-0.33	-8.35	-2.24	-6.86	-1.57	-1.89	-2.56
Country 6	-2.25	-0.64	-2.33	7.04	-0.61	2.75	-0.45	-0.58	-0.45
Country 7	-7.08	-2.03	3.67	0.68	-1.13	1.79	-0.64	-0.74	-0.78
Country 8	-5.99	-2.81	-2.00	-15.62	-0.56	-0.66	-0.74	-0.76	-0.99
Country 9	-1.74	0.03	-0.33	18.33	-0.45	2.40	-0.25	-0.43	-0.23
Country 10	-0.96	2.02	4.67	16.63	-0.14	2.14	-0.02	-0.1172	0.05
Country 11	2.46	3.45	0.33	10.07	0.25	-0.87	0.18	0.16	0.21
EAA	-3.06	0.96	1.54	7.48	-0.81	2.32	-0.36	-0.47	-0.37
EAM	-2.25	0.03	1.33	7.46	-0.56	1.79	-0.29	-0.38	-0.30
T1	0.25	2.00	0.50	5.00	0.10	-2.30	-0.10	-0.10	-0.10
T2	1.25	4.00	1.50	10.00	0.35	-1.50	0.10	0.10	0.10
T3	2.25	6.00	2.50	15.00	0.60	-0.80	0.20	0.20	0.20
Median	1.00	4.10	0.10	2.30	0.10	-0.40			
Standard deviation	5.10	6.90	5.60	24.40	1.60	5.10			
Weights SRI	0.36	0.05	0.17	0.17	0.05	0.20			
Weights SRI (ex. Equity)	0.45	0.05	0.23	0.00	0.05	0.22			
Weights SRI (ex. CA)	0.52	0.05	0.21	0.17	0.05	0.00			

Source: ECB calculations based on various data sources.
Notes: The benchmark SRI is constructed as a weighted average of the normalised scoreboard indicators, where the normalisation is performed by subtracting the median and dividing by the standard deviation of the pooled indicator distribution across countries and time. The optimal weighting scheme for the benchmark SRI based on the full sample of data assigns the largest weight to the bank credit-to-GDP change (32%), followed by the current account balance (21%), the residential real estate price-to-income ratio change (19%), real equity price growth (18%), the debt service ratio change (5%) and real total credit growth (5%). The two supplementary SRI versions exclude the equity price and current account indicators respectively, and weights are re-optimised for the remaining SRI components. For the current account-to-GDP ratio, lower values indicate higher risk. The transformations are expressed as annualised averages, e.g. three-year changes are divided by 3 and two-year changes are divided by 2. The scoreboard is designed to identify countries early on in the upswing phase of the financial cycle. The low, medium and high thresholds correspond to the lowest early warning thresholds that result in conditional pre-crisis probabilities of 12.5%, 15% and 17.5% upon a warning signal being issued. The unconditional pre-crisis probability in the sample at hand is around 9%. Pre-crisis periods are defined as 12 to 5 quarters prior to systemic financial crisis episodes that are not purely due to foreign factors (See ECB Occasional Paper No 194 for details). Colours refer to the following risk levels: “no risk” in white, “low risk” in yellow, “medium risk” in orange and “high risk” in red. Thresholds are not the basis for any mechanical form of inference and decision. “EAM” refers to the median across euro area countries. The latest observation is for Q4 2017.

The Basel gap is considered to be the standard input for expert assessments. Recent analysis has, however, shown that the Basel gap has shortcomings, especially in the aftermath of major crises. This relates to the high persistence in the trend. In the aftermath of severe crisis episodes, the Basel gap is distorted downwards as the trend adjusts only very slowly. Furthermore, the calculation of the Basel gap depends on the length of the time series available, which would determine the initial calculation of the trend. Not surprisingly, therefore, the scoreboard approach generates an indicator that would have performed much better in revealing cyclical vulnerabilities in-sample and out-of-sample for a pooled set of 19 European banking crises since the 1970s.

The risk identification is then supplemented with results from the early warning models described in Section 4.2.2, and, most importantly, expert judgement obtained from discussions with experts from national competent and designated authorities.

After identifying cyclical risks in individual countries, the task is to ascertain the appropriate level of the countercyclical capital buffer (CCyB). The Basel Committee has provided guidance based on the Basel gap. The guidance suggests a linear mapping of the Basel gap to a CCyB rate. However, owing to the shortcomings of the Basel gap, the ECB is very careful in interpreting this "buffer guide"[31], and following ESRB Recommendation 2014/1, supplements its assessment with other model-based inputs, as well as, importantly, the national authorities' assessments based on the national frameworks of how to calibrate a CCyB. The ECB is currently developing a robust quantitative framework for suggesting calibrations for the CCyB, based on a suite of model approaches to complement the Basel buffer guide. Model- based inputs will serve as the ECB's starting point for calibration discussions within the Eurosystem, in which expert judgement and knowledge about the sources of cyclical risks, as well as detailed information on the specificities of national financial sectors, will always be a key input.

4.2 Addressing real-estate-related risks

Risks to the real estate market are assessed in several steps. The starting point is a scoreboard approach similar to cyclical risk assessment. The scoreboards differ between residential and commercial real estate, but the principle is similar.

For residential real estate, the scoreboard is organised in three sections. The first is the collateral value of bank lending and is captured by house price indicators intended to identify the cyclical situation of the housing market. An overvalued housing market suggests risk for a bank's collateral valuation. Determining over- or undervaluation of house prices is a difficult task and model risk is significant. The ECB uses several approaches, ranging from an estimated inverted demand model to changes in simple ratios of house prices to rent or to income. An overvalued housing market is not a necessary condition for real estate risk, as market prices tend to undershoot fundamental values in a crisis, but consistent overvaluation messages across different types of model provide a warning signal for potentially large corrections in the future.

[31] See BCBS (2010).

Exuberant price dynamics attract speculative demand and tend to suggest a relaxation of lending standards. The second section is the bank's lending activity. The focus is on mortgage loan growth and mortgage loan spreads to gauge whether risk is appropriately priced in. The last section monitors household balance sheets. Vulnerabilities are connected with high debt-to-income and high debt service ratios. Low financial-asset-to-debt ratios also constitute a weakness. The scoreboard indicators are converted into colour codes to individually signal low, medium or pronounced risk. The scoreboard ratings are then aggregated into summary risk measures (see Table 5). In a second step, these mechanical ratings are adjusted by expert judgement taking into account country-specific information. The systemic importance of the real estate sector and real estate lending are also considered at this stage and can result in further adjustments to the risk ranking. These adjustments are documented internally for transparency reasons. An overall risk ranking is thus derived. The risk level is then compared with the existing macroprudential measures in place to assess whether the policy stance is appropriate. The likely effect of recently implemented measures is simulated with existing models reflecting a macroprudential transmission mechanism. Unfortunately, such models do not yet exist for all possible policy measures. In particular, there is a gap in assessing effectiveness when several different policy measures are implemented simultaneously. The outcome of this assessment is discussed with the national authorities represented in the Eurosystem's Financial Stability Committee.

Table 5

Residential real estate scoreboard

Country	Indicators										Summary measures				
	Price Indicators				Lending Indicators			Household Balance Sheet							
	Residential real estate price index, 36m real growth, av. %	Residential price index relative to trend	House price to income ratio (deviation from average in percent)	Econometric model (overvaluation in percent)	Loans to HH for house purchases, 36m real growth, av. %	Loans to HH for HP relative to trend	HH Loan spread	HH debt, % of income	HH financial assets to debt, %	Debt service to income ratio for HH, %	Average rating across indicators	Average rating across Price Indicators	Average rating across Lending Indicators	Average rating across HH BS Indicators	Composite indicator
Country 1	10.7	1.05	-6.0	-10.0	-1.6	0.76	3.1	144.0	262.5	17.2	1.2	1.3	0.0	2.3	-0.067
Country 2	1.0	0.94	15.0	-3.0	7.4	1.12	2.2	105.6	516.5	10.8	1.1	0.5	1.3	1.3	-0.009
Country 3	5.1	1.15	5.0	3.0	2.9	1.00	1.8	84.4	347.5	9.2	0.8	1.8	0.3	0.3	0.134
Country 4	0.5	0.94	7.0	2.0	1.9	0.95	0.7	115.6	220.4	11.7	1.3	0.5	1.0	2.3	0.188
Country 5	-0.5	0.85	-8.0	-5.0	-1.3	0.84	1.4	196.8	211.5	25.2	1.2	0.0	0.7	3.0	0.209
Country 6	-1.8	0.87	-3.0	-8.0	0.9	0.89	1.3	61.0	609.5	11.2	0.3	0.0	0.7	0.3	-0.429
Country 7	5.1	0.91	5.0	-3.0	-3.7	0.75	1.8	100.3	296.3	11.8	0.8	0.8	0.3	1.3	-0.186
Country 8	-2.7	0.83	-17.0	-9.0	-5.6	0.73	2.3	89.4	254.7	20.4	0.8	0.0	0.0	2.3	-0.449
Country 9	7.3	1.21	2.0	-11.0	3.5	1.11	1.9	71.9	288.9	7.7	0.9	1.3	1.3	0.0	0.119
Country 10	4.0	1.05	27.0	17.0	3.2	0.96	1.6	84.8	355.7	10.0	1.1	2.3	0.7	0.3	0.275
Country 11	0.9	0.92	16.0	10.0	4.0	0.99	1.4	91.1	402.1	9.8	1.0	1.3	1.0	0.7	0.069
EA average	3.77	1.02	3.53	-3.95	2.44	0.95	1.82	100.08	342.21	12.01	0.9	0.9	0.7	1.2	0.009
EA median	4.9	1.03	2.00	-3.00	3.16	0.96	1.79	91.07	299.76	11.2	0.9	1.0	0.7	1.0	0.069
Low	2.5	1.00	4.0	0.0	3.0	1.05	1.0	75.0	240.0	10.0	1.0	1.0	1.0	1.0	0.00
Medium	5.0	1.04	10.0	6.0	6.0	1.10	1.5	85.0	260.0	12.0	1.2	1.2	1.2	1.2	0.19
High	7.5	1.08	16.0	12.0	9.0	1.15	2.0	95.0	280.0	14.0	1.7	1.7	1.7	1.7	0.51

Source: ECB and ECB calculations.
Notes: Each cell of the scoreboard reports the latest available value of the respective indicator. Colour coding: a discrete risk rating with four categories is applied to each indicator based on whether the indicator value exceeds certain indicative threshold values. The threshold values, which are reported in the lower part of the table (T1, T2 and T3), are based on early warning model thresholds and/or the views of experts after checking the overall distribution of the indicator across time and countries. The risk ratings are as follows: 0 – no risk, no colour; 1 – low risk, yellow; 2 – medium risk, orange; 3 – high risk, red. The average risk rating is computed across indicators in the same category (last three columns). The final mechanical risk rating is the average of risk ratings across the categories. It ranges from 0 to 3 and it is calculated as the average across indicators after they are converted into ratings on the basis of the thresholds The latest observation is for Q4 2017.

The sections in commercial real estate (CRE) are similar but not exactly the same, as vulnerabilities in the CRE market are more complex. The first section is the same as for RRE, i.e. the risk of falling collateral values. The difference is that CRE price cycles have a larger amplitude and are more volatile. The second section is the risk related to income and activity. Here, the sustainability of CRE as an income-generating activity for investors is assessed. A challenge is the fact that CRE encompasses a very heterogeneous set of sub-sectors (office, retail, industrial facilities and some types of residential property, such as multi-household dwellings and potentially buy-to-let residences), which might follow different cycles. These cycles are also potentially more aligned with a global investment cycle rather than the domestic business or financial cycle. The CRE investor base is often very international, which could both add to or mitigate the related financial stability risks. The third CRE section is related to the funding of CRE activities. Bank lending activities to CRE are monitored, as well as potential excessive risk-taking related to the non-bank financing of CRE. A fourth section explicitly measures spillover risks related to the exposures of banks and non-banks, as well as the cross-sectoral and cross-border linkages of CRE. It is fair to say that, at this stage, assessing CRE risks is more difficult than assessing RRE risks, as the data situation is more challenging and the market is much more complex.

In contrast to the CCyB, for which the ECB has the legal responsibility to apply higher buffer requirements, if necessary, the situation is more complicated with regard to real-estate-related risks. Dealing with the cyclical risk of excessive credit developments is the joint responsibility of the national designated authorities and the ECB, and the key policy instrument, the CCyB, is available to both. With regard to real estate, the allocation of macroprudential policy instruments is not symmetric. Borrower-based measures, which are supposed to address the flow of new real estate lending, are only at the disposal of national authorities if national legislation has provided the appropriate framework following the relevant ESRB Recommendation. At present, national laws differ in terms of which precise borrower-based instruments are available to national authorities. In some countries, legislation is still pending. The ECB has been arguing for the set of legally available borrower-based tools for national authorities to be completed as soon as possible, especially for those countries where real estate risks are building up. The tools available to the ECB relate to the lender-based instruments mentioned in the CRR[32] and CRD IV[33]. Tools available to the ECB for addressing real estate risks are: higher risk weights for residential or commercial real estate exposures for banks that use the standardised approach (see Article 124 of the CRR) or for explicitly targeting asset price bubbles (see Article 458(2)(d)(vi) of the CRR) for IRB banks; higher LGD floors for such exposures (see Article 164 of the CRR); the countercyclical capital buffer (see Article 136 of the CRD IV) if overall cyclical credit risk is affected; and a systemic risk buffer (see Article 133 of the CRD IV) if the real estate exposures constitute a structural systemic risk for the banking sector. The latter two measures are not targeted at the real estate

[32] Regulation (EU) No 575/2013 of the European Parliament and of the Council of 26 June 2013 on prudential requirements for credit institutions and investment firms and amending Regulation (EU) No 648/2012 (OJ L 176, 27.6.2013, p. 1).

[33] Directive 2013/36/EU of the European Parliament and of the Council of 26 June 2013 on access to the activity of credit institutions and the prudential supervision of credit institutions and investment firms, amending Directive 2002/87/EC and repealing Directives 2006/48/EC and 2006/49/EC (OJ L 176, 27.6.2013, p. 338).

sector and are unlikely to be the first choice of any macroprudential authority for risks related to the housing market.

4.3 Structural risk and capital buffers for systemic institutions

The rationale for requiring global systemically important banks (G-SIBs) to hold a specific capital buffer in addition to all other capital requirements is that the failure or default of such banks would generate major negative externalities and ripple effects internationally. Therefore, the buffer, which can theoretically reach 3.5% of the CET1 ratio, is calibrated to variables that are related to the extent of the externality: size, interconnectedness, substitutability, complexity and cross-jurisdictional activity (see Basel Committee on Banking Supervision, 2014). The methodology was agreed on at the Basel Committee and is implemented collectively on a yearly basis.

A complementary approach was devised for domestically important banks by focusing on the impact that the default or failure of banks (including by international banks) has on the domestic economy. In the EU framework, this took the form of a buffer for other significantly important institutions (O-SIIs), which currently can reach 2% of CET1.[34]

Under the mandate stated in Article 131(3) of the CRD IV, the European Banking Authority (EBA) published a guideline on how to identify an O-SII in a way that is reminiscent of the G-SIB methodology: a scoring process based on a set of indicators captures the dimensions of size, importance (including substitutability and financial infrastructure), complexity, cross-border activity and interconnectedness. The EBA methodology asks each national authority to calculate the market share of banks in its jurisdiction for each indicator, then adds the scores together (which are implicitly equally weighted, as for G-SIBs) and sets a threshold above which an institution is considered domestically significant. This methodology is equivalent to calculating a summary measure of “domestic systemic relevance” (the final score) for each bank, which might be compared across countries taking into account national specificities since the score is calculated for the domestic market.

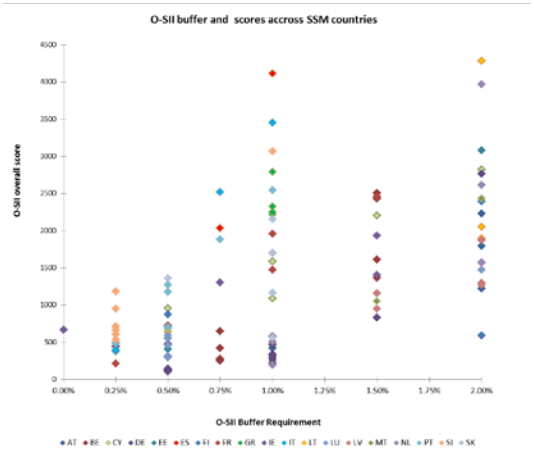
However, the EBA has so far not proposed any methodology to calibrate O-SII buffers. Consequently, national authorities have developed a variety of approaches for assessing the costs associated with the failure or default of a bank and calibrating its buffer. This variety spans the extremes, from considering the G-SIB buffer of the largest banks (when such banks are present) as a cap for O-SII buffers to considering the G-SIB buffer as a floor. As a result, the level of buffers applied for a given EBA score still exhibits substantial heterogeneity (see Chart 15). This applies both to their levels and implementation schedule, which is also left to national authorities within the bounds specified by EU legislation.

[34] Note that under draft legislation currently under discussion, this ceiling would be raised to 3%.

Chart 15

O-SII buffer and scores across SSM countries

(2017 data)



Sources: ECB and ECB calculations.

The ECB, as with all macroprudential measures, can top up this buffer but not reduce it. This power requires a transparent framework that describes how such a top-up would be calibrated. However, with such a variety of methodologies adopted by the national authorities, consistency across jurisdictions is critical, along with due attention to the role of national specificities.

Building on this, the floor methodology adopted by the ECB takes advantage of the fact that the systemic relevance of banks can be easily compared across countries via the EBA score.

A cluster analysis of banks' scores shows that they can be sorted into four buckets (ECB 2016). This groups banks by similar degrees of "domestic systemic importance". A minimum buffer is then applied to each bucket to act as a floor. As the overall O-SII buffer currently can reach 2%, the highest bucket of the ECB methodology was set at half this value, 1%, to allow scope for national authorities to take national specificities into account. Buffers are set with 25-basis-point increments, with the first one set at 25 basis points. Based on the national authorities' decisions in 2016, 2017 and 2018, most banks' O-SII buffer was higher than the ECB floor, thus validating a methodology that acts as a backstop against inaction bias and as a cross-country harmonisation factor.

The thresholds of the buckets in the cluster analysis are revised every three years. This is seen as a good compromise between ensuring stability in the calibration exercise while taking into account changing patterns in domestic banking markets.

While the O-SII buffer deals with specific dimensions of individual banks' contribution to structural systemic risk, the systemic risk buffer was introduced in the EU legislation to deal more generally with structural risk, whether it also affects individual institutions as well or the whole banking sector.

4.4 Policy use of the macroprudential stress testing toolkit

A primary and initial function of the stress testing framework was to assess the impact of potential sources of systemic risk on the euro area banking system.[35] The corresponding exercises can be termed macro stress tests. These stress tests are stand-alone and top-down, in that, respectively, they are not related to supervisory exercises and do not involve the banks in the computations. The results of such analysis (notably, the simulation results) have been published regularly in the ECB Financial Stability Review.

The scenarios employed are mapped to the list of risks reported in the identification section and then to specific exogenous shocks (interest rates, world trade, demand components, equity and housing prices, exchange rate, commodities, etc.) for euro area countries and the rest of the world. These shocks are jointly input to a set of macro models, which then provide for each given scenario – e.g. a global repricing of bond yields implying activity declines and asset price adjustments worldwide – a complete macro-financial picture. These overall assumptions feed into the infrastructure, usually under the assumption of a static balance sheet, to obtain bank risk parameters, which, when aggregated, translate into system-wide capital losses.

The results contribute to policy-related reports in a variety of ways. Capital depletion under stress can first be compared across scenarios, which helps rank risks in terms of their potential impact. They can be aggregated across risks and reviewed over time to assess banks' resilience to the whole set of currently prevailing risks. Stress results can also be seen in the light of changes in capital under a baseline scenario. This boils down to using this infrastructure, initially conceived for stress testing, to produce bank-level and banking sector projections that are consistent with those available for the real side of the macroeconomy. Such "baseline" results can then help analyse, for example, medium-term prospects for profitability and its drivers, such as loans losses or interest margins. They can also help evaluate the impact of policy moves that result in yield curve shift, or prudential measures, such as those relating to non-performing loans (NPLs).

Alongside the generation of stand-alone macro stress tests, the toolkit can be run to carry out simulations where supervisory microprudential stress tests are taken as a given input. In this MPE (MacroPrudential Extension) of the SSM stress-test[36], the bottom-up results produced by the banks (after validation by the supervisors) are submitted to a sequence of top-down amendments. The first iteration in the process consists of triggering the dynamic balance sheet module, as described above, i.e. aligning overall credit with the scenario underlying the SSM stress test – in other words, deleveraging the overall loan book in line with historical regularities. This largely mechanical adjustment affects banks in different ways, depending on each bank's characteristics (in particular, its NPL ratio, but also the riskiness of its book).[37]

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35 Henry, J. and Kok, C. (eds.), (2013), "A macro stress testing framework for assessing systemic risk in the banking sector", *Occasional Paper Series*, No. 152, European Central Bank, Frankfurt am Main.

36 European Central Bank (2016), "Macroprudential effects of systemic bank stress", *Macroprudential Bulletin*, Issue 2, Chapter 1, October.

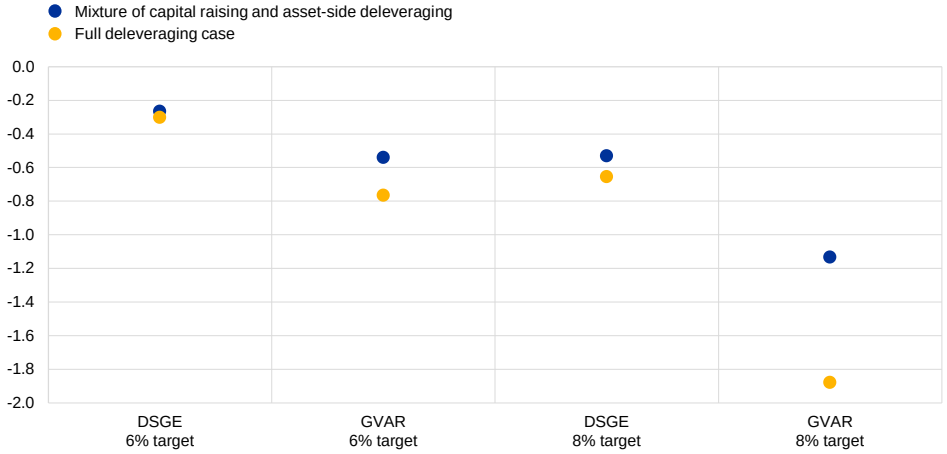
37 See Dees, S., Henry, J. and Martin, R (eds.) (2017), "STAMP€: Stress-Test Analytics for Macroprudential Purposes in the euro area", European Central Bank, Frankfurt am Main.

The second step assumes that banks have to respond to market pressures or to regulators, which, following the stress period, require banks to hold more capital. In the likely event that banks cannot fully cover the shortfall by equity issuance, deleveraging kicks in further, which also affects GDP, now lower than in the original stress scenario. The estimated GDP impact increases with the solvency target, and crucially hinges on the degree of loan deleveraging assumed. Alternative models also provide differing estimates – the Global Vector AutoRegressive model generating sizeable cross-country spillovers that the country-specific Dynamic Stochastic General Equilibrium models do not capture (see Chart 16).

Chart 16

Impact of banks' reaction on euro area GDP

(percentages, deviation from baseline levels, end-2018)



Source: STAMP€.

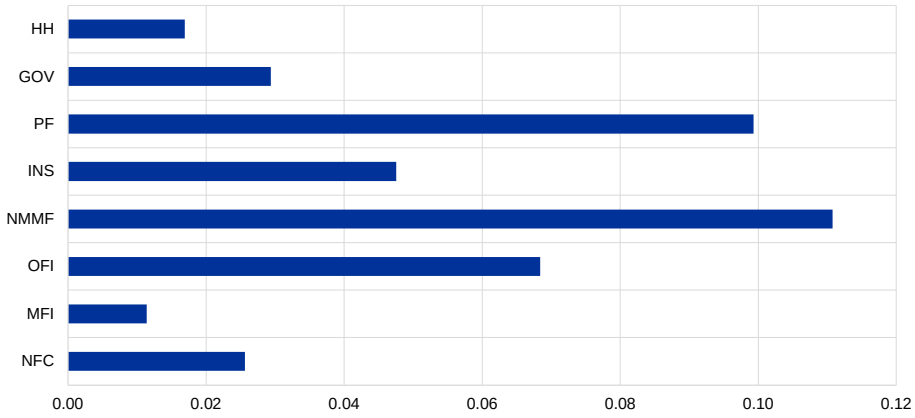
Apart from providing information on the potential impact on activity as a result of bank lending contraction under stress, the exercise also provides additional policy-relevant information. The resulting update to the macro-financial scenario leads to an update on banks' solvency results, which can be interpreted as the incremental impact of loan deleveraging under stress triggered by higher capital targets. While some banks, in isolation, benefit from their own decision to shrink their loan book, once the overall impact on activity of individual banks' decisions is accounted for, banks' solvency across the system as a whole is further degraded by the aggregate credit contraction. At all stages of the MPE process, the solvency results can moreover feed into a contagion analysis, both within the sector and to other financial sectors on the two above-mentioned types. The 2016 MPE demonstrated that other financial institutions (OFIs) appeared particularly exposed to capital declines in the banking sector (see Chart 17), in line with reduced-form analysis from, for example, Co-ES (co-expected shortfall) estimates.[38]

[38] See Gross et al. (2017).

Chart 17

Cross-sectoral spillovers via equity holdings

(percentage of the sector's total assets)



While DSGE models can help evaluate banks' reactions to given capital targets under stress, as in the MPE, they can also be enriched to evaluate banking sectors and activity responses to a broader set of macroprudential measures.[39] Simulations can be carried out to assess the impact of a range of alternative policy tools, for example, increasing systemic capital buffers, capping Loan-To-Value (LTV) or Loan-To-Income (LTI) ratios or upping sectoral risk weights, both for a given country or at euro area level.

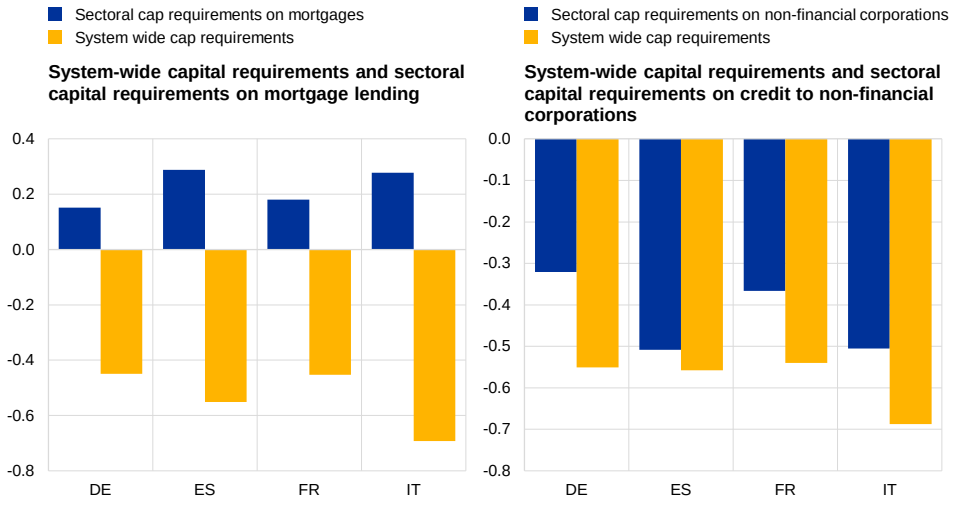
The impact of higher capital requirements can be seen, for example, as a change in the banks' steady-state capital ratio, which causes activity to deteriorate more than an exogenous shock driving capital below its (unchanged) steady state. The impact is channelled through a reduction in loans to households and corporates or a corresponding hike in risk premia. Measures that focus on a specific sector rather than economy-wide have a less negative effect on the economy overall, *ceteris paribus*, since the credit adjustment by banks can differentiate across sectors and re-allocate to corporates that support activity (see Chart 18). Simulations conducted can also document the value of employing country-specific tools, such as capping LTVs with respect to an increase in euro area monetary policy rates, in the case of, for example, localised overheating on specific housing markets.

[39] For example, Darracq-Pariès M., Kok, C. and Palenzuela, D. (2010), "Macroeconomic propagation under different regulatory regimes: evidence from an estimated DSGE model for the euro area", *Working Paper Series*, No 1251, European Central Bank, Frankfurt am Main and Rancoita, E. and Hilberg, B. (2017), "Estimating the macroeconomic feedback effects of macroprudential measures – Dynamic Stochastic General Equilibrium (DGSE) models", Chapter 10 in Dees et al. (eds) "STAMP€".

Chart 18

Impact on real GDP of system-wide and sectoral capital requirements

(percentage deviation from the baseline)



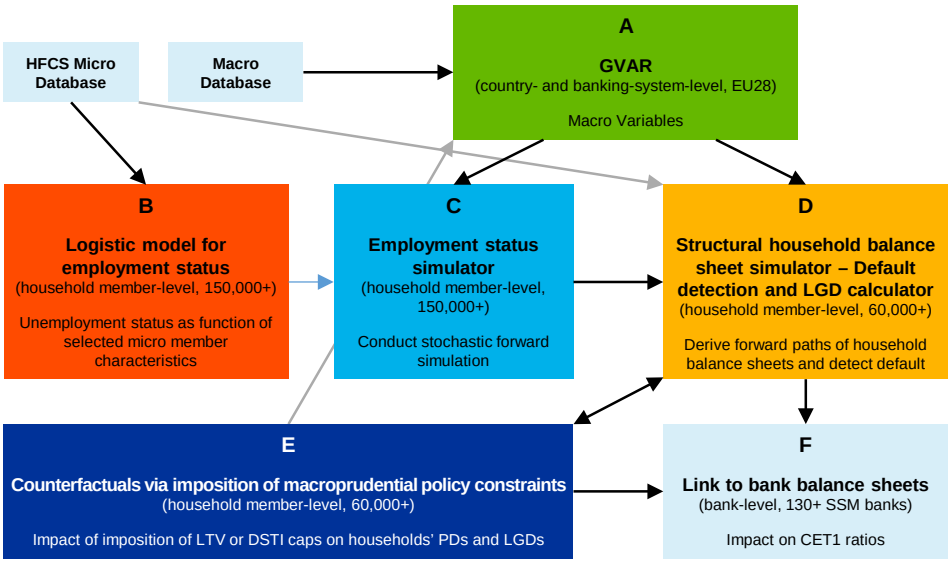
Source: STAMP€.

Measures affecting borrowers such as LTV and LTI may be assessed in an even more granular fashion by using detailed micro data, such as the Household Finance and Consumption Survey (HCSF) conducted across 15 European countries for more than 60,000 households. An innovative way of using this uniquely comprehensive dataset was to set up an agent-based model allowing each individual household to respond to shocks – with employment status as a pivotal variable.[40] The framework (see Chart 19) considers a scenario as a first input – generated by a GVAR or any other macroeconometric tool – which then feeds into a given household account via the latter's employment status, the key link between the micro and macro sides in this framework. Employment status is modelled at household member level – related to member characteristics, such as age, and conditional on a given country's overall (macro) unemployment rate. A given household is considered to be in the default state when its liquid assets turn negative – reflecting determinants such as real and financial wealth, income and expenses, and employment status. Aggregated default parameters and credit for each country/banking sector then provide a macro view, which drives bank solvency and activity.

[40] See Gross, M. and Población, J., (2017) "The Integrated Dynamic Household Balance Sheet (IDHBS) model of the euro area households", Chapter 15 in Dees et al (eds), "STAMP€".

Chart 19

Households agent-based model structure



Source: STAMP€.

If an LTV/LTI measure were implemented, the population of households would face some loan rationing. This would lead, *ceteris paribus*, to a decline in the probability of default system-wide (as less robust households would not get loans) and, at the same time, to a decrease in GDP (since overall credit would also contract). Integrating the micro household-level reaction with the macro set-up makes it possible to distinguish the respective impact of overall lower loans from that of better quality loans on both activity and banks' capital. Overall, the predominant effect on capital is that of the policy measure, i.e. loan rationing, while adversely affecting GDP, does not undermine the objective of the policy step, namely improving the banking system's solvency and thus its overall resilience and stability.

Another field of application of agent-based models is the interaction between banks and non-banks in financial markets. This has drawn increasing attention with the growing takeover of investment bank activities by a large number of smaller and specialised funds, which are generally less regulated or monitored than banks. Apart from the analysis of the impact of banks'stress on such players, which, as mentioned above, can be sizeable, another stream of work focuses on shocks that originate in the shadow banking sector.[41]

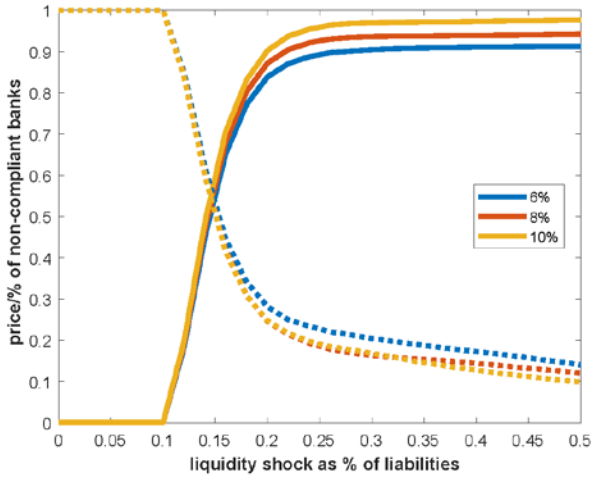
Following redemption shocks, some funds may be forced to sell assets at fire sale prices. The extent to which the implied decline in prices endangers the whole financial system depends on both the relative size of the non-banks in the market and the shock-absorbing capacity of banks. When some funds are confronted with illiquidity, banks can step in to buy the assets that funds wish to sell. This stabilises the whole system by preventing the induced asset price declines to become so sizeable that not

41 See Calimani, S., Halaj, G. and Zochowski, D. (2017), "Simulating fire sales in a banking and shadow banking system", *Working Paper*, No 46, European Systemic Risk Board, Frankfurt am Main, and Ari, A., Darracq-Pariès, M., Kok, C. and. Zochowski, D. (2016), "When shadows grow longer: shadow banking with endogenous entry", *Working Paper Series*, No 1943, European Central Bank, Frankfurt am Main.

only funds but also banks experience strong and unsustainable valuation drops. However, this cushioning mechanism may be endangered when, owing to balance sheet or regulatory constraints, banks are unable to limit price declines. A particularly interesting comparison is illustrated in Calimani et al. (2017) (see Chart 20). Simulations show that, for a given liquidity shock to the system, the portion of banks that may fail increases with the capital ratio required for banks. *Ceteris paribus*, when banks face higher capital requirements, they can only buy the less risky assets that funds want to sell, thereby being less in a position to mitigate the price impact of funds' illiquidity on the whole system.[42] This can be interpreted as an illustration of misusing policy tools owing to a mismatch between instrument and objective, i.e. targeting banks to solve a problem solely originating in the non-bank sector can become counter-productive or even self-defeating.

Chart 20

Households agent-based model structure



Source: Calimani et al. (2017).

[42] See Calimani, S., Halaj, G. and Zochowski, D. (2017), "Simulating fire sales in a banking and shadow banking system", *Working Paper* No 46, European Systemic Risk Board, Frankfurt am Main.

5 Challenges and open issues

Macroprudential policy is still in its infancy, at least in developed countries. As such, there are a number of challenges and open issues surrounding the macroprudential framework. To date, macroprudential policies have mostly been targeted at the banking sector, but open questions remain on the overarching objectives of such policies, the appropriate instrument set and the strategy for deploying different tools. The application of macroprudential policies has also raised concerns over the potential for leakages and international spillovers. Indeed, since the crisis, regulatory reform has incentivised some migration of financial activity to the non-bank financial sector. While market-based finance can provide a "spare tyre" in relation to bank-based finance, it also generates new systemic risk, which may warrant a macroprudential response, and highlights the clear need to retain flexibility to introduce possible new tools as risks develop and evolve. Taking an even broader view, fierce debate persists over the role that monetary policy might have to play in addressing financial sector imbalances and how monetary and macroprudential policies should be coordinated. While these issues are all important areas for further research, analysis and practical exploration, this section briefly sets out some key considerations in these various debates (see also Aikman et al., 2018, for discussion of some of these topics).

5.1 Objectives, banking toolkit and macroprudential strategy

As discussed in Section 3.2, the ultimate objective of macroprudential policy is to contain systemic risk and thus ensure financial stability. There is broad agreement that this should encompass protecting and enhancing resilience of the financial system. In terms of cyclical risks, the ECB's macroprudential strategy also includes an operational objective to smooth the credit cycle. But there are a range of views about the extent to which macroprudential policies should target asset prices. As argued by Constâncio (2016), it may be more plausible to target real estate prices than other financial asset prices. But others have argued that it is not the role of macroprudential authorities to control house prices (Cunliffe, 2015). Open questions also remain over the extent to which macroprudential policies should be used to target the potential for aggregate demand externalities associated with, for example, excessive household indebtedness, even if there is a limited threat to the resilience of the core financial system.

Debates also persist about the appropriate macroprudential banking toolkit, how different instruments might interact and the circumstances in which they might be deployed. As argued by Constâncio (2017), the existing toolkit might usefully be complemented with borrower-based instruments (such as limits on loan-to-value or loan-to-income ratios), as well as sectoral buffers and a time-varying leverage ratio add-on, which broadly resembles the toolkit currently available to the Bank of England's Financial Policy Committee. In particular, there is considerable evidence highlighting the potential potency of borrower-based measures in mitigating risks in

the housing market (Crowe et al., 2013; Kuttner and Shim, 2013)[43]. Sectoral capital requirements have also been deployed in a range of countries internationally (Bank of England, 2014). Furthermore, the adoption of time-varying leverage ratios could help to maintain complementarity with the countercyclical capital buffer (CCyB) and the overall balance of the capital framework across risk-weighted and unweighted measures (ESRB, 2015).

However, with such an array of tools, it is also important to deepen understanding of the appropriate strategy for their deployment and the relationships between them. For example, when might it be appropriate to implement a sectoral capital buffer rather than the CCyB? When targeting housing sector vulnerabilities, what are the trade-offs between increasing risk weights on mortgage lending and seeking to restrict such lending directly via the use of loan-to-value or loan-to-income restrictions? More generally, as discussed by Aikman et al. (2015), important questions remain over how macroprudential policy should handle uncertainty and how resilience should be balanced against credit supply when deciding how to release macroprudential requirements during a downturn.

5.2 Leakages and international spillovers

Like any other form of regulatory action, macroprudential policies provide incentives to market participants that have an impact on their behaviour. In particular, affected entities may be incentivised to engage in regulatory arbitrage and thus leakages may ensue.[44] Regulatory arbitrage is typically defined as a change in the structure, but not on the underlying substance of an activity, with the primary aim of minimising the impact of regulation on the institution. This includes leakage to differently regulated domestic sectors (e.g. shadow banks or non-banks outside the regulatory perimeter of the measure taken). In some circumstances, these entities may still be linked to the initial affected institution. Moreover, macroprudential policies may also lead to unintended negative cross-border spillovers, which may affect both conditions abroad and incentivise foreign banks and non-banks that are not subject to tighter policy to increase their activity.

5.2.1 Leakages

As mentioned above, macroprudential policies may be subject to regulatory arbitrage or to “leakages” or “waterbed effects”. The following aims to further illustrate these concepts:

First, higher macroprudential requirements may increase incentives for banks to exploit the flexibility granted in the regulatory framework in an unwarranted manner.

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43 Crowe, C., Dell’Ariccia, G., Igan, D. and Rabanal, P. (2013), “How to deal with real estate booms: lessons from country experiences”, *Journal of Financial Stability*, Vol. 9 (3); Kuttner, K. and Shim, I. (2013), “Taming the real estate beast: the effects of interest rate, credit and housing-related tax policies in housing prices and credit”, *Working Paper*, Bank for International Settlements, Basel.

44 Constâncio, V. (2014), “The ECB and Macroprudential policy: from research to implementation”, speech given at the Third Conference of the Macroprudential Research Network, June.

For example, an increase in the CCyB may increase the incentives to optimise (i.e. reduce) risk-weights in order to dampen the impact on the overall level of capital requirements. This may point towards the desirability of allowing for time-varying leverage ratios in the macroprudential toolkit.

Second, the financial intermediaries affected may have incentives to circumvent regulation by moving activities into less regulated or differently regulated parts of the financial sector. For example, banks may shift activity off-balance sheet by moving it to entities that are not consolidated, for prudential purposes. As a result, banks may become vulnerable to "step-in risk" as they may be incentivised to guarantee losses of such entities in a crisis situation.[45]

Third, activity may leak to other sectors outside the banking sector, as less regulated or differently regulated entities may increase their exposures. The significant growth of market-based finance could be considered a clear sign of this development, including an increase in credit creation outside the banking sector. Such effects are often referred to as "waterbed" effects.

5.2.2 International spillovers

Recent analytical work at the ECB[46] highlighted that macroprudential measures implemented in individual Member States may have cross-border or cross-sectoral repercussions. The authors emphasise that, by their very nature, macroprudential policy measures are intended to address specific financial stability risks in individual Member States. If successful, they should also enhance financial stability for the Union as a whole in the long term, as lower probability of a systemic crisis in one Member State entails less risk of contagion to the others. However, macroprudential policy may lead to unintended negative cross-border spillovers in the short term due to leakages and arbitrage by financial institutions. The design of policy instruments should therefore try to reap the benefits of positive spillovers related to increased financial stability and at the same time contain potential negative spillovers.

To inform the design of macroprudential policies, it is important to understand that spillovers of macroprudential policy may come in different ways and via different transmission channels. In a first step, Fahr and Zochowski (2015) distinguish the direction of spillovers into outward and inward effects, informing the potential need for reciprocity.

Outward spillovers imply that other countries are affected by a macroprudential policy action of one Member State and may trigger macroprudential policies regardless of reciprocity.

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45 Authorities have already taken steps to address this issue, including the BCBS (see, for example, BCBS, Identification and management of step-in risk, Guidelines, October 2017).

46 Fahr S. and Zochowski D. (2015), Special Feature A: "A framework for analysing and assessing cross-border spillovers from macroprudential policies", *Financial Stability Review*, European Central Bank, Frankfurt am Main, May.

By contrast, inward spillovers imply that foreign banks circumvent the macroprudential policy action because the macroprudential policy may not apply to foreign institutions. An example of the negative inward spillover or regulatory arbitrage would occur when branches of foreign banks increase lending as a result of tighter credit standards or capital requirements imposed on local borrowers or lenders, since branches – in the absence of reciprocity arrangements – are not bound by local macroprudential policy measures. There is convincing evidence of such inward spillovers in the work of Aiyar, Calomiris and Wieladek (2014).[47] The authors show that regulated banks (UK-owned banks and resident foreign subsidiaries) reduce lending in response to tighter capital requirements. But unregulated banks (resident foreign branches) increase lending in response to tighter capital requirements for a relevant reference group of regulated banks. Hence, the lack of reciprocity might generate substitution effects towards branches of foreign banks which would reduce or ultimately undermine the effectiveness of macroprudential policy.

The channels of propagation through which macroprudential policy action can have cross-border effects may take different forms. Fahr and Zochowski (2015) identify the risk adjustment channel (in particular, adjustments of cross-border credit exposures, as banks may adjust cross-border portfolio allocation), the network formation channel (in particular, adjustments of cross-border liquidity/funding lines) and the regulatory arbitrage channel (in particular, capital regulatory arbitrage as most relevant while other channels appear less relevant).

The importance of spillovers from macroprudential policies and the need for reciprocity may grow over time in the monetary union when financial integration increases. It also highlights the importance of policy coordination and having a reciprocity framework to address concerns about leakages and spillovers. It will, therefore, be very important to obtain international cooperation to enhance the effectiveness of macroprudential policies. In the euro area, the SSM framework helps by internalising some issues.[48] For example, the ECB can take action in the case of reciprocation if needed. It also highlights the importance of having a comprehensive macroprudential toolkit for the banking sector and monitoring the migration of systemic risk to the non-bank financial sector.

5.3 Beyond banking

Systemic risk from the non-bank financial sector, or “shadow banks”, played a key role during the crisis. Subsequent regulatory reform has largely focused on strengthening the regulatory framework for banks, which has, in turn, potentially incentivised some migration of financial activity to non-banks, particularly within Europe. As a result, credit and funding risk on bank balance sheets is evolving into market and liquidity risk in the wider financial system (see Stein, 2013). While market-based finance can provide a “spare tyre” in relation to bank-based finance, it also generates new

47 Aiyar, S., Calomiris, C.W. and Wieladek, T., (2014), "Does Macro-Prudential Regulation Leak? Evidence from a UK Policy Experiment", *Journal of Money, Credit and Banking*, Vol. 46. s1 pp. 181-214.

48 Constâncio, V. (2014), “The ECB and Macroprudential policy: from research to implementation”, speech given at the Third Conference of the Macroprudential Research Network, June.

systemic risk, which warrants monitoring and potential macroprudential policy responses.

Financial markets experienced significant growth in market-based activities before the financial crisis. For example, securitisation volumes in Europe had grown from levels of around €100 billion in the year 2000 to a peak of around €900 billion in 2008 (see ESRB Macroprudential policy beyond banking: an ESRB strategy paper). Similarly, outstanding repo and reverse repo transactions have risen from around €2 trillion in 2000 to close to €7 trillion in 2008 (see ECB (2017) Financial Stability Review Special Feature C, November).

Since the global financial crisis, there has been a significant decline in the activities that were at the centre of the crisis. For example, the volume of securitisations, asset-backed commercial paper (ABCP) programmes, structured investment vehicles (SIVs), subprime residential mortgage-backed securities (RMBS) and collateralised debt obligations (CDOs) has significantly fallen from the pre-crisis peak.[49] This decline resulted from broader market developments following the crisis, as well as regulatory efforts to reign in risk.

The FSB[50] identified a number of key regulatory developments that helped in this respect. As a reminder, enhancements to bank consolidation rules for off-balance-sheet entities have significantly reduced the ability of banks to move risks to special-purpose vehicles (SPVs) and similar; new bank prudential rules ensure that banks' exposures to shadow banking and their involvement in market-based activities such as securitisation and repos are adequately captured. There have also been significant regulatory efforts to reduce risks emanating from the shadow banking entities and activities by targeting them directly. Reforms in a number of key jurisdictions, including the EU and the United States, have mitigated the susceptibility of MMFs to "runs". For security financing transactions (SFTs), the FSB has published policy recommendations aimed at reducing liquidity and the maturity transformation of liquidity risk associated with SFTs, as well as limiting their contribution to the build-up of leverage in the financial system.

In contrast, the assets of the non-bank, non-insurance financial sector in the euro area have continued to grow since the financial crisis (see Chart 21). In particular, the investment fund sector has been subject to tremendous growth, with total net assets of European investment funds more than doubling from €6.1 trillion to €14.1 trillion[51]; the

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49 Financial Stability Board (2017a), "Assessment of shadow banking activities, risks and the adequacy of post-crisis policy tools to address financial stability concerns", Basel, July and European Systemic Risk Board (2016), "Macroprudential policy beyond banking: an ESRB strategy paper", Frankfurt am Main, July.

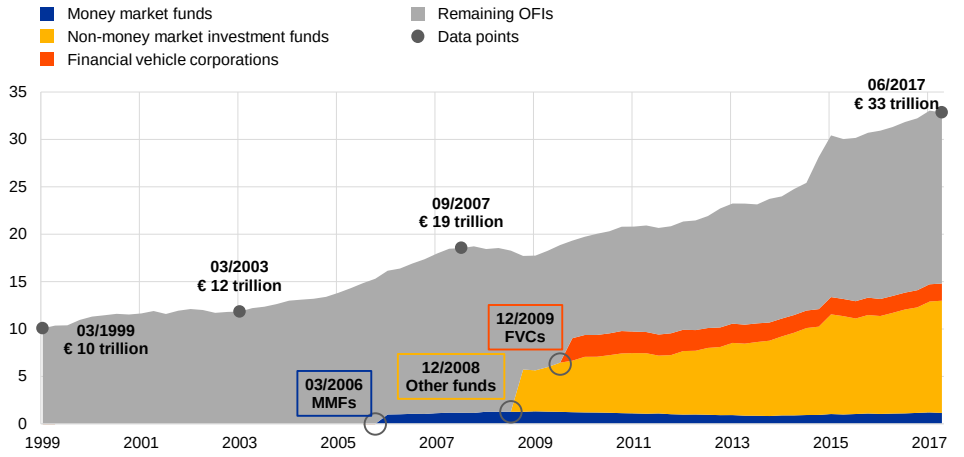
50 Financial Stability Board (2017b), "Policy Recommendations to Address Structural Vulnerabilities from Asset Management Activities", Basel, January and Financial Stability Board (2017c), "Transforming Shadow Banking into Resilient Market-based Finance – Re-hypothecation and collateral re-use: potential financial stability issues, market evolution and regulatory approaches", Basel, January.

51 European Central Bank (2017), *Financial Stability Review*, Frankfurt am Main, November and European Central Bank (2017), *Report on Financial Structures*, Frankfurt am Main, October.

remaining other financial institution (OFI) sector has also steadily increased in this period.[52]

Chart 21

Assets of the non-bank, non-insurance financial sector have continued to grow



Sources: ECB and ECB calculations.
Notes: A breakdown of statistical data for MMFs, other funds and FVCs is available only from the indicated dates onwards. The non-bank, non-insurance financial sector includes MMFs and all other non-monetary financial institutions apart from insurance corporations and pension funds. Further statistical breakdowns are available at national level, including for non-securitisation special-purpose vehicles (SPVs) in Ireland and special financial institutions (SFIs) in the Netherlands.

Owing to the growing importance of market-based finance, the regulatory community has to remain vigilant and even step up its efforts in monitoring and assessing risks stemming from this sector. The ECB has therefore called for a three-pronged approach[53]: first, work to establish a monitoring framework with enhanced supervision tools needs to continue; second, the regulatory framework needs to develop (macroprudential) instruments targeted at market-based finance risks, and third, it is important that the institutional and supervisory framework in the EU be strengthened.

5.3.1 Establish a monitoring framework

Since the financial crisis, significant efforts have been made to shed more light on market-based finance, with regard to both activities and entities. To monitor market-based finance, transaction-level reporting of derivatives via EMIR has been ongoing since 2014. Similarly, transaction-level reporting of SFTs via SFTR reporting requirements is scheduled to start in 2019. With regard to entities, the ECB has statistics on the types of investment funds, and their breakdown into assets and liabilities. Moreover, the recent financial vehicle corporation (FVC) classification

52 Analysis in the ECB, *Financial Stability Review* (2017), shows that the share of entities in the OFI sector engaged in credit intermediation and liquidity transformation outside the banking sector is relatively low, suggesting limited risks to the financial system at this stage. However, concerns remain that vulnerabilities may be building up in the remaining entities which engage in risky activities and are still opaque.

53 Constâncio V. (2015), “Reinforcing financial stability in the euro area”, speech at the European Central bank, Frankfurt am Main, May.

exercise has provided detailed data and enabled better supervision of the euro area non-bank financial sector.

However, since not all aspects of the new monitoring framework are in place yet, it is too early to assess whether all these efforts have been sufficient. Moreover, a number of gaps have already been identified that limit the authorities' ability to monitor and assess risks to date. At entity level, additional efforts are required in the following areas: (i) some parts of the OFI universe still cannot be identified by type in the national accounts and remain outside the monitoring perimeter; (ii) higher risk-taking may remain undetected in some parts of the system as available metrics capture average developments – this calls for the assessment of distributions across entities and possibly for further sectoral breakdowns; (iii) the risk assessment would benefit further from better data on a consolidated and non-consolidated basis; (iv) using the Legal Entity Identifier (LEI) is not yet mandatory for investment funds and other entities, which significantly hampers efforts to identify these entities in the available data sets.

At activity level, there are also gaps: (i) in some cases, metrics are not sufficient to provide a definitive risk assessment, such as for monitoring synthetic leverage created through derivatives; (ii) better data is also needed on asset liquidity and the redemption features of investment funds; (iii) consistent mapping of cross-border and cross-sector links via exposures and activities, including the assessment of ownership structures; (iv) enabling the matching of different data sets that will improve the ability to monitor risks that cut across sectors, such as procyclicality in margining and haircut practices and liquidity risk propagation in collateralised securities financing and derivatives.

A broader set of data available for the non-bank sector may also support system-wide stress testing. As discussed previously, stress testing has evolved considerably since the financial crisis and is now a cornerstone of the regulatory regime in many jurisdictions. However, one key challenge relates to the scope for such simulations to include the non-bank financial sector and capture new market and liquidity risks and their propagation across the financial system. Specifically, the FSB has recommended that system-wide stress testing be considered for asset management, which could capture the effects of collective selling by funds and other investors on the resilience of financial markets and, more generally, the financial system. Going forward, combining transaction-level data from derivative and SFT markets with enhanced balance sheet information for non-bank entities could significantly improve the ability of system-wide simulations to inform the monitoring of risk arising from the non-bank sector.

5.3.2 Develop instruments targeted at market-based finance risks

As in the banking area, liquidity mismatch between the asset and liability sides of entities and the use of leverage are the focus of regulatory scrutiny in the non-bank area. The mismatch between the liquidity profile of entities' assets and their liabilities may result in unstable funding structures, which may increase their susceptibility to runs as well as to the danger of fire sales, potentially creating externalities on the wider

financial system. This particularly holds for investment funds, where the FSB highlighted the mismatch between the liquidity fund investments and daily redemption of fund units as a key vulnerability. As a result of unanticipated large losses, investors may make significant redemptions from underperforming funds to minimise further negative returns, potentially amplifying downward pressure on asset prices.

In order to address vulnerabilities related to liquidity mismatch, the FSB has issued a number of recommendations in the areas of investment funds[54] and SFTs[55]. For investment funds, the FSB recommends that authorities should have requirements or guidance stating that funds' assets and investment strategies should be consistent with the terms and conditions governing fund unit redemptions. Furthermore, authorities should broaden the availability of liquidity risk management tools to open-ended funds, and reduce barriers to the use of those tools, including tools to reduce first-mover advantage. Most importantly, from a macroprudential perspective, the FSB recommends that authorities should provide guidance on their use in stressed conditions, and where appropriate, authorities should also provide direction in extraordinary circumstances regarding open-ended funds' use of such liquidity risk management tools.[56] In the same context, and taking into account the work of the FSB, on 14 February 2018, the ESRB published recommendations to European authorities and legislators that addressed systemic risk in the asset management sector, including those related to liquidity mismatches.[57] In particular, the ESRB advocates the introduction of additional liquidity management tools, further supervisory requirements and tighter liquidity stress testing practices to address risks from liquidity mismatches.

For SFTs, the FSB published policy recommendations to address financial stability risks associated with SFTs in August 2013 aimed at reducing liquidity and maturity transformation via such transactions. For example, the principles for regulations governing re-hypothecation of client assets stipulate that only entities subject to adequate regulation of liquidity risk should engage in the re-hypothecation of client assets.

The use of leverage, especially with derivatives and SFTs, may further increase the vulnerabilities created by liquidity mismatch in non-bank entities. Leverage may increase losses for equity holders as it increases the balance sheet's sensitivity to changes in asset prices.

To constrain the procyclical build-up of leverage via SFTs in non-bank financial entities, the FSB developed a regulatory framework for haircuts on non-centrally cleared SFTs.[58] In the context of its work on asset management managers, the FSB

54 Financial Stability Board (2017), "Policy Recommendations to Address Structural Vulnerabilities from Asset Management Activities", Basel, January.

55 Financial Stability Board (2013), "Policy Framework for Addressing Shadow Banking Risks in Securities Lending and Repos", Basel, August.

56 In addition, the FSB recommendations target (iii) operational risk and challenges in transferring investment mandates in stressed conditions; and (iv) securities lending activities of asset managers and funds.

57 Recommendation of the European Systemic Risk Board of 7 December 2017 on liquidity and leverage risks in investment funds (ESRB/2017/6), 14 February 2018.

58 Financial Stability Board (2014), "Regulatory framework for haircuts on non-centrally cleared securities financing transactions", Basel, October.

asked IOSCO to identify and/or develop consistent measures of leverage in funds to facilitate more meaningful monitoring of leverage for financial stability purposes, and help enable direct comparisons across funds and at global level. In its recommendation addressing systemic risk in the asset management sector, the ESRB considers the introduction of harmonised reporting frameworks and the operationalisation of macroprudential leverage an important way of addressing risks arising from excessive leverage in the investment funds sector.

More generally, the FSB Re-hypothecation and Re-use Expert Group also highlighted the leverage ratio as the main brake put in place after the crisis to address risks stemming from the repo market.[59] Hence, it is important to preserve the leverage ratio as a measure for constraining repo activity in the financial system as otherwise it may again sow the seeds for the build-up of excessive leverage and over-reliance on short-term wholesale funding in the financial markets related to securities financing transactions and the re-use of collateral.

While the above policy measures represent an important step towards a resilient non-bank sector, authorities still lack the powers to apply macroprudential tools in a large part of the non-bank sector. For SFT and derivatives markets, in particular, margin and haircut-setting practices, which can affect financial system procyclicality, may contribute to the build-up of excessive leverage. Macroprudential margins and haircuts have been identified as potentially powerful tools to address these concerns.[60] In particular, raising margin and haircut requirements in times of price exuberance would work against the build-up of leverage when it is deemed necessary, and would also lower the impact of procyclical changes in margins and haircuts in bad times driven by higher volatility and the higher risk aversion of market participants.[61] Work should continue on how to operationalise such tools.

For the asset management sector, it is crucial that the FSB recommendations concerning the role of authorities in using liquidity tools in extraordinary circumstances are implemented carefully. Specifically, for Europe, the macroprudential leverage limit that is already in use for alternative investment funds should be operationalised. This is needed to ensure that authorities have the powers to limit the leverage of these entities when necessary. Indeed, recent evidence suggests that investor outflows of leveraged funds exhibit stronger to bad past performance than unleveraged funds, which could exacerbate systemic risk.[62] Finally, there is a wider debate on the potential need of insurance companies for macroprudential instruments, which is beyond the scope of this paper but has been the focus of recent discussion by the European Insurance and Occupational Pensions Authority (EIOPA –2017).

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59 Financial Stability Board (2017), "Transforming Shadow Banking into Resilient Market-based Finance – Re-hypothecation and collateral re-use: potential financial stability issues, market evolution and regulatory approaches", Basel, January.

60 See, for example, Committee on the Global Financial System (2010), "The role of margin requirements and haircuts in procyclicality"; or European Central Bank (2016), Special Feature A: "A case for macroprudential margins and haircuts", *Financial Stability Review*, Frankfurt am Main, May; European Systemic Risk Board (2017), "The macroprudential use of margins and haircuts", Frankfurt am Main, February.

61 European Central Bank (2016), Special Feature A: "A case for macroprudential margins and haircuts", *Financial Stability Review,* Frankfurt am Main, May.

62 European Central Bank (2017), "Developing macroprudential policy for alternative investment funds", *Occasional Paper* No 202, November.

5.3.3 Strengthen the institutional and supervisory framework in the EU

The increasing role of the non-bank sector in the EU financial system also requires the institutional and supervisory framework for EU capital markets to be strengthened; this will include expanding the competent authorities' mandate to take into account financial stability, and creating a single capital markets supervisor. It is particularly important that the framework is strengthened in the light of the ongoing work to create a Capital Markets Union, which will further increase the importance of capital markets and the non-bank financial sector in the EU.

To date, the current system focuses on investor protection. However, the role of non-bank activities in the recent financial crisis and the increasing size of the non-bank sector call for enlarging the mandate of capital market supervisors beyond investor protection to include financial stability. In this context, the ECB has already highlighted that the discussion of financial stability issues in the non-bank sector warrants the involvement of central banks, given their expertise in assessing systemic risk, and requires changes in the competences and governance of the European Securities and Markets Authority and EIOPA.[63]

A strong CMU will, in the long run, also require the creation of a single capital markets supervisor. The supervision of securities markets still occurs at national level, which fragments the application of EU legislation and keeps the EU capital markets segmented. A successful CMU will increase cross-border activity and thereby expand risk-sharing. Increased cross-border activity, however, requires taking a holistic view of European capital markets, which is arguably best served by a single capital markets supervisor. Efficient supervision also requires promoting and implementing greater standardisation of the information provided to the authorities and markets, including loan information.

5.4 Interaction with monetary policy

The global financial crisis and emergence of macroprudential policy have re-ignited the debate over the extent to which monetary policy should "lean against the wind", while also raising important issues on how monetary and macroprudential policies might be most effectively coordinated.

The debate on "leaning against the wind" – using monetary policy to curb financial imbalances and overvaluations in asset prices – intensified in the late nineties.[64] The practice implies increasing policy rates pre-emptively, above what would be adequate, to attain the goal of price stability. The BIS composite asset price index, relating asset prices to changes in credit, as in Borio, Kennedy, and Prowse (1994), raised the possibility of using monetary policy to contain credit growth and avoid overstretched asset valuations.

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63 European Central Bank (2017), contribution to the European Commission's consultation on the operations of the European Supervisory Authorities, Frankfurt am Main, July.

64 For a description of this debate over time, see Constâncio, V. (2018), "Financial stability risks and macroprudential policy in the euro area", speech at the European Central Bank and its Watchers XIX Conference, Frankfurt am Main, March.

But later in the decade, Bernanke and Gertler (1989) argued forcefully that monetary policy should only respond to fluctuations in asset prices to the extent that they affect forecasts of inflation or the output gap (see also Bernanke and Gertler (2001)) and Kohn (2008). The authors stressed that, in normal times, price and financial stability objectives usually converge, relating financial stability to the absence of excessive movements in asset prices. In their view, when targeted inflation is assured or below target, monetary policy should not become over-restrictive just to pre-empt possible asset bubbles for two main reasons. First, the early identification and precise measurement of price bubbles in real time was difficult, if not outright impossible; second, even if such price misalignments were observed, it was argued, monetary policy would not be able to deal with them adequately. This was because the interest rate adjustments necessary to contain asset price bubbles could not be easily calibrated on a theoretical basis. Furthermore, the increase in rates needed to curb an asset price bubble could be significant with a substantially negative impact on growth and inflation, thus compromising the mandatory goal of monetary policy and affecting its credibility.

In contrast to this view, White (2006) called for monetary policy to play a more active role in addressing financial stability risks. They argued that if expected inflation were to remain unaffected by an asset price bubble, which would be the case if the bubble were not too long-lasting, then reacting only to expected inflation would not prevent bubble-induced macroeconomic volatility.

In this first stage of the debate, the arguments hovered around a view of financial stability associated with asset price behaviour and concentrated on whether monetary policy rates, viewed as the only monetary policy instrument, should be used to serve the two objectives. The financial crisis changed the terms of the debate. The notion of systemic risk replaced the narrow concern of overvaluations in asset prices, while naturally also including them. And macroprudential policies emerged as a new set of policy instruments designed to tackle systemic risk.

Accordingly, the main view became that two separate policy functions should be the norm, keeping the pre-crisis, price stability-oriented, monetary policy frameworks largely unaffected (see Bean et al. (2010) and Svensson (2012)). The new main argument justifying this stance is that macroprudential policy is now available and is the most effective tool for safeguarding financial stability and that monetary policy should only be deployed as a “last line of defence” (Kohn, 2015), if at all. This is because policy instruments directly address excessive leverage behaviour and do not have the same cost or negative spillovers as a “leaning against the wind” policy. In addition, higher interest rates also increase the debt service burden and lower the income of borrowers, who may then borrow more to smooth consumption, as argued by Alpanda el al. (2014), Gelain et al. (2015) and Korinek and Simsek (2016).

At the same time, some policymakers continue to argue that monetary policy should be deployed to lean against the wind (Stein, 2013; Juselius et al, 2016). Such arguments appeal both to a risk-taking channel of monetary policy (Borio and Zhu, 2008; Adrian and Shin, 2010) and to the idea that only monetary policy “gets in all the cracks” in a system characterised by growing market-based finance over which macroprudential policies are likely to have less influence. Others argue that monetary

and macroprudential policies should play a complementary role in tackling systemic risk (Bruno et al, 2017).

Empirically, Svensson (2017) has applied cost-benefit analysis to assess this issue. He finds that the marginal costs of using monetary policy to "lean against the wind" by far exceed the benefits. In other words, the cost of higher unemployment as a result of the monetary policy tightening far outweighs the benefits of the reduced probability and severity of financial crises. Svensson's conclusions have been criticised by Adrian and Liang (2016) and by several BIS researchers for not properly accounting for systemic risk and the persistence of the financial cycle, which risks ignoring the long-lasting effects on the real economy that financial crises may have (see Filardo and Rungcharoenkitkul (2016), Adrian and Liang (2016) and Gourio et al. (2017)). Accounting for these aspects, it is argued, would create a case for a more active use of monetary policy to lean against the financial cycle.

To date, much of this empirical debate has been developed in frameworks without a clear role for macroprudential policy. Recent contributions by Kockerols and Kok (2019) and Aikman et al. (2018) consider the joint deployment of macroprudential and monetary policies in tackling systemic risk. Both papers find that macroprudential policies are typically more effective than monetary policy. Kockerols and Kok (2019) demonstrate how the marginal benefits of macroprudential policy outweigh the marginal costs. They also show that the relative effectiveness of macroprudential policy in tackling the build-up of financial stability risks is even more pronounced in the euro area context, owing to the fact that, in a monetary union, a single monetary policy is not well-suited to dealing with financial imbalances emerging at national level. Such imbalances are better tackled with targeted national macroprudential measures. Aikman et al. (2018) show how the instruments are typically substitutes for monetary policy loosening when macroprudential policy tightens, while also exploring when the instruments might be complementary, and considering the implications of allowing for market-based finance and a risk-taking channel of monetary policy.

Overall, there are synergies and trade-offs between monetary and macroprudential policy. These interactions may become even more pronounced in a monetary union where monetary policy, by definition, will be focusing on area-wide economic and financial conditions. In such circumstances, macroprudential policy targeting imbalances building up at national level within the monetary union can help to achieve better policy outcomes in terms of price and financial stability.

6 Conclusions

Financial stability has been a key function for the ECB since its inception. In this sense, the macroprudential policy tasks with top-up powers conferred on the ECB were a natural extension once it had assumed the role of performing prudential oversight activities for the euro area. Given the ECB's multinational dimension, global macroprudential standards needed to be tailored to the euro area's uniqueness – culminating notably in a joint role for policy-setting between the ECB and the national authorities.

These tasks have required strong governance, as well as the adaptation of existing tools and development of new tools to measure and assess systemic risk. The ECB's analytical work has, accordingly, been strengthened to support financial stability supervision and assessment, as well as macroprudential policy analysis, in three key areas: (i) methods to gauge the state of financial instability or prospects of near-term systemic stress: (ii) measures to capture, on a timely basis, the build-up of systemic risk focused on country-level financial cycle measurement and early warning methods, and (iii) macro-financial models to assess the potential severity of systemic risk, which complement this suite of methodologies to support the macroprudential policy function.

This analytical strengthening has provided the ECB with systemic risk identification and assessment tools appropriate for supporting macroprudential policy calibration, such as the countercyclical capital buffer to address cyclical risks or capital buffers for systemic institutions to address structural risks. While the framework has come a long way since its infancy, there are still a number of challenges and open issues, and therefore work continues on tackling boundary issues with regard to a growing non-bank sector and associated market-based finance.

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