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CORRIGENDUM:

This document corrects document SWD(2022) 93 final of 4.04.2022

Correction of layout mistakes only.

The text shall read as follows:

COMMISSION STAFF WORKING DOCUMENT

European Financial Stability and Integration Review (EFSIR)

This document has been prepared by the European Commission's Directorate-General for Financial Stability, Financial Services and Capital Markets Union (DG FISMA).

This document is a European Commission staff working document for information purposes. It does not represent an official position of the Commission on this issue, nor does it anticipate such a position. It is informed by the international discussion on financial integration and stability, both among relevant bodies and in the academic literature. It presents these topics in a non-technical format that remains accessible to a non-specialist audience. For information on the methodology and quality underlying the data used in this publication for which the source is neither Eurostat nor other Commission services, users should contact the referenced source.

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LIST OF ABBREVIATIONS

Countries (in alphabetical order)

AL	Albania	IT	Italy
AT	Austria	JP	Japan
BE	Belgium	LT	Lithuania
BA	Bosnia and Herzegovina	LU	Luxembourg
BG	Bulgaria	LV	Latvia
CH	Switzerland	MC	Monaco
CN	China	MK	Republic of North Macedonia
CY	Cyprus	ME	Montenegro
CZ	Czechia	MT	Malta
DE	Germany	NL	Netherlands
DK	Denmark	NO	Norway
EE	Estonia	PL	Poland
EL	Greece	PT	Portugal
ES	Spain	RO	Romania
FI	Finland	SE	Sweden
FR	France	SG	Singapore
HR	Croatia	SI	Slovenia
HU	Hungary	SK	Slovakia
IE	Ireland	UK	United Kingdom
IS	Iceland	US	United States

Others

BBMs	Borrower-based measures	HICP	Harmonised index of consumer prices
BIS	Bank for International Settlements	ICO	Initial coin offering
bps	Basis points	IMF	International Monetary Fund
CRE	Commercial real estate	LTI	Loan to income
CRR	Capital Requirements Regulation	LTV	Loan to value
DAO	Decentralised autonomous organisation	MCD	Mortgage Credit Directive
DLT	Distributed ledger technologies	MIP	Macroeconomic Imbalances Procedure
DSTI	Debt service to income	NFC	Non-financial corporation
DSTI	Debt-service-to-income	NFT	Non-fungible token
DTI	Debt to income	NPLs	Non-performing loans
EA	Euro area	OECD	Organisation for Economic Co-operation and Development
ECB	European Central Bank	PI	Portfolio investments
FDI	Foreign direct investments	RE	Real estate
GDP	Gross domestic product	RRE	Residential real estate

EXECUTIVE SUMMARY

Published annually, the European Financial Stability and Integration Review looks at recent economic and financial developments and discusses some specific issues pertaining to the financial sector that might pose challenges to financial integration and stability and also raise policy issues.

Chapter 1 reviews the economic recovery from the COVID-19 pandemic and discusses financial stability and integration in the EU, in particular the developments in 2021. The recovery was strong but uneven across industries and Member States and remains dependent on how the pandemic, rising inflationary pressures and the crisis stemming from the Russian invasion of Ukraine evolve. Inflation was stronger and stickier than expected in 2021, fuelled by global demand, supply constraints and rising energy prices.

European and global economic activity rebounded strongly in 2021, following the deep COVID-19 recession that started in 2020. In 2021, GDP grew by 5.3% in both the EU and the euro area, despite a slowdown towards the end of the year due to supply bottlenecks, sharply rising energy prices and increased COVID infections. Rising infection rates and more contagious coronavirus variants forced many Member States to tighten containment measures again, illustrating that the coronavirus has not entirely lost its hold on the EU economy.

Financial markets were resilient and stock markets performed strongly throughout 2021, despite some bouts of volatility. Investors were willing to take on risk, prompted by low interest rate levels and recovery, fiscal and accommodative monetary policy measures. However, in the beginning of 2022, investors started to become more concerned about the reduced monetary policy support by central banks amid the strong rise in inflation (and inflation expectations). Moreover, in February 2022, risk asset markets tanked severely, following the rapid escalation of the Ukrainian crisis and the Russian invasion. Market volatility increased significantly and prices of financial assets, including European share prices, fell. Share prices of the banking sector underperformed, in particular of those EU banks that are more strongly exposed to Russia. The uncertainty surrounding military escalation and its implications for the real economy and financial markets is expected to be the dominating factor that determines how markets will evolve in the short term.

In 2021, financial stability risks receded somewhat but remained elevated. Policy measures helped to stabilise the financial sector, but several vulnerabilities remain, such as high levels of corporate debt, increasing sovereign debt and rapid rises in real estate prices. Threats to financial stability stem mainly from risks related to (i) a disruptive repricing in major financial market asset classes, (ii) renewed balance-sheet stress in the non-financial corporate sector or the household sector, and (iii) a resurgence of stress in parts of the EU banking sector. How vulnerabilities will develop will strongly depend on the outlook for growth, inflation and interest rates.

The conflict in Ukraine is likely to slow down EU growth and raise inflation in the coming months. This will hamper the correction of existing imbalances and contribute to some financial stability risks. At the time of writing, the direct effect on EU financial markets and institutions is expected to be limited. Exposure to, and financial linkages with, Russian counterparties are in general relatively small compared to the overall depth of EU financial markets, and have in many cases even receded since 2014. However, there are risks that could

affect the EU financial system, also depending on the further development of the situation in Ukraine on the ground. In particular, indirect effects via foreign trade and investment and possible dislocations of some market segments, including energy spot and derivatives markets, might very well materialise and could further accentuate pressure on financial asset prices or the proper functioning of some segments of financial markets.

Following the COVID-19 pandemic, financial integration resumed at a substantially faster pace than after previous crisis episodes, thanks to the prompt policy response and the positive effect of longer-term regulatory and institutional reforms. Price-based and quantity-based financial integration measures fully recovered by Q3 2021, although the longer-term effects of the pandemic remain to be seen. From a policy perspective, it remains important to monitor sector-specific developments and analyse structural changes in the financial system, including those that might emerge in response to the digital and green transition.

Chapter 2 reviews key developments and systemic risks in the EU real estate sector since the global financial crisis. Real estate prices have been rising strongly in most Member States in recent years, a trend showing few signs of abating. The current risks posed by real estate to financial stability remain high. The increase of vulnerabilities and the risk of a correction in these markets is one of the main medium-term systemic risks, especially in Member States with elevated household debt levels, high bank exposures to real estate markets and overvalued properties, although a significant residential real estate (RRE) price correction is in the short term partly mitigated by supply side constraints. The build-up of medium-term vulnerabilities in EU residential real estate markets warrants continued close monitoring by national and European authorities, given that housing and credit booms and busts have triggered major banking and financial crises in the past.

Macroprudential tools have been introduced in the aftermath of the global financial crisis to limit system-wide risks in the EU banking sector. Many Member States have responded to rising real estate market vulnerabilities by adopting macroprudential measures to curb imprudent lending and bolster bank resilience to real estate shocks. Member States mostly use tighter capital requirements and borrower-based instruments such as loan-to-value (LTV) and debt-service-to-income (DSTI) limits. A few Member States temporarily relaxed certain of these measures in response to the COVID-19 crisis.

In recent years, the approach of Member States to address real estate risks through macroprudential policy instruments has converged. However, significant differences remain, for instance with respect to how capital and borrower-based measures are calibrated and designed. This diversity, and other factors such as the impact of climate-related financial risks, need to be considered as part of the further development of macroprudential policies for real estate risks in the EU and in the context of the ongoing review of the EU macroprudential regulatory framework.

Chapter 3 discusses decentralised finance (DeFi), which is an emerging form of autonomous financial intermediation in a decentralised digital environment, powered by open source software. DeFi seems to replicate key features of the traditional financial system through innovative solutions adapted for the blockchain environment. Lending applications currently represent the widest use in DeFi, followed by decentralised exchanges. While still very small compared to the size of the traditional financial sector, DeFi is growing rapidly, and the chapter aims to provide an overview of the relevant issues that need to be closely monitored.

Compared to the traditional financial system, DeFi could potentially increase the security, efficiency, transparency, accessibility, openness and interoperability of financial services. As a result, DeFi could provide substantial opportunities to foster cross-border financial integration, which is an important policy objective of the EU. It could also enhance financial stability via risk sharing, which is rooted in its decentralised governance and liquidity provision. While its contribution to the financing of real economic activity is so far minimal, it is already proving to be useful in the virtual economy.

However, the DeFi ecosystem is subject to many risks, notably conduct and operational risks. Conduct risks arise in the absence of any regulation and are amplified by the quasi-anonymous nature of DeFi, whereas operational risks occur in view of the vital part played by software. Continued rapid growth of the DeFi ecosystem could also have future financial-stability implications in light of the prominent role played by stablecoins. Adapting the EU financial services regulatory framework to a decentralised environment will require a rethink; and regulatory cooperation with the main jurisdictions relevant to the DeFi ecosystem might prove indispensable. To benefit from the inherent data transparency on public blockchains, the Commission announced that it would launch a pilot project on embedded supervision¹ in 2022.

Overall, any future policy action should balance the risk of curtailing innovation versus the risks that the DeFi ecosystem may pose and the public policy benefits that regulatory intervention is expected to bring.

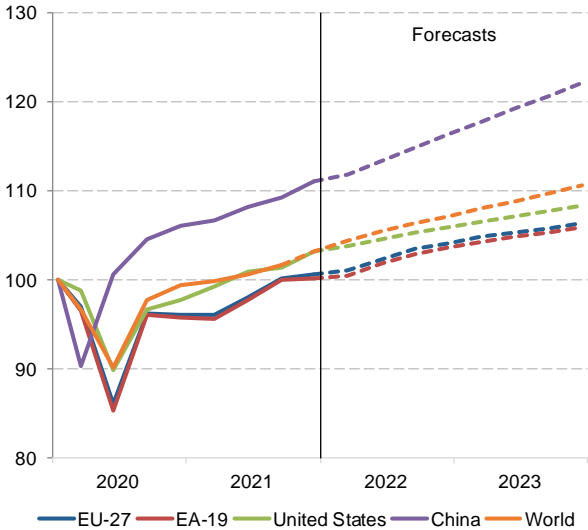
¹ See Communication from The Commission to the European Parliament, the Council, the European Economic and Social Committee and The Committee of the Regions, Strategy on supervisory data in EU financial services, COM/2021/798 final of 15 December 2021.

Chapter 1 THE MACRO-ECONOMY, MARKET DEVELOPMENTS, FINANCIAL STABILITY AND FINANCIAL INTEGRATION

1.1 Macroeconomic developments

After the COVID-19 outbreak, the EU plunged into its steepest recession since World War II, but European and global economic activity rebounded strongly in 2021. As the vaccination roll-out gathered steam, containment measures were gradually lifted, although some were temporarily re-introduced due to renewed spikes in COVID-19 infections. Consumption and investment in 2021 continued to benefit from highly supportive fiscal and monetary policies, including unprecedented stimulus packages in response to the pandemic, combined with pent-up demand and surplus household savings accumulated due to lockdowns and other restrictions. Although the recovery remains partial and uneven, thanks to stronger-than-expected global growth major developed economies – including most EU Member States – have been able to recoup their pre-crisis output level over the course of 2021 (see Chart 1.1 and Chart 1.2). Future developments are subject to elevated risks caused predominately by the economic impact of the crisis in Ukraine and the uncertain development of the pandemic.

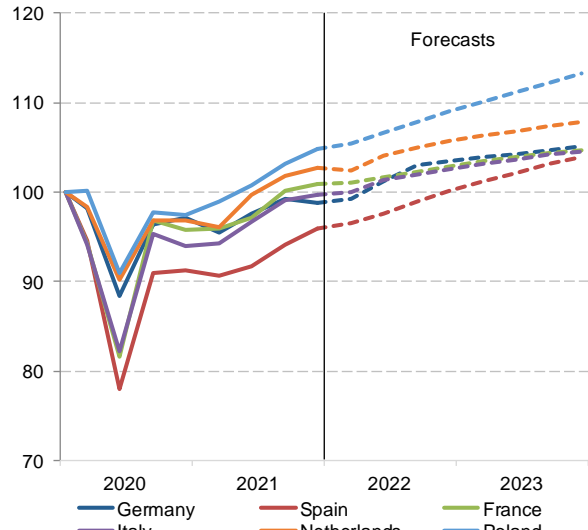
Chart 1.1: Real GDP – major global economies



Source: OECD, Eurostat, European Commission (2022), European Economic Forecast Winter 2022, *Institutional Paper* 169, February 2022.

Note: Quarterly data, indexed (Q4 2019 = 100). Forecasts pre-date the Ukraine crisis escalation in late February 2022.

Chart 1.2: Real GDP – EU Member States



Source: Eurostat, European Commission (2022), European Economic Forecast Winter 2022, *Institutional Paper* 169, February 2022.

Note: Quarterly data, indexed (Q4 2019 = 100). Forecasts pre-date the Ukraine crisis escalation in late February 2022.

Overall, GDP grew by 5.3%² in both the EU and the euro area in 2021. At the start of 2021, economic activity flat-lined, as most Member States were still in partial lockdown in response to a spike in infections over the winter months. Specifically, EU (seasonally adjusted) GDP remained roughly unchanged in Q1 2021 compared with the previous quarter. Following this trough, economic momentum picked up rapidly in spring, which was reflected in consumer and business survey data that recovered sharply and reached record highs in the summer. EU GDP grew by 2.1% and 2.2% quarter-on-quarter (q-o-q) in the second and third quarter. Yet, the combination of continuing supply bottlenecks, sharply rising energy prices and a renewed pick-

² Based on preliminary national accounts data for Q4 2021.

up in COVID infections resulted in a slowdown of GDP growth in the EU to 0.4% q-o-q in the fourth quarter. Consistent with this, sentiment indicators declined somewhat in late 2021. Overall, corporate survey data remain broadly upbeat by historical standards (Chart 1.3). Concerns about new COVID variants and higher energy prices, among other things, however further weakened consumer sentiment in the beginning of 2022.

Inflation pressures were stronger and stickier than expected. Headline inflation in the euro area hovered at around 1% y-o-y at the start of 2021, but started to rise steadily from the spring to reach 5.8%³ y-o-y in February 2022. This is the highest rate since the early 1990s, and well above the European Central Bank's 2% target. Although this acceleration was partly driven by a sharp rise in energy prices, core inflation also increased to 2.7% y-o-y as of February, pointing to general pressure on consumer prices. Consumer price inflation accelerated to above-target levels also in most other regions in the world. This global trend is largely due to the combination of strong and rapid recovery in global demand and ongoing supply constraints. The demand growth was fuelled by the reopening of major economies, while many industries such as semiconductors, building materials or commodities were still confronted with supply constraints. This was compounded by logistical bottlenecks. For instance, ports had to close because of local lockdowns or a lack of shipping capacity. Inflation was also pushed up by a shift in demand from services to goods during the pandemic, partly because capacity for goods is more difficult to expand in the short term. This pressure eased but did not fully unwind at this moment. Although inflation is expected to gradually decline in the upcoming years as supply bottlenecks progressively subside (see Chart 1.4), some sources of upside risk are present, including the impact of the crisis in Ukraine on energy and other commodity prices and the fact that wage growth might accelerate⁴.

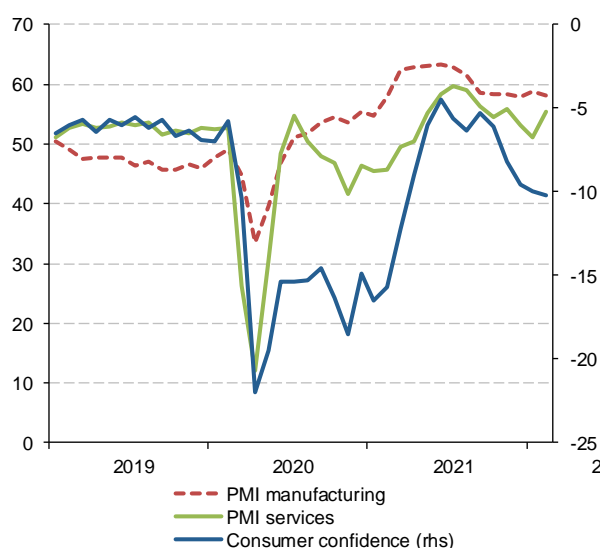
EU labour market developments mirrored the overall trend in economic activity. After a 'double dip' in the first quarter due to pandemic containment measures, labour demand started to recover strongly from the spring onwards. By Q4 2021, headcount employment grew by 2.2%, equivalent to about 4.6 million workers, relative to the first-quarter trough. The unemployment rate declined from 7.5% at the start of 2021 to 6.2% in January 2022, an all-time low. However, broader measures of labour market performance suggest that some slack remains. For instance, average hours worked have not fully recovered from the impact of the pandemic and remain about 4% below their end-2019 level, and the underemployment rate (which also includes involuntary part-time workers and those on the fringes on the labour market) remains 0.4 percentage points above its historical low. Consistent with this, wage growth remains fairly muted, with negotiated wages⁵ in the euro area having grown by 1.5% y-o-y as of Q4 2021. Nevertheless, there are more and more signs that the labour market is tightening. For instance, in many sectors the vacancy rate is well above pre-pandemic levels and it has become harder for firms to hire people.

³ Based on preliminary data releases.

⁴ Although there are currently little signs of strong second-round effects via higher wages, increasingly tight labour markets (see below) combined with the impact of automatic wage and social benefits indexation in some Member States suggest that there may be growing risks of second-round dynamics taking hold.

⁵ The index of euro-area negotiated wages is a better measure of underlying wage growth than compensation-per-employee statistics which are distorted by the impact of employees transitioning out of job retention schemes.

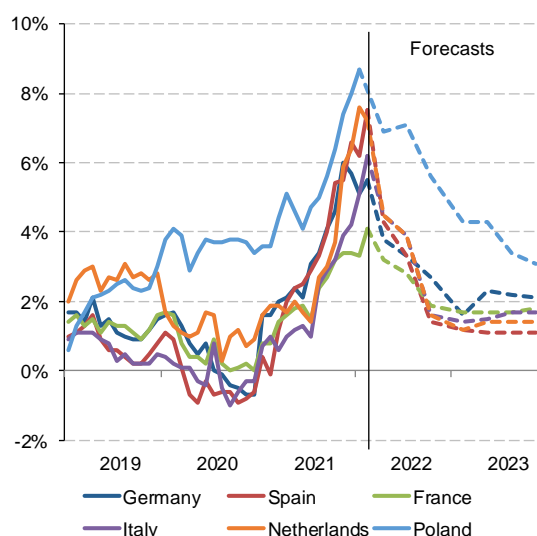
Chart 1.3: Euro-area business and consumer sentiment indicators



Source: IHS Markit, European Commission (2022), *Business and consumer survey results*, DG ECFIN, 25 February 2022⁶.

Note: Monthly data, index points.

Chart 1.4: HICP inflation – EU Member States



Source: Eurostat, European Commission (2022), *European Economic Forecast Winter 2022, Institutional Paper 169*, February 2022.

Note: Headline data, y-o-y % change. Monthly data, except forecasts (quarterly data). Forecasts pre-date Ukraine crisis escalation in late February 2022.

Despite the robust economic rebound, the recovery remains partial and uneven across industries and among Member States. Economic developments have varied widely across industry sectors, with a notable difference in performance between manufacturing and services (see Chart 1.3). Contact-intensive sectors such as hospitality and travel were especially hard hit. The severity of the pandemic was different between Member States, and also the recovery has been uneven due to differences in economic structure⁷ and different policy approaches, for instance in terms of pandemic containment measures or in the fiscal impulse. In particular for southern European Member States with substantial cross-border tourism sectors, the initial GDP contraction was sharper than average and the recovery comparatively slower. As a result, Q4 2021 GDP in Spain, Portugal and Italy remains well below the Q4 2019 level, although it is expected that these three Member States will be able to close the gap in 2022. Overall, the pandemic has exacerbated economic divergence across countries.

1.2 Financial market developments

Financial markets remained resilient throughout 2021, despite a challenging environment and some bouts of volatility. Concerns about the way that the pandemic would affect economic growth (expectations) and uncertainty around its virus variants weighed on markets, mostly in the first half of the year. Over the summer, concerns emerged about the weakening Chinese growth momentum, fuelled by the case of the troubled Chinese construction giant, Evergrande, early September, and its spillover risks to the EU. The dominant theme in the latter half of the year was rising inflationary pressures, but investors remained willing to take a risk-on stance in view of the very supportive monetary, fiscal and prudential policy measures in place. This

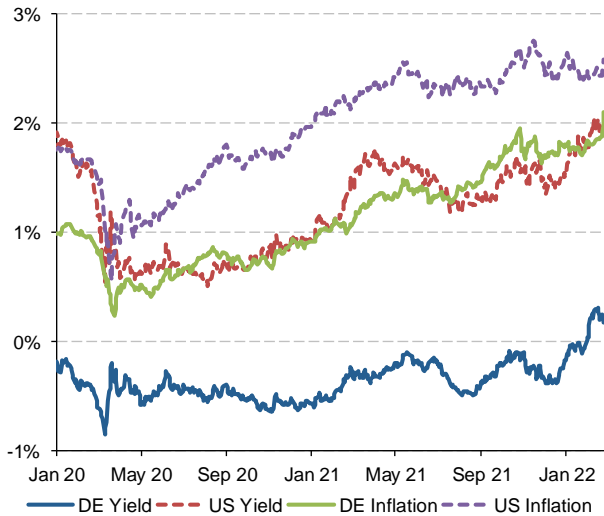
⁶ https://ec.europa.eu/info/business-economy-euro/indicators-statistics/economic-databases/business-and-consumer-surveys/download-business-and-consumer-survey-data/time-series_en

⁷ This is especially the case for the relative weight of contact-intensive services industries.

willingness to take risks was further supported by the ongoing recovery and its positive impact on corporate earnings. In the beginning of 2022, investors started to become more concerned about the reduced monetary policy support by central banks amid the strong rise in inflation (and inflation expectations). Finally, the crisis in Ukraine made investors more risk averse amid a spike in volatility across asset classes. EU financial markets have reacted quite sharply, experiencing falling asset prices and higher volatility. European stock indexes hit nearly one-year lows. The banking sector underperformed and a handful of EU banks with direct exposures to Russia had significant losses. The uncertainty surrounding military escalation and the fear for negative implications for the real economy and for financial markets is expected to dominate market evolutions in the short term.

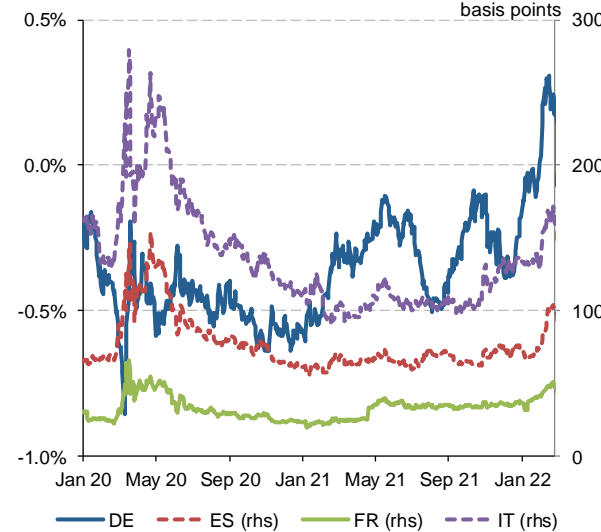
In sovereign bond markets, the euro-area (EA) benchmark (German Bund) mid- and long-term nominal yields gyrated higher over 2021, driven by the ongoing economic recovery and by significantly rising market-implied inflation expectations for the EA. The 10-year German Bund yield started the year at around -0.60% and closed the year at -0.13%, while the real 10-year Bund yields declined from -1.48% to an historically very low -2.00%. The ECB policy stance proved to be effective in keeping nominal bond yields in check, even in the face of increasing inflation. Several factors such as the sustained asset purchases by the ECB under the pandemic emergency purchase programme (PEPP) and the asset purchase programme (APP) contributed to this. In addition, the ECB (and other central banks) persistently signalled that fresh measures might be brought in to support the economy if needed. Finally, there was the explicit recognition that some of the ‘exceptional’ monetary policy measures like forward guidance, asset purchases and targeted longer-term refinancing operations (TLTROs) are now officially part of the standard toolbox. In early 2022 the 10-year Bund yield was positive again, and this for the first time since January 2019. This increase was driven by a rise in real yields amid the prospects of higher growth and a tighter monetary policy stance. This trend was already reversed by the end of February as investors fled towards low-risk assets in response to the Ukrainian crisis, despite climbing market-implied inflation expectations.

Chart 1.5: Sovereign bonds yields and expected inflation



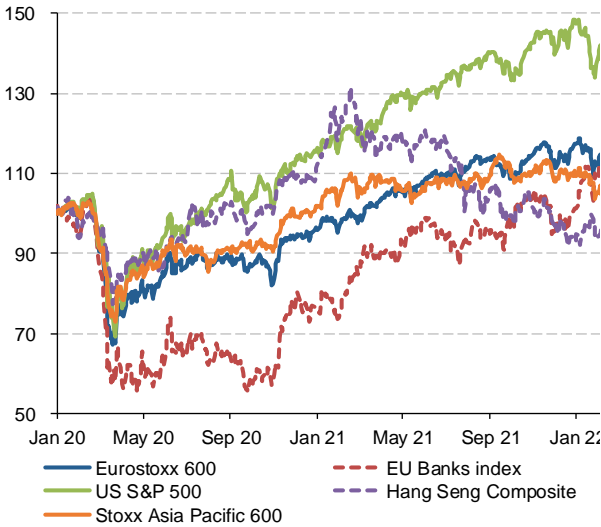
Source: Bloomberg.
 Note: 10-year maturity bond data. Daily data. 10-year inflation expectations based on the break-even inflation rate on inflation-linked bonds.

Chart 1.6: Sovereign bond spreads



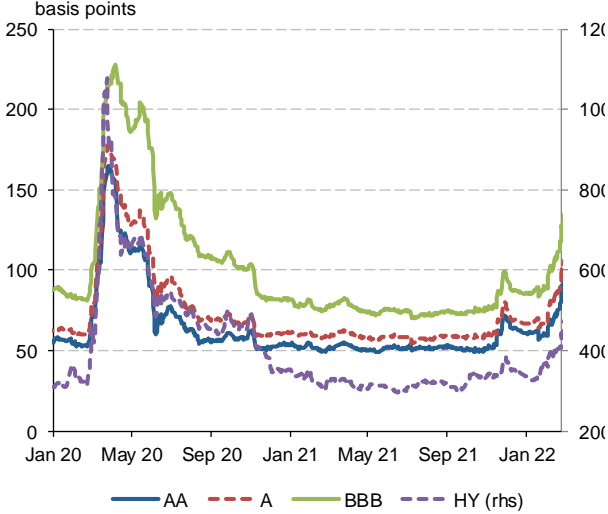
Source: Bloomberg. DG FISMA calculations.
 Note: Spreads are calculated against the 10-year German Bund.

Chart 1.7: Stock market performance



Source: Bloomberg.
 Note: Daily data, indexed (Jan 2020 = 100).

Chart 1.8: Euro-area corporate bond spreads



Source: Bloomberg, DG FISMA calculations.
 Note: 5-year maturity bond data. Daily data. Spreads are calculated against the 5-year German sovereign bond yield. HY stands for high yield.

EA sovereign bond spreads widened vis-à-vis the German Bund benchmark in particular towards the end of 2021 and the beginning of 2022 in view of the expected lower monetary policy support. Ten-year bond spreads to the Bund for non-EA Member States’ bonds widened significantly amid a strong upswing in inflation, followed by responsive central bank policies.

In corporate credit markets, bond spreads in the investment grade and high-yield segment tightened further in the first half of 2021, resulting in a strong increase in corporate bond issuances in the primary market. However, since 2022, corporate bond spreads in all risk segments have widened strongly. Some existing bonds may be particularly exposed to interest rate risk as they have been issued with very low coupons in view of the low interest rate environment.

Stock markets performed strongly in 2021, in particular in the first half of the year, in line with the recovery of the economy. In the second half of the year, stock markets swung increasingly on a risk-on/risk-off investors’ mode. Main market drivers were, on the one hand, strong corporate earnings, and, on the other hand, concerns over the impact of the COVID-19 variants on the economic outlook, a possible earlier-than-expected scaling back of bond purchasing programmes by central banks and mounting inflation pressures amid a rise in energy prices and supply chain disruption in the manufacturing sector. Over 2021, the Europe 600 index gained 22%. A major sector rotation took place during the year which benefited the more cyclically sensitive sectors such as energy, as well as the banking sector, supported by an improving economic outlook and a widening interest rate margin. The banking sub-segment of the Europe 600 index rallied an impressive 25% higher. However, in February 2022, equity markets tanked severely following the rapid escalation of the Ukrainian crisis. The outperformance of the banking sector was completely undone as European bank stocks sold off sharply, with in particular banks active in Russia being hit severely.

1.3 Financial stability

Over the past year, financial stability risks receded somewhat but remained elevated. The very supportive set of monetary, fiscal and prudential policy measures helped to stabilise the financial sector. Many vulnerabilities were, and continue to be, present in the macro-financial environment, including high levels of corporate debt and rapid rises in real estate prices (see Chapter 2). In addition, financial market participants seemed to be willing to take on much risk, which may increase existing vulnerabilities and lead to high price levels for financial assets. How vulnerabilities will develop will depend partly on the outlook for growth, inflation and interest rates. The conflict in Ukraine is likely to slow down EU growth and raise inflation in the coming months. This will slow down the correction of existing imbalances, adding a new layer to some of the financial stability risks described hereafter. Inflation will also influence interest rates. The ECB has kept real interest rates negative to alleviate the debt service burden of indebted economic actors. However, more sustained inflation might prompt the ECB and other EU central banks to raise (nominal) interest rates. The effect of such interventions on financial stability is uncertain. It could make bank lending more profitable if long-term interest rates rose more than short-term rates. At the same time, it would make it harder for borrowers to meet their debt servicing payments, which increases the risk of corporate and household defaults.

The three main risks that are identified are (i) a disruptive repricing in major financial market asset classes, (ii) renewed balance sheet stress in the non-financial corporate sector and household sector and (iii) the resurgence of stress in parts of the EU banking sector. The remainder of this section provides a succinct discussion of these main risks, followed by a review of some other financial stability risks.

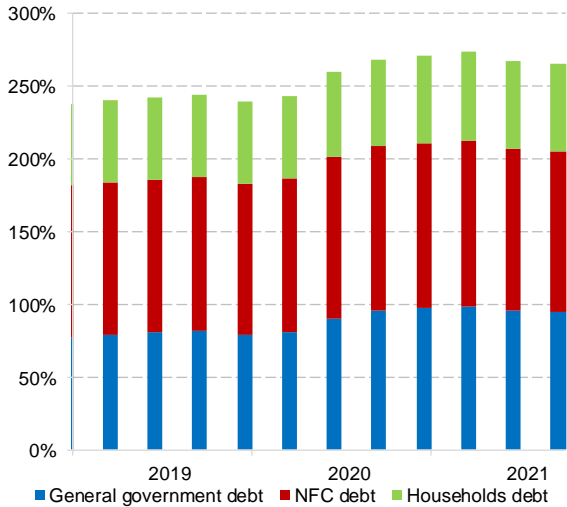
Early 2022, valuations of both risky and safe assets are high with thin credit, interest and liquidity premia (see Section 1.2). Safe assets are returning record low real yields. If inflationary pressures were to persist longer than expected by markets, bond yields could rise steeply due to investors demanding a higher compensation for increased inflation expectations and inflation uncertainty. To the extent that bond prices have been supported by central banks' asset purchases, the ending of such programmes may add upward pressure on yields. Moreover, as investors have increased the duration of their bond portfolios in a search for yields, portfolios have become more sensitive to yield increases and, a fortiori, to an interest rate shock. Conversely, risk asset valuations such as those of stocks and corporate bonds seem stretched, although the market reaction in February 2022 following the Russian invasion in Ukraine corrected these high valuations to some extent. Many factors could trigger a more pronounced reassessment of asset prices, including a weaker-than-expected economic recovery, further waves of COVID-19 infections, more persistent inflationary pressures, changes in monetary policy and negative spill-overs from adverse developments in emerging markets, such as China or Turkey. If investors became even more risk averse, this may set in motion a disorderly downward spiral of deleveraging, falling asset prices and increasing defaults. Borrowers would face tighter financing conditions, in particular for risky credit.

Risks in the non-financial corporate (NFC) sector have receded somewhat due to the economic recovery, rebounding profits and ample liquidity. For instance, aggregate corporate debt levels declined somewhat to 115% of GDP in Q2 2021 (see Chart 1.9 and 1.10). However, medium- to longer-term vulnerabilities remain firmly in place. Aggregate corporate debt levels mask pockets of highly indebted companies. Highly indebted companies have so far not deleveraged;

their debt levels are still close to record levels. This leaves these firms exposed to risks related to a pronounced shift in inflation (possibly squeezing NFCs’ profit margins and debt-servicing capacity), tighter financial conditions, an early withdrawal of government support measures or a stalling economic recovery.

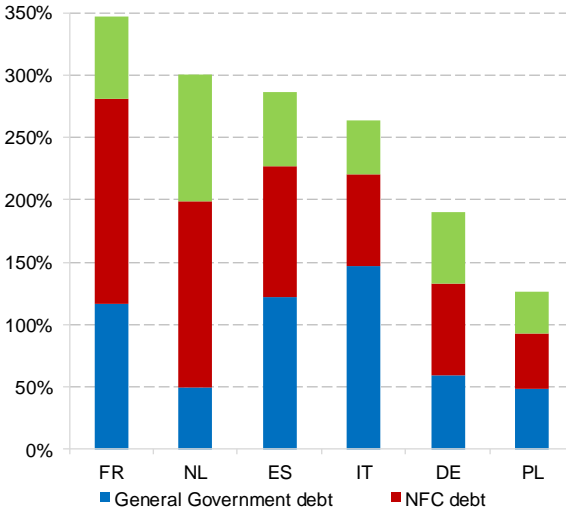
Household debt sustainability concerns have been tempered by an improved labour market outlook, record low debt servicing costs and buoyant residential property markets (see Chart 2.4). However, households remain exposed to vulnerabilities, in particular in those Member States with high unemployment rates, overvalued residential property or where many households have a high debt-to-disposable income ratio or loans with variable lending rates.

Chart 1.9: Debt levels in the euro area



Source: Eurostat.
 Note: Quarterly data from Q1 2019 to Q3 2021. Debt levels are expressed as percentage of GDP. Figures refer to general government debt (debt securities), non-financial corporations (NFCs - loans and debt securities), and households (loans).

Chart 1.10: Debt levels in selected Member States



Source: Eurostat.
 Note: Quarterly data. Debt level at the end of Q3 2021 expressed as percentage of GDP. Figures refer to general government debt (debt securities), non-financial corporations (NFCs - loans and debt securities), and households (loans).

Vulnerabilities in the residential real estate (RRE) market have continued to increase in many EU Member States (see Chapter 2). They relate mainly to house price overvaluation and strong mortgage credit growth, fuelling an increase in household indebtedness. A housing market correction could give rise to a self-reinforcing dynamic, with falling prices inducing banks to tighten mortgage credit standards, thus putting further pressure on the property market. It could also weigh on broader economic growth via reduced residential investment and weaker consumer confidence. Meanwhile, higher interest rates on existing floating-rate loans may weigh significantly on households’ debt servicing capacity. In the commercial real estate (CRE) sector, vulnerabilities remain high, in particular in the lower quality segments of the market. CRE markets have also been hit hard by the COVID-19 pandemic (see Chapter 2). A further decline in CRE prices could also affect financial stability through declining collateral values and losses on direct CRE holdings.

As for sovereign debt, short-term risks to debt sustainability have been mitigated by very favourable financing conditions and the creation of the Recovery and Resilience Facility

(RRF⁸). However, shocks to expected growth or interest rates could lead to a deterioration in debt dynamics, particularly in highly indebted Member States. Beyond the accrued macroeconomic challenges for public finance, political factors have significantly gained importance.

The EU banking system has so far proved resilient⁹. Capital levels and liquidity have remained strong¹⁰, but banks' profitability¹¹ is still significantly dependent on the economic recovery and the successful phasing-out of pandemic-related support measures. Higher long-term interest rates should reasonably translate into widening interest rate margins, thereby improving profitability. So far, asset quality has improved across the board, but the outlook remains uncertain as moratoria expire and loan guarantees are unwound¹². A rise of non-performing loans (NPLs) in banks' balance sheets is likely, even if this rise might turn out much more benign than feared in 2020. Rising yields would also increase credit risk for the banks' most vulnerable debtors. There are pockets of underprovisioning in some banks in view of exposures to severely affected sectors. In particular, differences in Member States' economic structure may lead to divergent economic and inflationary developments that might feed into bank fragility in those Member States with economic structures more prone to the effects of the pandemic.

EU financial institutions, banks, institutional investors, markets or financial-market infrastructures only have a limited exposure to Russian counterparties. The exposure was already reduced in view of the set of EU measures taken in response to the Russian annexation of Crimea in 2014. Direct exposures of EU banks are also small and concentrated among a handful of banks. Subsidiaries of EU banks in Russia could nevertheless be the target of counter measures taken by the Russian government in reaction to the EU sanctions, even if the EU measures do not target subsidiaries of Russian banks in the EU. The conflict in Ukraine also has consequences for some EU central securities depositories (CSDs) with exposure to Russia, which were necessarily cancelled under the EU sanctions regime. The potential effects on these entities is mainly operational in nature. In general, market infrastructures and in particular CCPs dealt well with the recent developments, although high levels of volatility in commodities markets in particular might present additional stress going forward. Higher margin calls could exacerbate tensions in short-term funding markets for financial firms looking for cash at the same time. There is a risk that ever higher margin calls in commodities markets could lead to broader market stress.

⁸ The EU Recovery and Resilience Facility was created in 2020 to mitigate the economic and social impact of the coronavirus pandemic and make European economies and societies more sustainable, resilient and better prepared for the challenges and opportunities of the green and digital transitions. It is a temporary recovery instrument, consisting of loans and grants to the EU Member States. For further details, see https://ec.europa.eu/info/business-economy-euro/recovery-coronavirus/recovery-and-resilience-facility_en.

⁹ See also, <https://www.eba.europa.eu/risk-analysis-and-data/risk-dashboard>.

¹⁰ The average common-equity tier-1 (CET1) ratio remained unchanged at 15.5% on a fully loaded basis in Q2 2021, amid a parallel rise in CET1 capital and risk-weighted assets (RWA). The liquidity coverage ratio (LCR) remained high at 172.4%. The lower end of the LCR's 5th percentile remains well above 100%.

¹¹ EU banks' profitability slightly decreased over the first half of 2021, after a very substantial recovery earlier in the year. The return on equity (ROE) decreased to 7.4% in Q2 2021 from 7.7% in the previous quarter. For many banks the ROE is lower than their estimated cost of equity.

¹² In aggregate, the non-performing loans (NPLs) ratio further trended downwards, reaching 2.3% at the end of Q2 2021, mainly reflecting the disposal of legacy NPL assets. The stock of loans with a significant increase in credit risk (IFRS 9 stage 2 loans) declined somewhat in Q2 to EUR 1 730 billion but with pronounced differences between Member States. The stock of forborne loans increased by 3.7% q-o-q in Q2 and, according to AnaCredit data, the stock of renegotiated loans increased by 6.5% q-o-q in Q2.

The conflict in Ukraine is bound to undermine the prospects for economic growth across Europe. Especially rising energy prices, which are a major driver of current inflationary pressures, may have a significant impact on the EU macroeconomic outlook and pose a threat to the post-COVID recovery. A moderation in the economic outlook will be negative for bank earnings and asset quality, putting further pressure on bank profitability. In turn, increased risk aversion in the banking sector could result in reduced lending to the real economy. Such second round effects may be particularly sizeable for Member States that have significant financial links with Russia or are most exposed to commodity price increases. Furthermore, supply chain and export market dependencies will take a toll in particular in Member States with the highest supply chain exposure.

Already before the conflict, risks have remained elevated in the fund sector due to higher risk-taking and high levels of valuation across asset categories¹³. Investment funds have taken on more credit risk by purchasing large volumes of lower quality corporate bonds. The duration of bond holdings also increased, rendering their portfolios more vulnerable to interest rate shocks. Risks are exacerbated by very low liquidity holdings. If bond yields were to rise significantly, valuation losses could trigger outflows from investment funds. Funds with low liquidity buffers might be forced to liquidate assets to meet investor redemptions. This could in turn amplify other financial market risks.

Several of these risks are strongly intertwined. If they were to materialise, they would be mutually reinforcing. For instance, if investors turn severely risk-averse, for instance in response to faltering growth figures or central banks announcing tighter financial conditions than expected, risk premia of financial assets may increase strongly. This would directly affect financial institutions by increasing the banks' funding cost and lowering net trading income. Sudden and large-scale redemptions by investors may in turn trigger a sale of bank debt securities and a further increase in the cost of funding of the banking sector. Much higher debt-servicing costs would undermine corporate profitability and affect their creditworthiness. In turn, this would impact bank asset quality and may call for higher provisioning and capital while external sources of capital become scarcer. A correction in house prices would dent economic growth (consumer and construction sector), stress real estate funds and might force banks to increase their provisions for NPLs.

Credit rating agencies downgraded Russia's debt¹⁴, cutting its rating to junk level and noting that a sovereign default is imminent. There is now a significant likelihood that Russia's ability to repay its sovereign debt obligations will be disrupted. The Russian government has borrowed about USD 49 billion in dollar- and euro-denominated bonds, and owes a series of interest payments to bondholders in the coming months. It has about USD 700 million in payments on debt coming due in March. Most of these payments have a 30-day grace period, implying that Russia could default as early as mid-April. The direct financial exposure of the EU is relatively low so the risk of direct financial contagion is limited. However, if Russia defaults on its debt, it could affect the broader financial markets.

¹³ See also, among others, European Securities Markets Authority (ESMA) (2021), *ESMA report on trends, risks and vulnerabilities 2*, 1 September 2021.

¹⁴ The restrictive measures against Russia that were established under the fourth sanction regime on 15 March 2022 prohibits credit rating agencies to rate Russian sovereigns. For further details, see <https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=OJ:L:2022:087I:FULL&from=EN>.

Finally, two cross-cutting issues, i.e. system-wide cyber incidents and risks related to sustainability such as climate change and other forms of environmental degradation, also pose a risk to financial stability. The number of cyber incidents has increased recently, and the nature of cyber threats is constantly evolving. Current geopolitical developments may increase the cyber risks faced by EU financial institutions. Rising cyber-related financial stability risks points to increased risks for banks, non-bank financial intermediaries and the entire financial infrastructure because cyber-attacks can have significant ripple effects via linkages in the financial ecosystem.

Meanwhile, climate change-related physical and transition risks are increasing substantially. Empirical findings of the European Systemic Risk Board (ESRB) and the European Central Bank (ECB)¹⁵ suggest that, while the extent of financial stability risks for the European financial system seem at this current juncture manageable overall, vulnerabilities across EU regions, sectors and financial institutions are uneven.

1.4 Financial integration

The outbreak of the COVID-19 pandemic has significantly affected the integration of European financial markets, while at the same time it also resulted in a de facto strengthening of EU economic, monetary and fiscal coordination. Several market segments became more fragmented in the beginning of 2020, but decisive monetary, fiscal and prudential policy responses contained the decline in financial integration. Financial integration resumed afterwards at a substantially faster pace than in previous crisis episodes¹⁶, and by Q3 2021 the price-based and quantity-based composite indicators of financial integration¹⁷ had surpassed their levels at the immediate onset of the pandemic (see Chart 1.11).

The resilience of financial integration amid economic or financial shocks can be assessed by analysing cross-border investment positions in the EU-27 by type of instruments¹⁸. This follows from the fact that financial integration achieved through cross-border equity instruments and foreign direct investments tends to be more resilient than financial integration through foreign debt instruments and portfolio investments. Therefore, the resilience of financial integration can be analysed based on two indicators: the first indicator compares the importance of equity and debt foreign holdings, while the second indicator compares the importance of FDI and portfolio cross-border investments (see Chart 1.12).

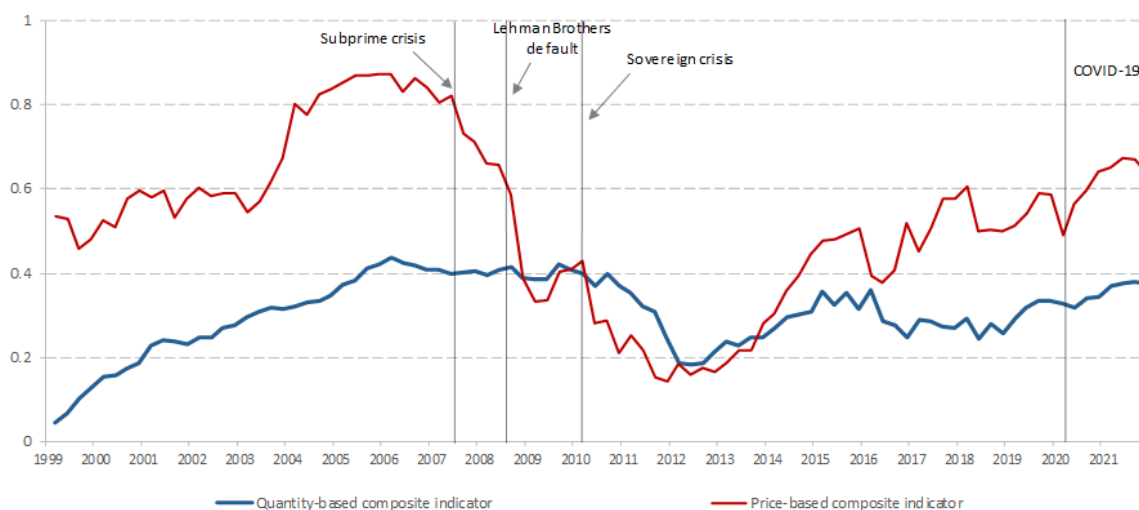
¹⁵ ECB, *Report on climate-related risk and financial stability*, ECB/ESRB project team on climate risk monitoring, July 2021.

¹⁶ Hartmann, P., Borgioli, S., Kempf, A., Molitor, P., and Mongelli F.P. (2021), [Financial integration and structure in EMU during the corona crisis](#), 28 May 2021.

¹⁷ For a detailed description of the indicators, see: ECB (2020), *Financial integration and structure in the euro area*, Statistical Annex; and Hoffmann, P., Kremer, M. and Zaharia, S., (2019) *Financial integration in Europe through the lens of composite indicators*, *ECB Working Paper 2319*, September 2019.

¹⁸ For an in-depth analysis of the euro area and more information on calculating the indicators, see ECB (2020), *Financial integration and structure in the euro area*, March 2020. A further analysis for the EU-27 is included in the study prepared by the CEPS for the European Commission, see Alcidi, C., Postica, D. and Shamsfakhr, F., (2022), *Analysis of developments in EU capital flows in the global context – Rise and fall after the Covid-19 outbreak*, forthcoming.

Chart 1.11: Composite indicators of euro-area financial integration



Source: European Central Bank (ECB).

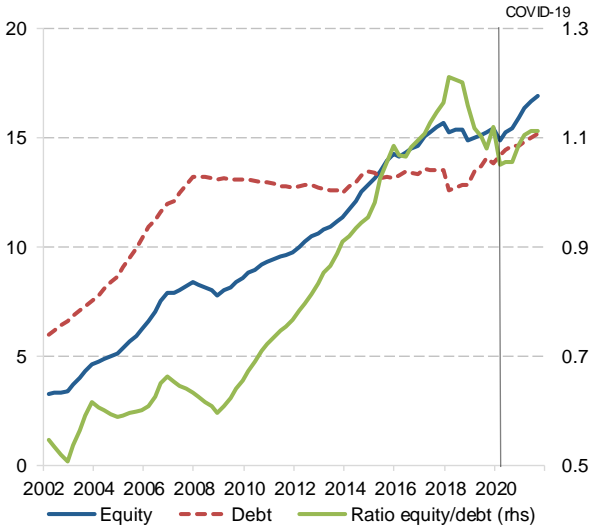
Note: The price-based composite indicator aggregates 10 indicators. The quantity-based composite indicator aggregates 5 indicators. Data period covers Q1 1999 – Q4 2021. A value of 1 corresponds to the highest degree of integration. Price-based indicator based on monthly data. Quantity-based indicator based on quarterly data.

The empirical evidence based on cross-border investments is mixed. On one side, based on the first indicator, the resilience of financial integration improved recently as the ratio of equity-to-debt instruments increased sharply after the outbreak of the pandemic because cross-border equity holdings outpaced cross-border debt claims (see Panel A). The increase of equity holdings was particularly strong following the rise in global equity markets after the initial fall triggered by the outbreak of the COVID-19 crisis. Conversely, the second indicator for the resilience of financial integration that is based on the relative importance of FDI and portfolio investments in cross-border assets in EU-27 shows more mixed results (see Panel B). This is due to the fact that while both FDI and portfolio investments have recovered after the start of the COVID-19 pandemic in 2020 and are now above the pre-crisis levels, portfolio investments have been increasing much faster and have contributed more to the post-COVID-19 increase in cross-border investments.

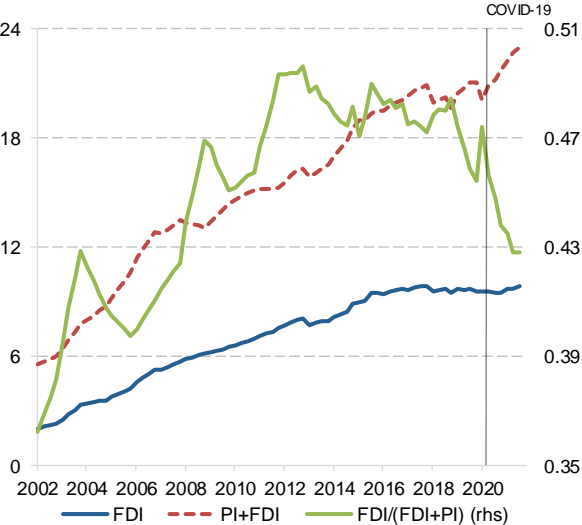
Another indicator for the resilience and quality of financial integration is international risk sharing. The concept of international risk sharing is based on the assumption that while country-specific shocks to economic output cannot be avoided, their effects can be distributed across other countries in order to reduce their impact on domestic consumption. International risk sharing becomes particularly important in times of crisis and in the context of a monetary union, as it could lead to a lower reduction in domestic consumption when economic output declines in the face of adverse shocks. International risk sharing declined further in the euro area in the beginning of the COVID-19 pandemic, and the correlation between domestic consumption and output increases sharply (see Chart 1.13).

Chart 1.12: Cross-border investments in the EU by type of financial instruments

Panel A. Intra-EU-27 cross-border holdings of equity and debt instruments



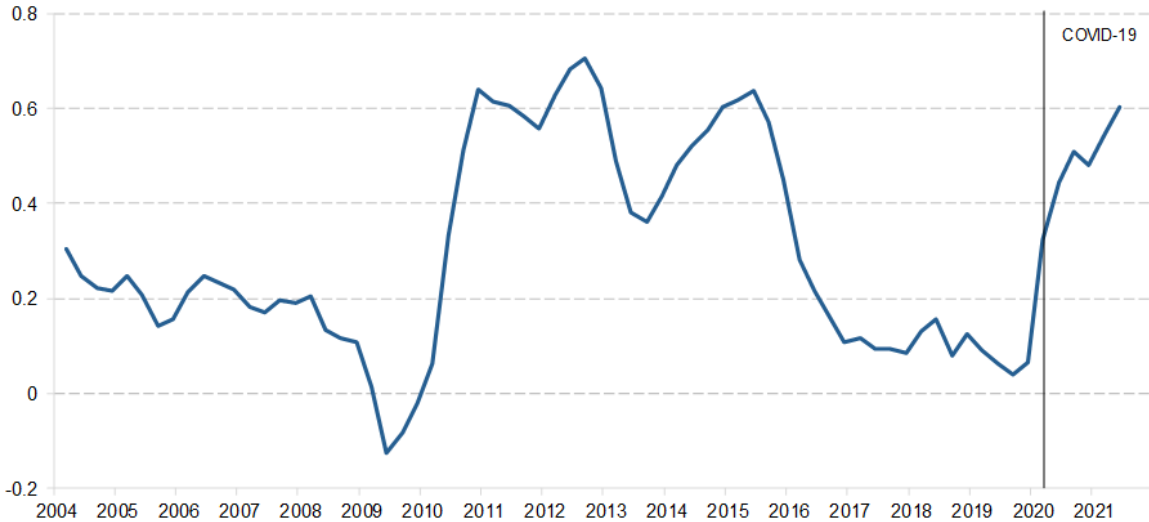
Panel B. Intra-EU-27 foreign direct investment and portfolio investments



Source: Eurostat and FinFlows database¹⁹. DG FISMA calculations.

Note: Data are expressed in EUR trillion. The data period covers Q1 2002 – Q3 2021. In Panel A, equity and debt figures refer to end-of-period positions, reported in EUR trillion on the left-hand side. Ratio of equity to debt on the right-hand side. Equity is defined as the sum of foreign direct equity investments (FDI), portfolio equity investment and equity investment funds. Debt instruments are defined for the purposes of this chart as debt securities in portfolio investment and other investment loans. Debt securities in FDI, which are intra-group operations and cannot lead to default, are excluded. Data for EU-27 (changing composition). In Panel B, figures refer to end-of-period positions based on quarterly data for EU-27 (changing composition). Foreign direct investments and portfolio investments in EUR trillion on left-hand scale. Ratio (green line) on right-hand side.

Chart 1.13: Consumption-output correlation across the euro-area Member States



Source: European Central Bank (ECB).

Note: Higher values indicate lower risk sharing. Data period covers Q1 2004 – Q3 2021. Data for Ireland is excluded due to the major revision in its GDP reporting in 2015.

One possible explanation for this change in the trend of risk sharing is the fact that diversification can provide real economic benefits in the context of asymmetric shocks to output and income, while the coronavirus health crisis impacted all EU economies in a similar

¹⁹ <https://data.jrc.ec.europa.eu/collection/id-00149>

way. Therefore, the benefits that could have been achieved through private international risk sharing were very limited.

An analysis of long-term risk sharing in the euro area since the introduction of the euro until the beginning of the COVID-19 pandemic in 2020 helps to better understand what appears to be a change in the trend in risk sharing in the euro area after the outbreak of the COVID-19 pandemic (see Box 1). It shows that overall risk sharing is limited. A shock to GDP still has, on average, a large effect on consumption. Risk sharing is mostly achieved via the credit channel and to a lesser extent via fiscal transfers. Risk sharing in the EU can further improve progressively as the large-scale financial support for investment and reforms from the NextGenerationEU recovery instrument and its Recovery and Resilience Facility are gradually implemented.

Box 1: Risk sharing within the euro area and the EU²⁰

A fully-fledged financial union can be an efficient economic shock-absorber during crisis periods. The EU and the Eurozone have significant untapped potential in terms of private cross-border risk-sharing compared to the US.²¹ The framework by Asdrubali et al. (1996) and refined in Sørensen and Yosha (1998) is the most widely used framework to measure the degree of risk sharing and analyse the different channels through which risk sharing is achieved. It is thus used to quantify the degree of risk sharing and risk smoothing achieved via the capital markets channel, the fiscal channel and the credit markets channel²².

Panel A of Table B.1 presents the empirical results on risk sharing through the three channels for 21 EU countries²³. The sample covers the period 2007-2020 and because the year 2020 is included the possible effect of the COVID-19 outbreak is captured. Results show that risk sharing is achieved primarily through the credit markets. Overall, a large proportion of shocks remain unsmoothed.

The level of risk sharing could be different in crisis and non-crisis periods. In addition, progress of EU policy initiatives could affect the relative importance of the channels. Panel B reports results for sub-periods covering (i) the 2008 global financial crisis, (ii) the post-crisis period prior to the COVID-19 break-out and (iii) the year of the pandemic outbreak (2020). Results are split between EA and non-EA countries to capture possible effects of EMU membership.

Two results stand out. First, the credit markets channel played a major role in absorbing the impact

²⁰ The box uses the findings from the study prepared by the CEPS for the European Commission, Alcidi, C., Postica, D. and Shamsfakhr, F., (2022), *Analysis of developments in EU capital flows in the global context – Rise and fall after the Covid-19 outbreak*, forthcoming. The sample in this study includes non-EA countries as a control group to assess how risk sharing is affected by membership in the monetary union. The sample period covers the 2008 global financial crisis and the outbreak of COVID-19.

²¹ Nikolov, P. (2016), Cross-border risk sharing after asymmetric shocks: evidence from the euro area and the United States, *Quarterly Report on the Euro Area* 15, 173–196 and Nikolov, P., and Pasimeni, P. (2019), Fiscal stabilization in the United States: Lessons for monetary unions, *Bank of Finland Economic Review* 6/2019.

²² The first channel comprises income from ‘productive assets’ (such as FDI, equity and debt securities, loans and labour income), while the second channel reflects international taxes and transfers. This includes EU structural funds and accounts for the difference between per-capita gross national income and disposable income. The third channel, the credit markets channel, captures net savings of households, government and corporate savings. For euro-area countries this also includes borrowing from the ESM.

²³ Luxembourg, Malta, and Cyprus are excluded because these small countries exhibit very large financial flows. This could be captured in the capital markets channel, although being largely unrelated to national consumption. Hence, including these countries could overestimate the importance of the capital markets channel and its role in risk sharing. In addition, Estonia, Bulgaria and Romania are excluded due to a lack of data availability.

of the GDP collapse on consumption during the first year of the COVID-19 crisis. This contrasts with the 2008 global financial crisis where this channel amplified the shock.

Secondly, the part of shocks that remains unsmoothed was identical for non-EA and EA Member States, in contrast with other periods where larger parts of shocks remained unsmoothed in non-EA Member States compared with EA Member States.

The results demonstrate the importance of developing the Banking Union as the effectiveness of the credit markets channel increased after 2010 for both EA and non-EA countries. Similarly, the results highlight that it remains important to further develop the Capital Markets Union. The progressive implementation of the NextGenerationEU recovery instrument and its Recovery and Resilience Facility, which is set to accelerate after 2021, is likely to have an impact on risk sharing in the EU.

Table B.1 Income and consumption smoothing

Panel A. Income and consumption smoothing in the euro area per channel, 2007-2020

	Capital markets	Fiscal transfers	Credit markets	Unsmoothed
GDP	0.05*	0.001	0.06**	0.87***

Panel B. Income and consumption smoothing in the euro and non-euro area per channel, by sub-periods

	Capital markets	Fiscal transfers	Credit markets	Unsmoothed
[2008-09]				
EA	0.01	0.02	0.02	0.94***
Non-EA	0.02	0.02	-0.13***	1.09***
[2010-19]				
EA	0.08	0.01	0.11**	0.80***
Non- EA	-0.04	-0.00	0.12***	0.92***
[2020]				
EA	0.11	0.02	0.43***	0.44***
Non- EA	0.10	0.04	0.41***	0.44***

Note: Percentage of shocks to GDP absorbed at each level of smoothing. ***p<0.01, **p<0.05, *p<0.1. We interpret the β -coefficients in the first 3 columns as the incremental amount of smoothing achieved through the risk-sharing channel considered. The fraction of shocks left unsmoothed is reported in the last column.

Source: Alcidi, C., Postica, D. and Shamsfakhr, F., (2022), *Analysis of developments in EU capital flows in the global context – Rise and fall after the Covid-19 outbreak*, forthcoming.

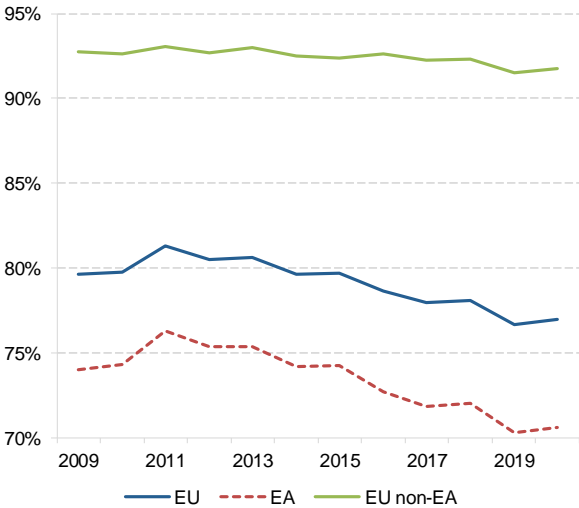
In 2020, the year of the outbreak of the COVID-19 pandemic in the EU, the intra-EU home bias in portfolio investments (or the average propensity to invest domestically instead of investing within the EU)²⁴ experienced a slight increase (see Chart 1.14, panel A) mainly driven by debt portfolio instruments. The propensity to invest domestically for debt

²⁴ Home bias in portfolio investments measures the average propensity of EU Member States to invest in other countries as compared with investing domestically. The indicator ranges between 0 and 1, with a value of 0 indicating that investors do not prefer domestic over foreign assets. Intra-EU home bias can be interpreted as a measure of financial integration among EU countries. The lower the intra-EU home bias, the higher the share of investment will be within the EU as compared to the domestic market. Extra-EU home bias measures the integration with global markets and is calculated as the proportion of domestic portfolio investments over portfolio investments outside the EU. For additional information on the methodology, see Nardo, M., Ndacyayisenga, N., Pericoli, F. and Poncela, P. (2018) *JRC.B1 contribution to the SWD on the Movement of Capital and the Freedom of Payments*.

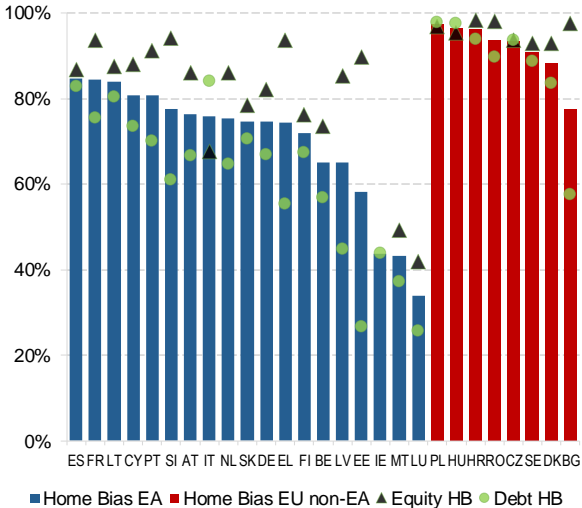
instruments, however, differs across countries, with Luxembourg, Malta and Estonia (within the EA country group) and Bulgaria (within the non-EA country group) displaying lower levels (see Chart 1.14, panel B). Yet, the average level of intra-EU home bias for debt instruments remains lower than that for equity instruments. In contrast, in 2020, intra-EU home bias for equity investments continued the downward trend that started in 2018.

Chart 1.14: Home bias in the EU

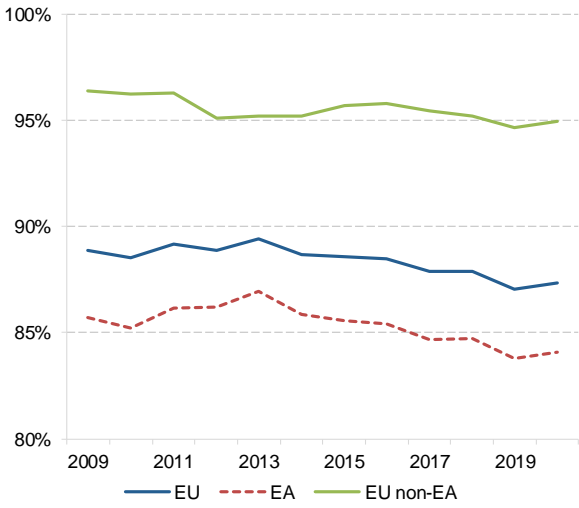
Panel A. Debt and equity intra-EU home bias



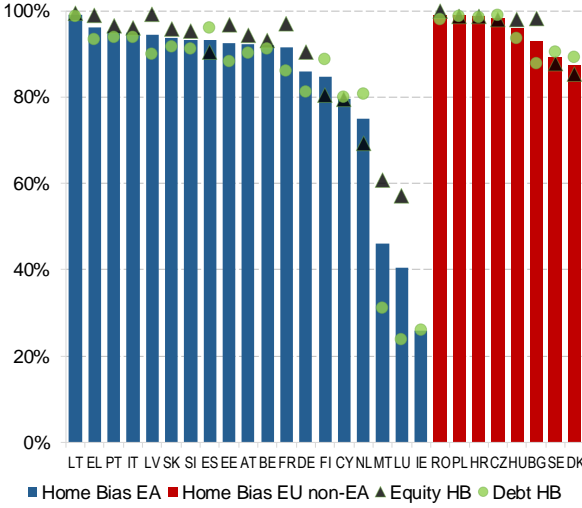
Panel B. Intra-EU home bias by Member State



Panel C. Debt and equity extra-EU home bias



Panel D. Extra-EU home bias by Member State



Source: JRC calculations based on FinFlows database.
 Note: Portfolio debt and equity investment positions are as defined in the national accounts. Equity includes listed equity, non-listed equity, and investment funds. Cross-border banking flows (measured with the Balance of Payments “other investment” category) and foreign direct investment (FDI) are excluded from the computation. For details on the calculation of home bias, see footnote 23. Average values are not weighted. Panels A and C are based on annual data. Panels B and D are based on data for 2020. Data for EU-27 (changing composition). Equity data is missing for Ireland.

On average non-domestic intra-EU investments represent a larger proportion of total investment than non-EU investment as EU countries tend to invest more within Europe than outside. Therefore, the financial integration indicator vis-à-vis non-EU countries is, on average, weaker than that observed within EU countries and the extra-EU home bias indicators is higher than intra-EU home bias.(see Chart 1.14, panel C). Similarly to the intra-EU indicators for

equity and debt instruments, extra-EU home bias for equity investments remains higher than for debt instruments (7 percentage points difference for the EU average in 2020). Overall, the extra-EU equity home bias continued the decline that began in 2015, with a stronger decrease in EA countries than in non-EA countries. In 2020, the propensity to invest outside the EU differed among countries (Figure 1.14, panel D). Depending on the instrument considered, Hungary, Ireland, Luxemburg and Malta show a higher propensity to invest outside the EU than inside the EU for debt instruments, while Cyprus, Denmark, the Netherlands and Sweden display this trend for equity instruments.

Overall, the prompt policy response and the longer-term impacts of regulatory and institutional reforms since the 2008 global crisis have helped to increase the resilience of financial integration and have, therefore, helped to mitigate the immediate socio-economic consequences of the COVID-19 pandemic. However, the longer-term effects of the pandemic still remain to be seen and will depend, among other factors, on the effectiveness of national and EU-level policy measures put in place to support the post-crisis economic recovery.

Chapter 2 REAL ESTATE IN THE AFTERMATH OF THE PANDEMIC: SYSTEMIC RISKS AND MACROPRUDENTIAL POLICY TOOLS TO ADDRESS THEM

2.1 Introduction

In many EU Member States, real estate appears overvalued. Real estate prices, particularly in residential real estate (RRE), have been rising strongly in recent years, at an accelerating pace in many countries²⁵. Price developments over the coming years can be expected to depend on factors such as monetary policy, fiscal support and its impact on household savings as well as supply-side constraints. The Russian invasion leads to more economic uncertainty which might decrease the demand in certain segments or where economic growth and interest rates are significantly impacted. In addition, structural changes such as the increasing role of institutional investors in residential property markets and shifts in housing preferences due to the pandemic will also be important. Shocks in the form of higher interest rates, higher unemployment and lower incomes and more stringent credit constraints could reverse recent trends.

Real estate markets are of key importance for financial stability. Real estate prices are volatile, and housing and credit booms were often crucial in triggering banking and financial crises. Property prices tend to evolve cyclically, also because supply is inelastic in the short term. Economic expansion often goes hand in hand with rising real estate prices, increased indebtedness of households and businesses and heightened bank exposures²⁶. A subsequent decrease of real estate values reduces household wealth and the value of collateral held with banks (asset valuation channel). Banks could respond by reducing lending or tightening conditions for loans which could further depress economic activity. During the global financial crisis, adverse developments in the residential and commercial real estate sectors in some Member States led to large losses for households, businesses and banks and had severe consequences for the real economy and public finances, illustrating the relevance of these sectors for macroeconomic and financial stability.

Macroprudential tools have been part of the EU legal framework since 2014 to limit the build-up of system-wide risks in the EU banking sector. National authorities have applied various policy tools to strengthen the resilience of borrowers and banks against the potential build-up of vulnerabilities stemming from real estate. Macroprudential instruments to address real estate risks are also among the tools being analysed in the ongoing review of the European macroprudential framework pursuant to Article 513 of the Capital Requirements Regulation (CRR).

This chapter is structured as follows. Section 2.2 presents the key developments and systemic risks in the real estate sector since the global financial crisis, with particular attention given to current vulnerabilities in RRE. Section 2.3 outlines the current macroprudential tools to manage these risks, such as measures targeted at borrowers. Section 2.4 concludes with some policy considerations.

²⁵ See European Systemic Risk Board (ESRB) (2022) *Vulnerabilities in the residential real estate sector of the EEA countries*, February 2020.

²⁶ European Commission (2021) Euro area housing markets: Trends, challenges & policy responses, *Discussion Paper 147*, 20 September 2021.

2.2 Real estate market developments and vulnerabilities since the global financial crisis

Following the 2008 global financial crisis and the 2012 euro-area sovereign debt crisis, EU house prices have been trending up in line with the resumption of economic growth (see Chart 2.1)²⁷. Moreover, in recent years, vulnerabilities have risen in an increasing number of RRE markets, and this trend continued after the outbreak of the COVID-19 pandemic. The European Systemic Risk Board (ESRB) and national authorities have been paying close attention to these vulnerabilities since 2016, given their persistence in some Member States. Rising RRE prices, combined with significant household indebtedness in relation to income, could increase systemic risks in several EU Member States²⁸. Vulnerabilities could be exacerbated further if the low interest rate environment currently in place should persist.

Systemic risks in the real estate sector can best be analysed by considering RRE and CRE (commercial real estate) markets separately²⁹. Important differences exist between these markets³⁰, especially in terms of the associated financial stability risks and the main actors active in each market³¹. Most property owners in the RRE markets are households, while in CRE markets professionals hold CRE to generate income. Compared to properties in RRE markets, CRE assets are more complex and diverse and are more often financed by tailor-made and complex financing techniques. However, CRE prices have, on average, also trended upwards since the global financial crisis and up to the start of the COVID-19 pandemic (see Chart 2.2). From a financial stability perspective, it is important to acknowledge that banks are less exposed to CRE than to RRE, but the default risk for CRE loans is typically higher because CRE markets are more cyclical and financing conditions more volatile.

²⁷ See European Commission, European Economic Forecast Autumn 2021, November 2021, *Institutional Paper* 160, 57-60.

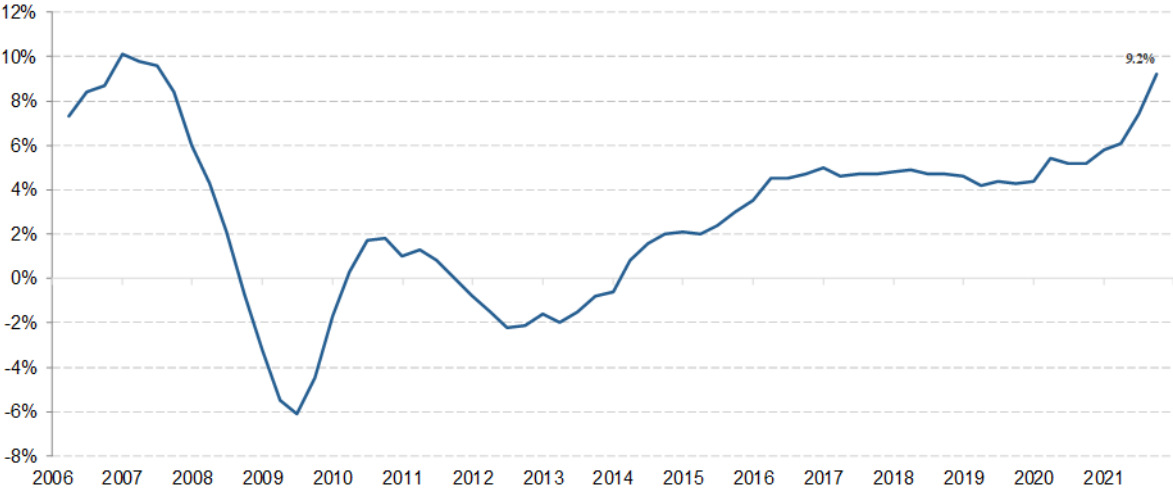
²⁸ See ESRB (2021), *Lower for longer – macroprudential policy issues arising from the low interest rate environment*, June 2021.

²⁹ The assessment of vulnerabilities in the EU CRE markets has been hampered by severe data gaps. The negative impact of the COVID-19 pandemic on these markets calls for further work to better understand the functioning of the market, the relevant transmission channels and the potential systemic risks.

³⁰ In some respects, these markets also exhibit similarities. For instance, the trend on both markets is affected by common factors. This is related, for example, to the fact that they both compete for the same endowments of land and building capacity. For instance, an increase in the demand for CRE triggered by favourable economic conditions is likely to cause an expansion of RRE in the surrounding areas. The value of both CRE and RRE properties will thus increase as the space available for future construction is restricted. For further details, see footnote 30.

³¹ ESRB (2019), *Methodologies for the assessment of real estate vulnerabilities and macroprudential policies: commercial real estate*, December 2019.

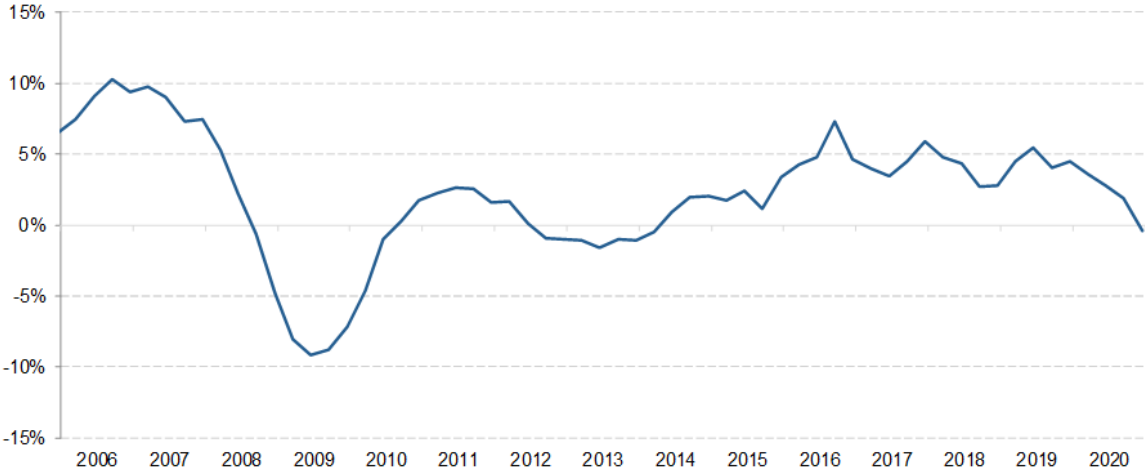
Chart 2.1: House price growth in the EU



Source: Eurostat.

Note: Figures refer to average nominal house price growth in the EU. House price index, total new and existing dwellings. Y-o-y % change based on quarterly data.

Chart 2.2: Commercial property price growth in the EU



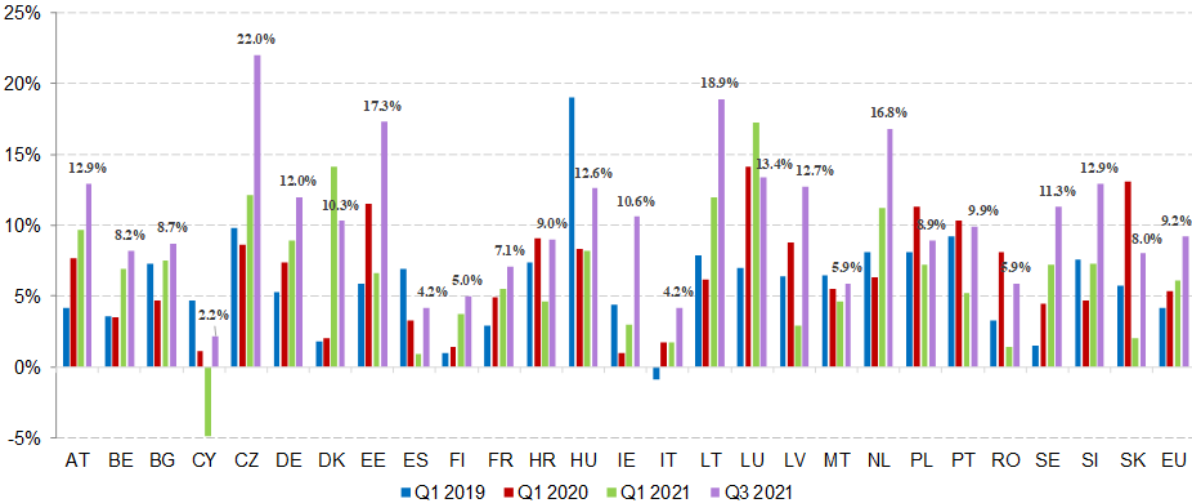
Source: European Central Bank (ECB).

Note: Figures refer to average commercial property prices in the EU. Y-o-y % change, based on quarterly data. ECB estimates based mainly on commercial Morgan Stanley Capital International (MSCI) data and supplemented with data from other national sources. Data on transactions or valuations differ, depending on the methodologies used.

2.1.1 Residential real estate markets

Nominal house prices continued to rise in most Member States, with an average y-o-y increase of 9.2% in Q3 2021, the highest since the global financial crisis (see Chart 2.1). However, annual growth rates have varied significantly across Member States in recent quarters, ranging from -5.8% in Cyprus in Q1 2021 to +22.0% in Czechia in Q3 2021 (see Chart 2.3), while a few Member States have also experienced temporary lower growth rates since the COVID-19 shock.

Chart 2.3: Growth in nominal house prices across EU Member States

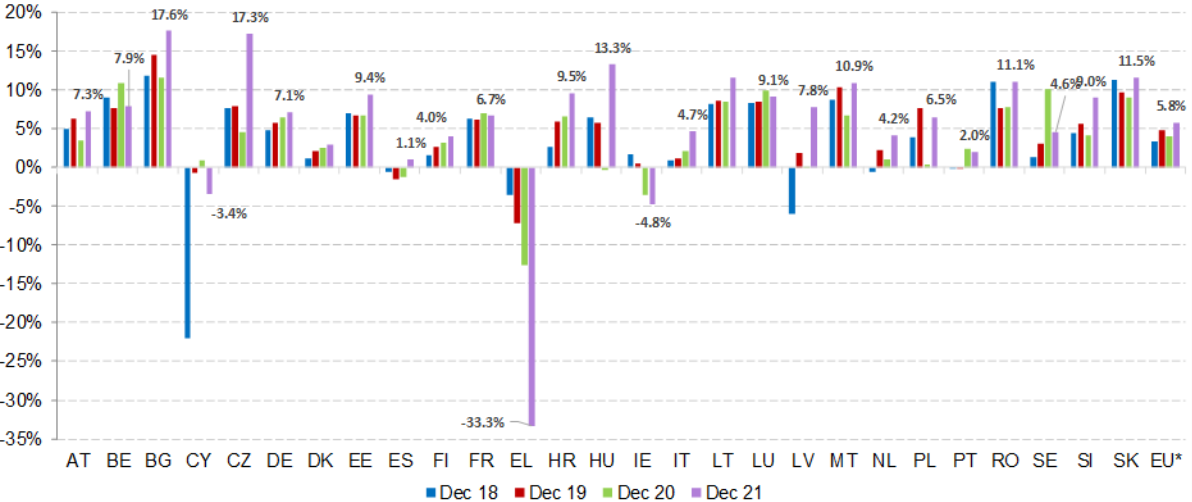


Source: Eurostat.

Note: House price index, total new and existing dwellings. Y-o-y % change. Data for Greece (EL) is not available.

Household demand for housing loans also continued to rise in Q3 2021, mainly driven by improving consumer confidence, low interest rates and favourable housing market expectations. On average, mortgage lending to households increased by 6.2% in September 2021, but growth rates varied considerably across Member States, as some experienced temporary lower or negative growth after the COVID-19 shock or negative net lending due to deleveraging or the sale of non-performing loans (see Chart 2.4).

Chart 2.4: Lending to households for house purchases



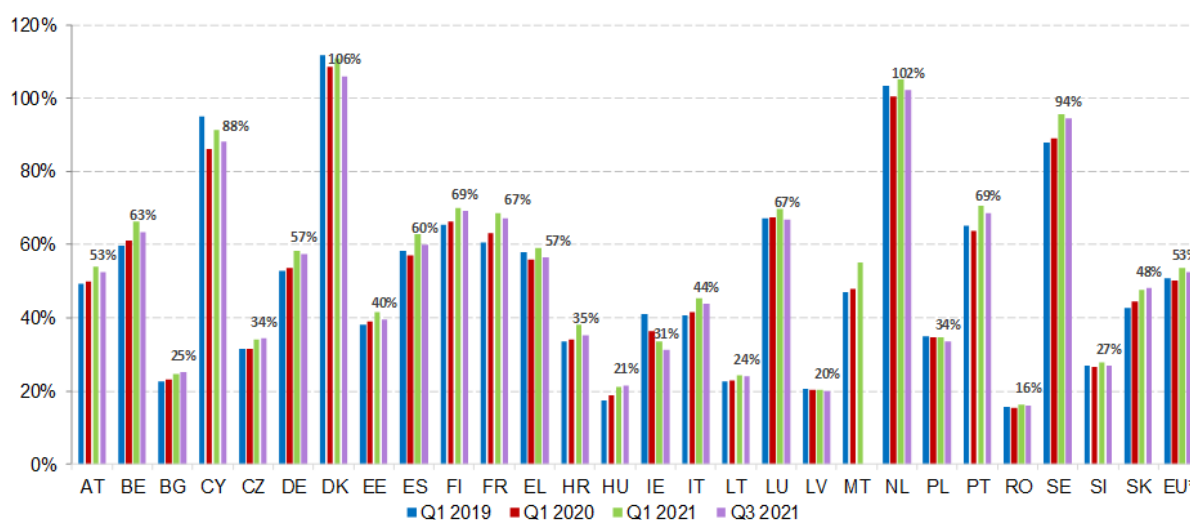
Source: European Central Bank (ECB), Balance sheet indicators (BSI). DG FISMA calculations.

Note: Lending to households and non-profit institutions serving households for house purchase. Figures refer to y-o-y changes in outstanding amounts at the end of the period. (*) EU percentage calculated as simple average for the 27 Member States.

Household debt increased both in terms of income and GDP. The average ratio of household debt to GDP in the EU stood at 52.6% at the end of Q2 2021, up from 50.4% in Q4 2019 (see

Chart 2.5). Over the same period, household debt to income increased from 101.9% to 105.2%³².

Chart 2.5: Household debt over GDP



Source: European Central Bank (ECB), Quarterly sector accounts (QSA). Eurostat, ESA 2010, Quarterly financial and non-financial sector accounts. DG FISMA calculations.

Note: Outstanding loans granted to households as a ratio of GDP. (*) EU percentage is the simple average for the 27 Member States.

In Q3 2021 the euro-area banks took a more cautious attitude in their loan approvals for housing loans, resulting in a net tightening of credit standards for loans to households for house purchases. A further moderate net tightening of credit standards in this market is expected in Q4 2021 amid a broadly unchanged loan demand, according to the 2021 October ECB bank lending survey³³.

While the price trends in RRE markets accelerated in many Member States during the pandemic, they did increase vulnerabilities in a large number of Member States. The ESRB³⁴ assessed the overall level of RRE risks and vulnerabilities in Q2 2021 as medium to high for most Member States³⁵. At the same time, vulnerabilities in EU RRE markets appear, overall, still more benign compared to the period preceding the global financial crisis³⁶ and to developments outside Europe, where significant downside risks in real estate markets exist following a surge in house prices and excessive risk-taking³⁷. House price dynamics and

³² Meanwhile the gross household savings rate also strongly increased during the pandemic from 11.9% of gross disposable income (adjusted for the change in pension entitlement of households) in Q4 2019 to 18.3% in Q4 2020 and back to 14.6% in Q3 2021 (seasonally adjusted data). For further details, see Eurostat, Quarterly sector accounts https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Quarterly_sector_accounts_-_households.

³³ See ECB (2021), *The euro area bank lending survey – Third quarter*, October 2021.

³⁴ See ESRB, *Vulnerabilities in the residential real estate sectors of the EEA countries*, October 2021. The ESRB concludes that at Q2 2021 these vulnerabilities were ‘high’ in 5 Member States and ‘medium’ in 18 Member States. The vulnerabilities relate to house price overvaluation and elevated house price growth, increased household indebtedness and the ability of households to repay their mortgage debt, and the growth of mortgage lending.

³⁵ The overall assessments consider both stock-related risks and flow-related risks. Stock risks account for the persistence of the same or higher levels of household indebtedness (see Chart 2.5) and the high share of existing loans with variable interest rates (see Chart 2.6) that are exposed to interest rate shocks. Flow risks account for the high share of new loans with high loan-to-value, debt-to-income and debt-service-to-income values, strong house price increases and high mortgage credit growth (see Chart 2.3 and Chart 2.4). Strong house price increases coupled with house price overvaluation could signal that there may be room for a house price correction.

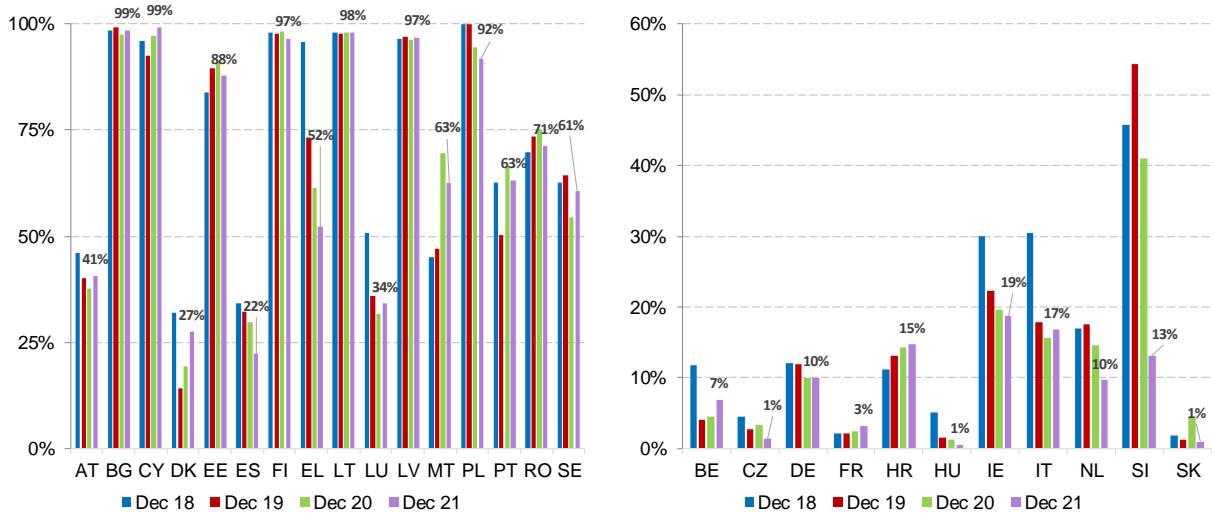
³⁶ See ECB (2021), *The euro area bank lending survey – Third quarter*, October 2021.

³⁷ See International Monetary Fund (IMF) (2021), *Global financial stability report*, October 2021.

overvaluation are at levels similar to those prior to the global financial crisis in 2007, although often affecting other Member States than those in 2007 the risk of a significant RRE price correction is in the short term partly mitigated by supply side constraints³⁸, less exuberant aggregate mortgage lending and more resilient household balance sheets, also thanks to the fiscal and other policy measures taken (see below). Furthermore, as a result of stronger capital positions and the improved quality of supervision, the banking system is more resilient to significant losses.

Although developments are less worrisome in Europe than worldwide, continued strong increases in EU house prices should be a concern to Member States³⁹. Vulnerabilities associated with a reversal of price trends could become more likely. Policy measures taken during the COVID-19 crisis may have mitigated short-term risks in the real estate market, but they have not halted the longer-term increase of heightened vulnerabilities. Household debt has been kept sustainable thanks to government schemes such as short term working programmes which have ensured steady household income during the pandemic. A rise in interest rates could trigger house price corrections and may raise concerns about debt sustainability in those Member States where variable-interest-rate mortgage loans are commonly used (see Chart 2.6, left-hand graph).

Chart 2.6: Share of new loans to households for house purchases with a floating rate or an initial rate fixation period of up to 1 year



Source: European Central Bank (ECB), Risk assessment indicators.
 Note: Share of new loans to households for house purchases with a floating rate or an initial rate fixation period of up to 1 year in total new loans from monetary and financial institutions (MFIs) to households for house purchases. The left-hand graph shows the Member States where this share exceeded 20%, the right-hand graphs shows the Member States where this share is below 20%.

³⁸ Subdued construction activity during lockdowns weighed on the housing supply and put some upward pressure on prices, especially in markets with an already tight housing supply. According to the Commission’s 2021 Autumn European Economic Forecast, limited construction activity has been acting as a brake on the supply of housing for a number of years. In addition, the zoning and building regulations across Member States are stricter than in previous decades, and building permits have remained at low levels in recent years. For further details, see European Commission (2021), European Economic Forecast Autumn 2021, *Institutional Paper* 160, November 2021.

³⁹ See ESRB, *Vulnerabilities in the residential real estate sectors of the EEA countries*, October 2021. For 5 Member States the RRE markets cyclical position is of a mature expansion, for 6 of a firm/mature expansion and for 10 of a firm expansion.

In addition, the margins of lenders with large portfolios of housing loans with long maturities and low fixed interest rates could be squeezed by rising interest rates. Box 2.1 discusses several adverse risk scenarios, their propagation channels and the preventive and mitigating actions that authorities can take. Potential real estate market corrections could give rise to self-reinforcing dynamics, with falling prices inducing banks to tighten mortgage credit standards, thus putting further pressure on the property market.

Box 2.1: Real estate and financial stability: what could possibly go wrong?

Risk scenario (historical)	Possible triggers in post COVID-19 environment	Risks to financial stability	Preventive and mitigating actions
<i>Price correction</i> (US subprime crisis)	Sudden shifts in real estate (RE) demand due to changing work patterns/consumer preferences; higher borrowing costs/tighter lending conditions; changing expectations (certain segments of RE, possibly particularly CRE, no longer seen as a safe investment).	Decline in economic activity in sectors depending on RE (e.g. construction, home furnishings) results in corporate insolvencies and NPLs; rising unemployment causes defaults on mortgage loans; RE investment funds face increased redemption demands, thereby amplifying pressure on prices; lenders trying to sell collateral further depress prices and thereby increase losses after a default.	Build up sufficient resilience (capital buffers, risk weight adjustments), borrower-based measures to slow down RE market dynamics.
<i>Accumulation of unsustainable debt</i> (Property crash in Spain and Ireland in 2008-2011)	High debt levels, accumulated in a low interest rate environment and in the expectation of rising property values, can quickly become unsustainable following a decline in economic activity and rising unemployment (i.e. due to further COVID-19 lockdowns without sufficiently supportive policies taken).	Credit losses reducing banks' capital ratios and their ability to lend. The sale of collateral depresses RE prices (see above), compounding the effects of unsustainable debt.	Build up sufficient resilience (capital buffers, risk weight adjustments), borrower-based measures to slow down RE market dynamics and constrain the build-up of debt.
<i>Squeezed bank margins</i> (Savings and Loan Crisis)	Rising interest rates (possibly caused by higher inflation) reduce the value of mortgage loan portfolios with low interest rates fixed for long durations.	Banks' profit margins are squeezed as they have to fund their asset portfolio at higher interest rates. If banks have hedged their interest rate risks, their counterparties will be affected – or the hedging banks themselves if their counterparties fail.	Make the scale and location of risks more transparent and assess the resilience of the institutions that carry the risks. Ensure that banks are funded with sufficient capital to withstand an interest rate hike shock, by means of capital buffer requirements or risk weight adjustments.

Source: DG FISMA.

2.1.2 Commercial real estate markets

In contrast to RRE, CRE markets have been hit hard by the COVID-19 pandemic, which triggered an extended freeze in market activity and a significant drop in prices and transactions in some segments (see Chart 2.2 for average price growth). Some CRE segments like retail, hotel and offices have been hit much harder than others, such as industrial, and could also face

structural changes after the COVID-19 pandemic. Further price declines could still take place, especially in lower quality CRE assets⁴⁰.

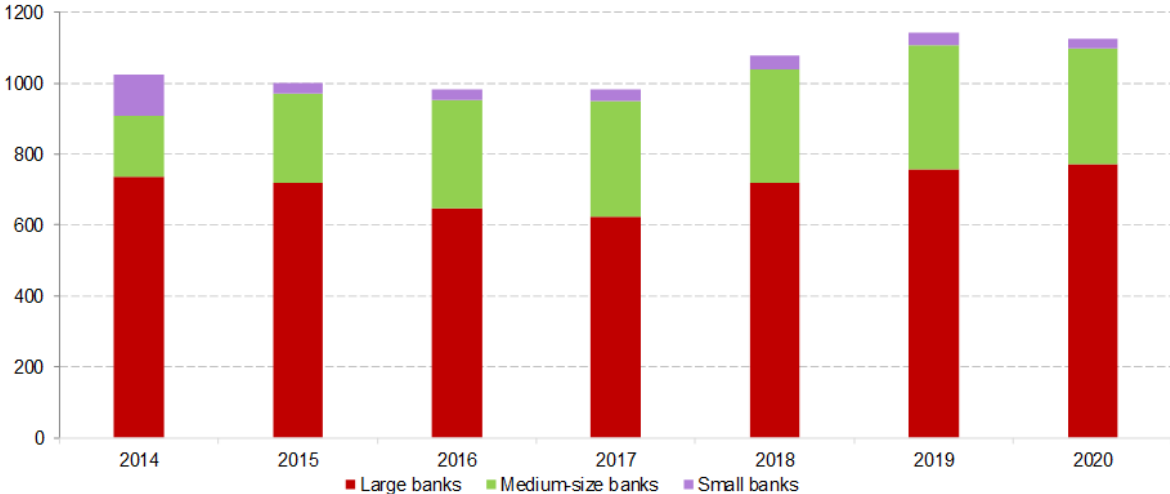
The correction in CRE prices was accompanied by deteriorating financing conditions for non-financial corporations, which may have to scale back activities and investments if they cannot secure financing. The latter is due to the fact that commercial immovable property used as collateral has declined in value.

From a financial stability perspective, the price correction could expose the financial system to increased credit risks, declining collateral values and bank losses on direct CRE holdings. It would impact the banking system of Member States with sizable and risky exposures to CRE markets both through direct exposures (i.e. loans to CRE activities) and, indirectly, through the use of CRE as collateral. In this respect, given the current exposures, the financial stability risks seem more limited on average for the EU banking sector.

In the EU, the financial sector’s indirect exposures to CRE markets (as reflected in the exposures collateralised by commercial immovable property) decreased slightly in 2020. Overall, the total exposures collateralised by CRE of EU banks decreased by -1.4% compared to 2019, which is largely explained by the drop in such exposures in small and medium-sized institutions (see Chart 2.7).

Moreover, developments in EU banks’ direct exposures to CRE do not raise significant concerns from a financial stability perspective. Loans to non-financial corporations (NFCs) for construction activities dropped by -1.7%, y-o-y, in Q2 2021, while the total of real estate loans to NFCs increased slightly, by 2.9% y-o-y, in Q2 2021 (see Chart 2.8).

Chart 2.7: Financial sector exposures to CRE in the EU – total exposures collateralised by CRE

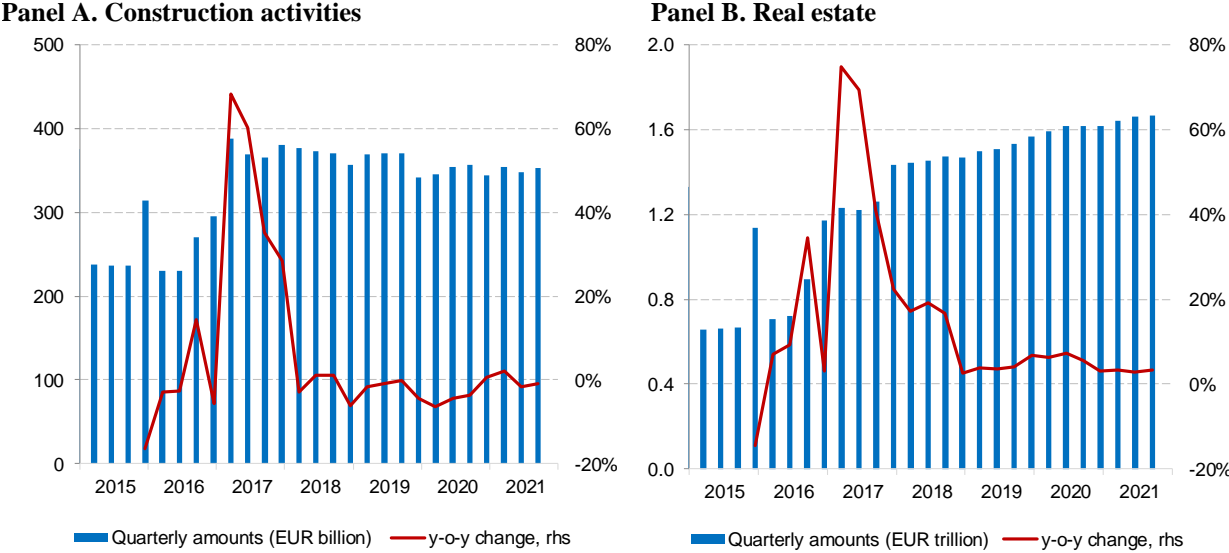


Source: European Central Bank (ECB), Financial sector exposures to commercial real estate (CRE).
 Note: Total exposures, in EUR billion, collateralised by commercial immovable property vis-à-vis all institutions. EU (changing composition), consolidated banking data. Large banks have assets greater than 0.5 % of the total consolidated assets of European Union banks, while this ratio for small banks is below 0.005%. Medium-size banks are those where the ratio is between 0.5% and 0.005%.

⁴⁰ See ECB (2021), *Financial stability review*, May 2021 and ECB (2021), *Financial stability review*, November 2021. According to the latter report, the outlook is poor for lower quality CRE assets, with the market intelligence flagging remote working, health concerns and the rush for greener property as channelling demand towards the prime segment.

For those parts of the non-bank financial sector that are highly exposed to CRE activity, a correction of CRE prices could have a larger impact. Investment funds intermediate more than half of the transactions in the European real estate market. They have increased their CRE exposure through a higher degree of leverage and are thus considerably exposed to property price fluctuations. Losses by investments funds could have an impact on banks, given that banks provide credit to funds and both are thus interlinked.

Chart 2.8: Financial sector exposures to CRE in the EU – Loans to NFCs



Source: European Central Bank (ECB), Financial sector exposures to commercial real estate (CRE).
 Note: Panel A shows credit to construction activities. Panel B, credit to real estate. All institutions, EU (changing composition), consolidated banking data.

Overall, the current risks to financial stability stemming from RRE and CRE markets remain high and have increased since the global financial crisis. The risk of a correction in these markets is one of the main medium-term systemic risks, especially in those Member States where elevated debt levels, high bank exposures to real estate markets and overvalued properties come together.

Looking forward, vulnerabilities could be compounded by climate risks. Climate change could negatively affect the value of real estate because extreme weather events such as floods or forest fires become more likely. In addition, investments may be required, for instance to make homes or offices more energy efficient. Recent analyses show that banks’ climate change exposures stem mostly from their real estate exposures that are subject to physical risks and transition climate-related risks⁴¹.

⁴¹ See ESRB (2021), *Climate-related risk and financial stability*, July 2021. See also De Nederlandsche Bank (2021), *Financial stability report*, Autumn; more specifically the chapter on ‘Climate change and financial risks of real estate’ for a recent example of an analysis of how climate change can impact real estate risks. For a further discussion on physical and transition risks, see European Commission (2021), *European financial stability and integration report (EFSIR)*, SWD(2021) 113 final of 25 May 2021.

2.3 Policies to address systemic risks in real estate markets

2.3.1 Available instruments and policies

Authorities in Member States are monitoring developments in real estate markets and have taken policy measures to curtail systemic risks. Monitoring of RRE and CRE risks requires reliable data. Several data-related initiatives exist at international⁴² and EU level. At EU level, the ESRB has issued a recommendation on closing real estate data gaps (ESRB/2016/14⁴³, as amended by ESRB/2019/3⁴⁴). This recommendation aims to improve the availability and comparability of RRE and CRE data in the EU. In addition, it tries to ensure that national macroprudential authorities implement a national RRE and CRE risk monitoring framework based on harmonised indicators. In June 2021, the ESRB concluded that for the domestic RRE sector, most national macroprudential authorities have a risk monitoring framework in place that includes the relevant harmonised indicators⁴⁵. Data related to CRE markets becomes more and more available⁴⁶, although currently it is still rather scarce. In addition, the monitoring of domestic CRE markets is still undergoing improvements.

In the macroprudential remit, several types of tools exist for mitigating the risk that adverse real estate developments could turn into a systemic crisis (see Table 2.1). In the EU, the most widely used tools are capital-based and borrower-based instruments – such as loan-to-value (LTV) and debt-service-to-income (DSTI) limits – while some Member States also require limiting currency or maturity mismatches in funding⁴⁷. These various types of tools are often complementary and address different aspects of the risks related to real estate markets and mortgage lending. The EU regulatory framework provides for macroprudential capital-based tools for banks, which are the dominant providers of mortgage credit. However, insurers, pension funds and other non-bank lenders appear to be gaining non-negligible market shares in some Member States (notably the Netherlands, Belgium and Ireland)⁴⁸. Borrower-based measures, by contrast, are based on national legislation and can apply beyond banks.

⁴² The G20 Data Gaps Initiative was launched in 2009 to address the data gaps revealed by the global financial crisis, with the aim of supporting enhanced policy analysis. For further details, see [G20 Data Gaps Initiative](#).

⁴³ European Systemic Risk Board (ESRB) (2017), *Recommendation of the European Systemic Risk Board of 31 October 2016 on closing real estate data gaps* (ESRB/2016/14).

⁴⁴ European Systemic Risk Board (ESRB) (2019), *Recommendation of the European Systemic Risk Board of 21 March 2019 amending Recommendation ESRB/2016/14 on closing real estate data gaps* (ESRB/2019/3).

⁴⁵ See ESRB (2021), Summary compliance report - Recommendation of the European Systemic Risk Board of 31 October 2016 on closing real estate data gaps as amended by Recommendation ESRB/2019/ (ESRB/2016/14), June 2021.

⁴⁶ See European Commission (2021), Progress report on commercial real estate statistics, SWD(2021) 421 final of 15 December 2021.

⁴⁷ Funding or liquidity requirements related to real estate loans are relatively rare and may concern mortgage loans in foreign currency and hence banks' risks related to currency mismatches (e.g. in Hungary and Poland); they may also be used to ensure the stable funding of banks that provide mortgage loans (e.g. supervisory expectations in Denmark).

⁴⁸ For information on the role of non-bank lenders in various Member States, see e.g. page 12 and the Annex of the Report from the Commission to the European Parliament and the Council on the review of Directive 2014/17/EU of the European Parliament and of the Council on credit agreements for consumers relating to residential immovable property, COM(2021) 229 final of 11 May 2021, as well as the annual statistical report of the European Mortgage Federation, available at <https://hypo.org/emf/publications/hypostat/>.

Table 2.1: Macroprudential policy tools in the area of real estate

	BASED ON EUROPEAN UNION LAW	BASED ON NATIONAL LAW
Main instruments	<ol style="list-style-type: none"> 1. Sectoral capital requirements (Art. 124, 164, 458 CRR) 2. Sectoral systemic risk buffer (sSyRB) 3. Countercyclical capital buffer (CCyB) 	<ol style="list-style-type: none"> 1. Loan-to-value (LTV), Loan-to-income (LTI), Debt-service-to-income (DSTI), Debt-to-income (DTI) caps 2. Maturity limits for mortgage loans 3. Mortgage funding requirements
Mitigating effects	<ul style="list-style-type: none"> - Enhanced resilience of banks (instruments under 1, 2 and 3) - Dampened credit growth (particularly instrument under 3) 	<ul style="list-style-type: none"> - Enhanced resilience of borrowers and banks (instruments under 1 and 2) - Dampened credit loan growth and borrower indebtedness through lending standards (instruments under 1 and 2) - Reduced funding, maturity and currency mismatches for lenders (instrument under 3)

Source: DG FISMA.

Note: CRR refers to the Capital Requirements Regulation.

Besides macroprudential tools, other tools also influence the resilience to, and mitigation of, risks and vulnerabilities in real estate markets. In 2014, the Mortgage Credit Directive (MCD), introduced requirements to ensure reliable property valuation standards as well as requirements for assessing a consumer’s creditworthiness before providing credit⁴⁹. The obligation to perform this assessment on the basis of the borrower’s repayment capability helps to avoid consumers taking on credit that they will be unable to pay back, as a recent review report indicates⁵⁰. The MCD stipulates that an assessment should not mainly be based on the loan amount compared to the value of the residential property and the assumption that it will increase in the future but instead on the borrower’s capacity to repay the credit. These general requirements⁵¹ help to ensure sound lending standards, similarly to borrower-based measures (see below). The Capital Requirements Regulation (CRR) also contains requirements to ensure independent and sound property valuation⁵². Recently, the Commission has proposed changes to reduce cyclical effects on valuations⁵³.

National tax rules and housing regulations also affect the housing market and the demand for mortgages. Property taxes, the possibility to deduct mortgage interest from taxable income, the regulation of the (social) rental market or notary and land register legislation are all factors that affect supply and demand, and hence prices in real estate⁵⁴. In recent years, in the context of the

⁴⁹ Directive 2014/17/EU of the European Parliament and of The Council of 4 February 2014 on credit agreements for consumers relating to residential immovable property and amending Directives 2008/48/EC and 2013/36/EU and Regulation (EU) No 1093/2010, OJ L 60, 34.

⁵⁰ See pages 14-15 of the Report from the Commission to the European Parliament and the Council on the review of Directive 2014/17/EU of the European Parliament and of the Council on credit agreements for consumers relating to residential immovable property, COM(2021) 229 final of 11 May 2021.

⁵¹ In addition, the Unfair Contract Terms Directive (Council Directive 93/13/EEC) and the Unfair Commercial Practices Directive (Directive 2009/29/EC) provide general protection against unfair standard contract terms and against certain commercial practices. These apply to goods and services in general, including loans and other financial services.

⁵² See Articles 208 and 229 of 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.

⁵³ Additionally, the proposed changes aim to ensure ‘that modifications made to the property that improve the energy efficiency of the building or housing unit must be considered as unequivocally increasing its value.’ (European Commission (2021:17), Proposal for a Regulation of the European Parliament and of the Council amending Regulation (EU) No 575/2013 as regards requirements for credit risk, credit valuation adjustment risk, operational risk, market risk and the output floor, COM(2021) 664 final of 27 October 2021).

⁵⁴ These are not the only factors. Other factors include demographics, consumer preferences and real GDP growth.

European Semester,⁵⁵ the Commission has recommended to several Member States to reduce tax incentives for debt-financing, to better monitor risks in real estate markets, to strengthen the framework of borrower-based measures and to address structural factors in real estate markets in order to improve housing supply⁵⁶.

2.3.2 Current use of macroprudential measures in the Member States

Banks are required to hold sufficient capital to avoid the need for excessive deleveraging in the event of a housing crisis. To ensure this, capital-based tools for real estate exposures comprise upward risk-weight adjustments as well as structural and countercyclical capital buffer requirements (see Table 2.1). The use of these measures increases the required level of capital and hence the resilience of banks against system-wide shocks. It aims to limit any detrimental effects of such shocks on mortgage loans, the housing market and the broader economy⁵⁷. A system-wide shock resulting in large losses on the stock of mortgage loans could therefore be absorbed by lenders. Such measures could also have a preventive effect through the pricing of and demand for these mortgage loans⁵⁸.

Over the past decade and also during the COVID-19 crisis, several authorities have taken measures to increase risk weights for residential and/or commercial real estate exposures, thereby increasing banks' resilience to the potential negative consequences of real estate price shocks. Some macroprudential authorities considered that banks in their jurisdictions might not be sufficiently resilient because their low and sometimes decreasing estimates of risk weights (internal-model based) did not fully reflect the increasing systemic risks in their domestic real estate markets. Those authorities usually increased risk weights by using powers available under Article 458 of the CRR (four Member States did so for RRE exposures). They considered that activating the countercyclical capital buffer was not sufficiently targeted, as it also affects other exposures than real estate and therefore could unduly hamper credit provision and loan pricing towards non-financial corporates (NFCs), if such credit had not grown excessively.

The design of risk-weight measures varies across Member States, from a flat risk weight floor to risk weight add-ons and multipliers and risk-sensitive floors. A number of authorities have adjusted risk weights for banks using the Standardised Approach, usually in the form of stricter requirements for applying lower risk weights for RRE exposures (4 Member States), or higher risk weights for CRE exposures (4 Member States). In 2022, 11 Member States were applying higher risk weights for real estate exposures, of which 9 Member States in relation to RRE exposures and 4 Member States concerning CRE exposures⁵⁹. Systemic risk buffers, which can

⁵⁵ The European Semester is the framework for integrated surveillance and coordination of economic and employment policies across the European Union. For further information, see https://ec.europa.eu/info/business-economy-euro/economic-and-fiscal-policy-coordination/eu-economic-governance-monitoring-prevention-correction/european-semester_en

⁵⁶ See e.g. the [2019 country-specific recommendations](#) to Finland, the Netherlands and Sweden.

⁵⁷ For instance, Kapan and Miniou (2018) found that it was easier for better capitalised banks to maintain credit supply when faced with liquidity shocks during the global financial crisis. Often, research finds that tightening macroprudential requirements constrains credit growth and that better capitalised banks have higher lending growth. For recent literature reviews on the effect of macroprudential policy and banking regulation on bank lending, see Araujo, J., Patnam, M., Popescu, A., Valencia, F. and Yao, W. (2020), Effects of macroprudential policy: Evidence from over 6 000 estimates, *IMF Working Paper* WP/20/67, May 2020; and Thamae and Odhiambo (2021).

⁵⁸ However, the introduction of a macroprudential risk-weight measure in Belgium in 2013 did not have a significant effect on mortgage rates. For further details, see Ferrari, S., Pirovano, M. and Rovira Kaltwasser, P. (2017), The impact of sectoral macroprudential capital requirements on mortgage lending: evidence from the Belgian risk weight add-on, *MPRA Paper* 80821, August 2017.

⁵⁹ Figures based on national notifications and ESRB (2021), *A review of macroprudential policy in the EU in 2020*, July 2021.

be applied at the sectoral level since the end of December 2020, have been used by 1 Member State so far for RRE exposures, while 1 Member State has announced its future application and 1 Member State intends to substitute its Article 458 CRR measure with such a sectoral systemic risk buffer⁶⁰.

Contrary to capital-based measures, borrower-based measures (BBMs) can directly affect the availability as well as the terms and conditions of newly issued loans. In general, Member States commonly set restrictions on ratios such as loan-to-value (LTV), debt-to-income (DTI), loan-to-income (LTI), debt-service-to-income (DSTI)⁶¹ and loan-service-to-income (LSTI)⁶². BBMs may reduce the probability of default or loss-given-default of banks' real estate loans portfolios. LTV limits the impact of negative house price shocks and affects the loss-given-default for a lender by reducing the likelihood that the value of the collateral is insufficient to cover losses in case of default. This contrasts with income-based limits that reduce the risk of non-repayment or the probability of default by borrowers. Borrower-based measures, and in particular income-based limits⁶³, can also dampen pro-cyclicality, as they automatically become more binding when the housing market booms⁶⁴. Some Member States may also use amortisation requirements or maturity limits⁶⁵, together with the other borrow-based restrictions mentioned above, also to ensure that DSTI limits remain effective in containing debt⁶⁶. BBMs are often activity-based and apply to all types of lenders. In addition, these tools can contribute to consumer protection and reduce household vulnerabilities by restricting the levels of debt and the debt-financing costs of households⁶⁷. They may also constrain house price growth.

Empirical research has shown that the use of maximum LTV, DTI and DSTI ratios is (relatively) effective in limiting (pro-cyclical) credit supply to households and reducing household debt levels⁶⁸. In sum, borrower-based measures increase the resilience of borrowers and lenders.

⁶⁰ Where measures did not automatically apply to branches of foreign banks and direct cross-border exposures, authorities have usually requested foreign authorities to voluntarily apply the activated measures as well to these exposures by reciprocating the measures. In general, foreign authorities did so for material exposures.

⁶¹ DSTI is defined as the share of monthly income used for the monthly debt payment. An example is interest payments and amortisation on all loans to a household.

⁶² LSTI is defined as the share of monthly income used for monthly interest payments and amortisation for a given mortgage loan only.

⁶³ This follows from the fact that income is less cyclical than house prices.

⁶⁴ The monetary amount of a down payment increases if house prices rise and the LTV limit stays the same. Income often increases less than house prices during a boom, meaning that DSTI, LTI and DTI limits also become more binding.

⁶⁵ Typically restricting the duration of mortgage loans to 25, 30 or 40 years.

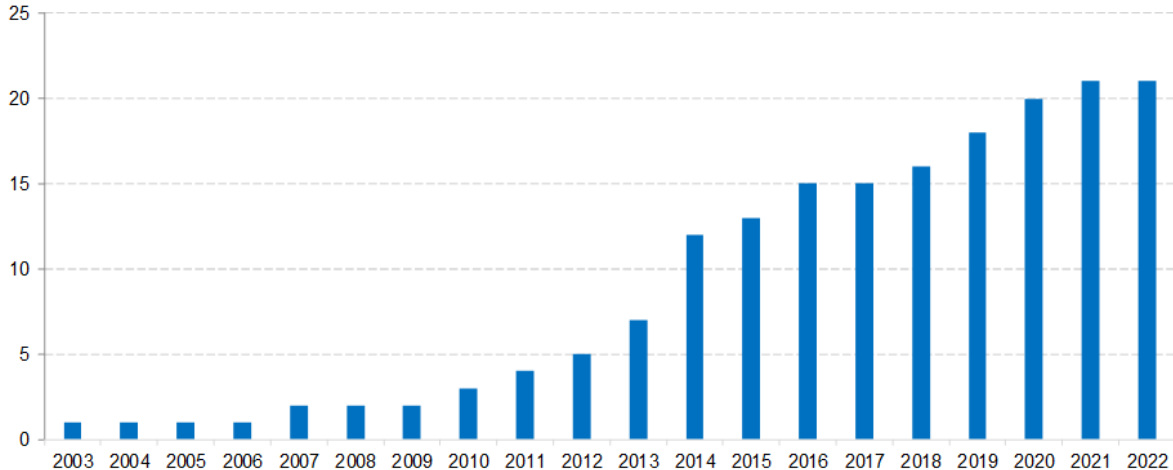
⁶⁶ BBMs are generally implemented as a bundle where there will be caps on at least two ratios. Generally LTV and either DTI or DSTI are considered in the bundle. In some cases, the choice of the particular BBMs will be conditioned on data availability or privacy laws.

⁶⁷ This is related to the fact that they apply to the flow of new loans at origination.

⁶⁸ Lim, C., Columba, F. Costa, A., Kongsamut, P. Otani, A. Saiyid, M. Wezel T. and Wu X. (2011), Macroprudential policy: What instruments and how to use them? *IMF Working Paper* WP/11/238, October 2011; ECB (2013), *Financial Stability Review*, May 2013; Kim (2014); Cerutti, E., Claessens, S. and Laeven, L. (2015), The use and effectiveness of macroprudential policies: New evidence, *IMF Working Paper* WP/15/61, March 2015; Jácome, L.I. and Mitra, S. (2015), LTV and DTI limits — Going granular, *IMF Working Paper* WP/15/154; McDonald, C. (2015), When is macroprudential policy effective? *BIS Working Papers* 496, March 2015; Kuttner and Shim (2016); Akinci and Olmstead-Rumsey (2018); Alam *et al.* (2019); Morgan *et al.* (2019); Poghosyan, T. (2019), How effective is macroprudential policy? Evidence from lending restriction measures in EU countries, *IMF Working Paper* WP/19/45, March 2019. Note that Kuttner and Shim (2016) found that especially DSTI caps have a significant effect on housing credit, more than maximum LTV ratios. Additionally, some recent research also provides corroborating evidence for the fact that these tools can constrain house

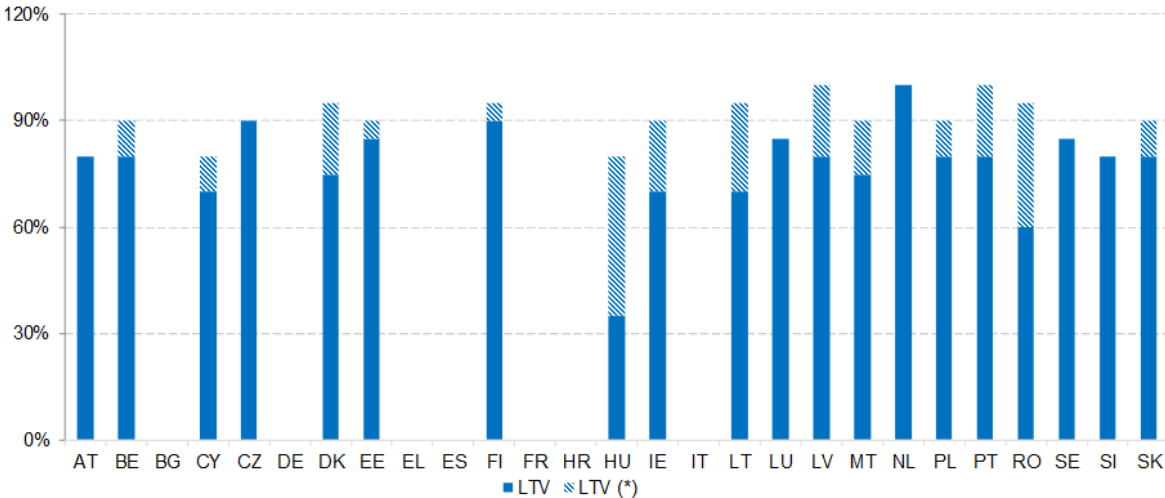
Member States have progressively introduced and often activated borrower-based measures for the RRE sector in the past years (see Chart 2.9) amid growing concerns for the build-up of systemic risks and vulnerabilities related to debt-financed RRE. The prevailing low interest rate environment made it more attractive and affordable to finance RRE purchases via debt. BBMs constrain debt-financing and thereby address risks for both borrowers and lenders.

Chart 2.9: Number of Member States activating borrower-based measures (BBMs) for RRE



Source: DG FISMA calculations based on ESRB (2021), *A review of macroprudential policy in the EU in 2020*, July 2021, and on notifications of national authorities, available at https://www.esrb.europa.eu/national_policy/other/html/index.en.html

Chart 2.10: Loan-to-value limits for residential real estate (RRE)

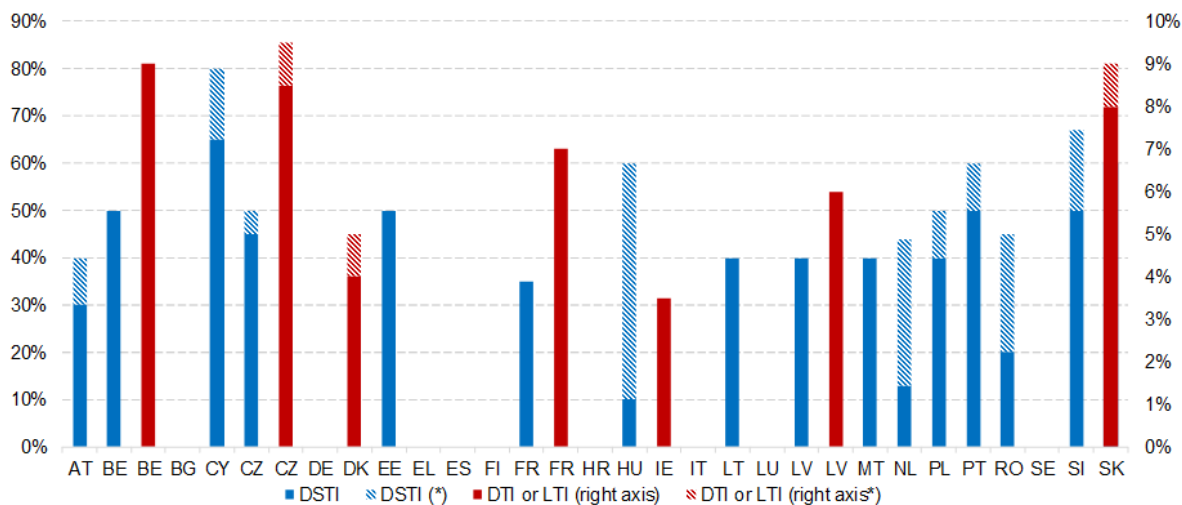


Source: DG FISMA calculations based on ESRB (2021), *A review of macroprudential policy in the EU in 2020*, July 2021, and on notifications of national authorities, available at https://www.esrb.europa.eu/national_policy/other/html/index.en.html.

Note: Shaded areas indicate the range of maximum loan-to-value limits (i.e. up to LTV*) for Member States having differentiated limits (e.g. for first-time, second and subsequent buyers, or for owner-occupied and buy-to-let dwellings). In Member States without a bar, no regulatory LTV limits apply. Member States may allow banks to exceed the limits for a certain proportion of their loans; this is not reflected in this chart.

price growth. For evidence based on a group of 50 countries, see e.g. Akinci and Olmstead-Rumsey (2018), and Alam, Z., Alter, A. Eiseman, J., Gelos, G., Kang, H., Narita, M. Nier, E. and Wang, N. (2019), *Digging Deeper—Evidence on the effects of macroprudential policies from a new database*, *IMF Working Paper WP/19/66*, March 2019. Similar results are reported by Poghosyan (2019) for a sample of the EU countries and Acharya *et al.* (2020) for the recent Irish BBMs. For further details, see Poghosyan, T. (2019), *How effective is macroprudential policy? Evidence from lending restriction measures in EU countries*, *IMF Working Paper WP/19/45*, March 2019; and Acharya, V.V., Bergant, K., Crosignani, M., Eisert, T. and McCann, F.J. (2020), *The anatomy of the transmission of macroprudential policies*, *IMF Working Paper WP/20/58*, May 2020.

Chart 2.11: Income-based limits for residential real estate (RRE)



Source: DG FISMA calculations based on ESRB (2021), *A review of macroprudential policy in the EU in 2020*, July 2021, and on notifications of national authorities, available at https://www.esrb.europa.eu/national_policy/other/html/index.en.html.

Note: Debt-service-to-income (DSTI) limits are displayed on the left-hand side and debt-to-income (DTI) or loan-to-income (LTI) limits on the right-hand side. Some Member States use a combination of these, but only the DSTI limits are displayed (BE, CZ, FR). Definitions of income greatly vary across Member States. Shaded areas indicate the range of maximum income-based limits (i.e. up to DSTI/DTI/LTI*) for Member States that have differentiated limits. In Member States without a bar, no regulatory income-based limits apply. Member States may allow banks to exceed the limits for a certain proportion of their loans; this is not reflected in this chart.

Although these measures are widely used, they differ across Member States (see Table 2.2), notably with regard to:

- the type of available measures, in particular for income-related BBMs;
- the purpose (macroprudential, microprudential, consumer protection, or a combination of the former);
- the legal base (binding or non-binding);
- the authority in charge of the implementation (government, central bank, supervisor, or a national financial stability committee);
- the scope (ranging from domestic banks only to all domestic and foreign credit providers beyond banks);
- the design and calibration.

For the design and calibration of BBMs, banks may have some flexibility to exceed the limits for a given share of loans (often referred to as ‘speed limits’) or have less restrictive limits for certain groups of borrowers, for instance to make it easier for first-time buyers to access the housing market. Such exemptions apply in 11 of the 21 Member States that have activated borrower-based measures. The level of limits and the definition of income for the income-based limits also vary across Member States⁶⁹.

⁶⁹ For instance, some Member States calculate the income-based limits based on gross income while others use net disposable income. In several Member States, ‘stressed DSTI ratios’ need to be used (i.e. simulating an increase in the interest rate) or lenders have to verify in other ways that the borrower would still be able to repay the loan if the interest rate increases.

Table 2.2: Characteristics framework of borrower-based measures for RRE

	Framework BBMs extends beyond banks	Activated BBMs are legally binding	Speed limits apply	Looser rules for young or first-time buyers apply
Yes	16	16	11	7
No	10	5	10	14
Not Applicable	1	6	6	6

Source: DG FISMA calculations based on ESRB (2021), *A review of macroprudential policy in the EU in 2020*, July 2021, and on notifications of national authorities, available at https://www.esrb.europa.eu/national_policy/other/html/index.en.html.

Note: Not applicable means that Member States have no framework for BBMs (second column), or have no active BBMs (third, fourth and fifth column).

Member States differ in particular in the way in which they adjust their macroprudential policies to facilitate access to housing finance for young and low-income households⁷⁰. Restricting access for these groups may increase wealth inequality⁷¹. On the other hand, research also shows that preventing real estate crises helps to fight unemployment and inequality in the longer-term⁷². Member States have taken different approaches to these issues. In 7 of the 21 Member States that have activated at least one borrower-based measure, young or first-time buyers can benefit from looser restrictions, and lenders may be allowed to exceed the limits set by borrower-based measures for a certain proportion of their loans.

Member States reassessed their macroprudential policies targeted at real estate risks after the outbreak of the COVID-19 pandemic. Most assessed the impact of the pandemic on RRE as transitory and therefore have not changed their macroprudential policies. Some relaxed their borrower-based measures, often with a view to supporting lending and reducing the burden for households that may face temporary income losses⁷³. By contrast, Luxembourg introduced borrower-based measures, and Czechia announced the introduction of legally binding borrower-based measures in 2021⁷⁴.

There is no comprehensive borrower-based macroprudential toolkit to address financial stability risks in CRE markets, as was also pointed out by the IMF and the ESRB⁷⁵. Only a handful of Member States (Cyprus, Denmark, Poland) apply CRE-related borrower-based measures. The limited use of these measures could be due to legal hurdles caused by the lack of

⁷⁰ For instance, Acharya *et al.* (2020:39) ‘document a reallocation of mortgage credit from low- to high-income households and from hot, mostly urban, housing markets to cool housing markets’ after the introduction of LTI and LTV limits in Ireland. See Acharya, V.V., Bergant, K., Crosignani, M., Eisert, T. and McCann, F.J. (2020), *The anatomy of the transmission of macroprudential policies*, *IMF Working Paper* WP/20/58, May 2020.

⁷¹ Outside the prudential remit, Member States have undertaken other policies: some have for instance pledged to invest more in creating affordable housing. See e.g. Chapter 2 in OECD (2021), *Brick by brick – Building better housing policies*, OECD Publishing.

⁷² Frost and Van Stralen (2018) find a positive association between LTV and DTI limits on the one hand, and the Gini coefficient measuring net income inequality on the other hand.

⁷³ Four Member States loosened restrictions on income-based limits (CZ, MT, PT, SI) and three (FI, MT, SE) did so for restrictions on LTV limits. In most cases, these measures were only relaxed temporarily. Finland and the Netherlands changed their policies for capital-based measures. More specifically, Finland did not extend the period of application of an existing risk-weight floor measure for RRE exposures. This freed up capital and made it easier for banks to provide credit during the pandemic. In 2020 the Netherlands decided to postpone the planned introduction of a risk-weight floor measure for RRE for similar reasons but still activated the measure later, as the overheating of the housing market continued.

⁷⁴ The income-based limits in Czechia that were loosened and/or abandoned were not legally binding.

⁷⁵ International Monetary Fund (IMF) (2019), *Global financial stability report*, April 2019; European Systemic Risk Board (ESRB) (2019), *Methodologies for the assessment of real estate vulnerabilities and macroprudential policies: commercial real estate*, December 2019.

a harmonised framework and the fact that CRE markets are more complex⁷⁶ than RRE markets⁷⁷, with much more CRE funding being available from non-bank lenders.

Currently, (macro)prudential policy does not include explicit requirements to address climate-related financial risks related to real estate, but work and analyses of financial stability risks of climate change and means of addressing these in (macro)prudential policy are ongoing at international and European level⁷⁸. Recently, the Commission has also proposed several changes to the Capital Requirements Directive (CRD)⁷⁹ and the CRR to address climate-related financial risks in the microprudential domain⁸⁰.

2.3.3 Coordination of macroprudential policies for real estate markets in the EU

Since the 2008 global financial crisis, several mechanisms have been created in the EU to coordinate policies aimed at limiting systemic risks. The crisis experience made it clear that a national crisis, for instance in real estate markets, could spill over to other Member States, underlining the importance of treating financial stability as a matter of common concern. In the area of economic policy, the Macroeconomic Imbalances Procedure (MIP) in the European Semester responds to the need for policy coordination. In the MIP, the Commission has recommended to some Member States to reform their real estate markets. Moreover, the ESRB was created in 2010 as an EU-wide body responsible for the macroprudential oversight of the financial sector in the European Economic Area and for the prevention and mitigation of systemic risks. It is also tasked with assessing requests to reciprocate macroprudential measures in order to ensure the effectiveness of policy in the internal market. Additionally, within the Banking Union, the ECB is being consulted before national authorities use macroprudential tools defined in the CRD and CRR. Within the Banking Union, the ECB can use its topping-up powers to set higher requirements for these tools but has not formally done this to date⁸¹.

The ESRB has developed an extensive methodology for assessing systemic risks in real estate markets. It has also developed a framework to assess whether policy measures were appropriate and sufficient⁸². In response to the growing vulnerabilities in some real estate markets, the ESRB issued warnings and recommendations to several Member States in 2016, 2019 and

⁷⁶ The lack of data in this market (see below) together with the fact that borrowers are of different kinds contribute to this complexity.

⁷⁷ European Systemic Risk Board (ESRB) (2019), *Methodologies for the assessment of real estate vulnerabilities and macroprudential policies: commercial real estate*, December 2019.

⁷⁸ For recent publications on analysing financial stability aspects of climate change in the European context, see for example: ESRB (2021), *Climate-related risk and financial stability*, July 2021; European Central Bank (2021), *Climate-related risks and opportunities, Macroprudential Bulletin*, October 2021.

⁷⁹ 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.

⁸⁰ Proposal for a Directive of the European Parliament and of the Council amending Directive 2013/36/EU as regards supervisory powers, sanctions, third-country branches, and environmental, social and governance risks, and amending Directive 2014/59/EU, COM (2021) 663 final of 27 October 2021 and Proposal for a Regulation of the European Parliament and of the Council amending Regulation (EU) No 575/2013 as regards requirements for credit risk, credit valuation adjustment risk, operational risk, market risk and the output floor, COM(2021) 664 final of 27 October 2021.

⁸¹ See Article 5 of 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 (SSM Regulation).

⁸² The ESRB applies a forward-looking assessment of the RRE market to all European Economic Area countries. This is based on an analytical framework that provides consistent guidelines on the detection of the sources and the intensity of systemic vulnerabilities stemming from RRE developments, and the assessment of the appropriateness and sufficiency of the related macroprudential policies implemented in a country. For further details on the methodology, see ESRB (2019), *Methodologies for the assessment of real estate vulnerabilities and macroprudential policies: residential real estate*, September 2019.

again in 2022, as it considers that medium-term risks and vulnerabilities in real estate markets in the respective Member States were, and sometimes still are today, not addressed sufficiently/adequately⁸³. In some cases, the ESRB concluded that non-compliance with the 2019 recommendations was justified in view of the COVID-19 circumstances⁸⁴. The ESRB has recommended several policy actions such as establishing or amending a legal framework for borrower-based measures or activating or tightening borrower-based or capital-based measures. It has also recommended other actions beyond macroprudential policy to address structural features of the housing markets.

2.4 Concluding remarks and policy considerations

In recent years, house prices and mortgage lending have strongly increased in most EU Member States. Household debt levels have risen as well. Member States responded by taking macroprudential policy measures to limit the systemic risks and vulnerabilities in RRE markets. Nevertheless, Commission recommendations in the context of the European Semester and ESRB warnings and recommendations underscore the need for further policy measures in certain Member States. To date, not all recommendations have been followed up. The build-up of medium-term vulnerabilities in the EU RRE markets warrants continued close monitoring by national and European authorities.

Some segments of CRE markets were severely hit by the pandemic. Fewer macroprudential policy tools to address risks and vulnerabilities in the CRE sector are available, reflecting notably the diversity in these markets, their smaller magnitude compared to RRE markets, a more diverse and international funding base and a lack of data. These factors make it more complex to establish, use and calibrate specific macroprudential tools for the CRE sector. Further work on the structural changes brought by the pandemic in the economy and their impact on the CRE market is also needed and will be key for understanding future developments in CRE markets.

In addition, further attention should be given to the impacts of climate change on real estate. Depending on the proportion of loans secured by real estate in financial institutions' balance sheets, the extent to which the value of real estate collateral is affected by climate risks potentially has a large impact on credit risk and poses a great challenge for risk management.

In recent years, policies in the Member States tended to converge. Data coverage for monitoring risks in RRE markets has become more consistent, in line with the non-binding minimum requirements and definitions developed by the ESRB. Borrower-based measures to address these risks have been developed and implemented in most Member States. The development and application of policy tools has been a process in which Member States have learnt from each other, notably as regards the calibration for first-time buyers and other ways of introducing some flexibility in borrower-based measures.

⁸³ In 2016, the ESRB issued 8 warnings (AT, BE, DK, FI, LU, NL, SE and UK); in 2019 it issued warnings to 3 Member States (CZ, DE and FR) and recommendations to 6 Member States (BE, DK, FI, LU, NL and SE); in 2022 it issued warnings to 4 Member States (BG, HU, SK and HR) and recommendations to 2 Member States (AT and DE).

⁸⁴ See ESRB (2021), *Summary compliance report - Country-specific recommendations of the European Systemic Risk Board of 27 June 2019*, March 2021.

At the same time, significant differences remain between Member States, for instance with respect to how they calibrate and design capital- and borrower-based measures, reflecting also the different definitions used for borrower-based measures. To a considerable extent, this may be attributable to the specific features of national mortgage markets in the EU, notably in terms of risks, types of credit providers, tax treatment for mortgage payments, loan characteristics (maturities, fixed or variable interest rate, etc.) and the functioning of national housing markets. This diversity and the experience with the functioning of the capital-based tools in the CRR and CRD need to be taken into account in the further development of macroprudential policies for real estate risks, an issue that will occupy a prominent place in the ongoing review of the European macroprudential framework pursuant to Article 513 CRR.

Chapter 3 DECENTRALISED FINANCE: STATE OF THE ART AND POLICY CHALLENGES

3.1 What is decentralised finance (DeFi)?

This chapter⁸⁵ discusses decentralised finance (DeFi), which is a newly emerging form of autonomous financial intermediation in a decentralised digital environment powered by software – ‘smart contracts’⁸⁶ on public blockchains⁸⁷. It involves uncontrolled access to financial services on a quasi-anonymous basis⁸⁸ using crypto asset⁸⁹ wallets. The DeFi approach puts smart contracts at the core of financial services and, in its purest form, executes all transactions on a public blockchain, ensuring full transparency of the associated data⁹⁰. While still very small compared to the size of the traditional financial sector, DeFi is growing rapidly and increasingly raising questions about its functionalities, opportunities and risks, as well as its relationship to traditional finance and regulation. This chapter will look into these issues in more detail. After introducing DeFi and presenting the recent market developments in Europe, the chapter will describe its current functionalities. To provide insights in the way DeFi works, it will also explain its main technical features. After that, its opportunities and risks are outlined, followed by a discussion on regulatory challenges.

The emergence of DeFi can be seen as the next step in the development of crypto asset ecosystems. The objective of the first (public) blockchain – the Bitcoin blockchain⁹¹ – was to serve as an alternative peer-to-peer electronic cash system that is independent of the banking system. The total supply of bitcoins is capped to avoid debasement and their issuance is designed as a reward for transaction processing. Many new blockchain implementations have since then come into existence, either through simple copying of existing blockchains or through development of more innovative types. The most notable innovative type is Ethereum⁹², which introduced the concept of smart contracts and took the crypto asset ecosystem to a whole new level. Whereas prior blockchain implementations only allowed for the transfer of ‘native tokens’⁹³, Ethereum smart contracts enabled the issuance of an unlimited number of other types of tokens on the same blockchain. This gave rise to a wave of initial coin

⁸⁵ This year’s edition of the European Financial Stability and Integration Review is the third instance that topics related to blockchain applications and their impact on the financial sector are analysed. [Crypto-token market developments](#) and the [impact of cryptocurrencies on banks and the wider financial system](#) were discussed in previous editions. For further details, see European Commission, *European Financial Stability and Integration Review* (EFSIR), SWD(2018) 165 final of 3 May 2018 and European Commission, *European Financial Stability and Integration Review* (EFSIR), SWD(2020) 40 final of 3 May 2020, respectively.

⁸⁶ A smart contract can be broadly defined as an algorithm that automates the execution of a transaction on specified terms once predetermined conditions are met.

⁸⁷ A public blockchain implies that no permission is required to access this blockchain. All users need to do is download free software that enables transactions. By contrast, access to a private blockchain is controlled by its owner and/or operators.

⁸⁸ Transactions are identified on the blockchain by a string of alphanumeric characters, referred to as addresses. Crypto assets are transferred from a sender’s address to a recipient’s address. These addresses are not anonymous in the sense that all transactions involving a specific address are publicly observable. However, it is not possible to directly link a specific address to a person or legal entity. Also, users can have as many addresses as they wish and can even choose to use a new address for each transaction. Note that there are also other ways to enhance privacy further in crypto asset transactions.

⁸⁹ There is no specific distinction between the terms ‘crypto assets’ and ‘crypto tokens’; both are used interchangeably.

⁹⁰ This contrasts with the centralised approach of established cryptocurrency exchanges where trading is executed on the exchange’s own internal ledger and involves discretion on the part of the service provider.

⁹¹ <https://bitcoin.org/bitcoin.pdf>

⁹² <https://ethereum.org/en/>

⁹³ ‘Native tokens’ are embedded in the blockchain and are indispensable for it to function. These tokens are issued by the blockchain to reward blockchain nodes for processing transactions and are also used for transaction fee payments. For instance, bitcoin (BTC) is the native token of the Bitcoin blockchain and Ether (ETH) is the native token of Ethereum.

offerings (ICOs) as a way of raising finance for blockchain projects⁹⁴ and led to intensified token trading that boosted activity on centralised crypto asset exchanges. DeFi is the outcome of further innovation with the use of smart contracts to replicate common functionalities of the traditional financial system in a decentralised setting. It has offered users the possibility to earn an income on their crypto assets⁹⁵.

DeFi is often contrasted to the traditional financial system⁹⁶, which relies on centralised intermediaries that control access to financial services, to the extent that it represents a genuine time-efficient, peer-to-peer financial system⁹⁷. In addition to uncontrolled access, DeFi is decentralised at two levels: infrastructure and governance.

Decentralisation of infrastructure stems from the fact that DeFi uses a public blockchain as its common settlement layer where transactions are processed by a decentralised network of nodes instead of a central authority (see Section 3.4). Some may question the effectiveness of this decentralisation due to a seeming increase in concentration of transaction processing activity known as ‘mining’. For example, two mining pools alone accounted for some 26% of all the transaction sets (referred to as ‘blocks’) added to the Ethereum blockchain in November 2021⁹⁸. However, these pools themselves unite large numbers of processing nodes that are organised in pools to be more efficient and manage their own individual risks. Thus, there seems to be no reason to question the decentralised nature of the settlement layer.

In theory, DeFi also involves decentralised governance arrangements. Once developed by individuals, DeFi applications are deployed on the blockchain and gradually take on a life of their own as governance is ceded to the user community via allocation mechanisms of governance tokens⁹⁹. The ultimate form of a DeFi application is the decentralised autonomous organisation (DAOs). In practice though, developers often reserve a substantial chunk of governance tokens for themselves, either to retain a certain amount of control and/or to be able to benefit financially by selling these tokens at a later stage. Some studies have found that the aggregate amount of a specific type of token held in the top 5 token addresses can account for more than 50% of the entire supply of these tokens while the aggregate amount in the top 50 addresses can account for over 90%¹⁰⁰. Other challenges to decentralisation include the

⁹⁴ See [Crypto-token market developments](#) for a more detailed discussion.

⁹⁵ Prior to DeFi, people could either buy and hold crypto assets or trade them. However, there was no possibility to earn any interest or other types of yield on these assets. DeFi has changed that by enabling lending and crypto asset staking, more broadly, whereby crypto asset holders provide liquidity to various DeFi applications in return for an income stream. In November 2021, the range of yield in various DeFi protocols for USD-pegged stablecoins, such as USDC, USDT and DAI was between 0.02% and 16.19%. For details, see <https://defirate.com/lend/>.

⁹⁶ DeFi is also contrasted to centralised crypto asset services, such as established cryptocurrency exchanges.

⁹⁷ As opposed to early peer-to-peer systems that only allowed for the matching of exact opposite interests and lacked liquidity.

⁹⁸ These pools are Ethermine and F2Pool Old. For details, see <https://etherscan.io/stat/miner?blocktype=blocks>. In November 2021, the Ethermine pool included 367 505 active miners. See <https://ethermine.org/>.

⁹⁹ Governance tokens give holders the right to participate in governance decisions on the respective DeFi applications and to receive a share of profits generated by them. For example, they enable holders to vote on specific governance decisions, such as the setting of interest rates or collateral requirements. Voting can be used either to instruct dedicated individuals to implement the respective changes in partially decentralised governance arrangements or to interact directly with smart contracts deployed as part of a decentralised autonomous organisation (DAO) in fully decentralised governance arrangements. Governance tokens can also be traded.

¹⁰⁰ See Nadler, M. and Schär, F. (2020). [Decentralised finance, centralised ownership? An iterative mapping process to measure protocol token distribution.](#)

widespread use of ‘admin keys’¹⁰¹ and interfaces feeding off-chain information on external prices into the blockchain known as ‘price oracles’¹⁰².

3.2 State of the market’s development in Europe

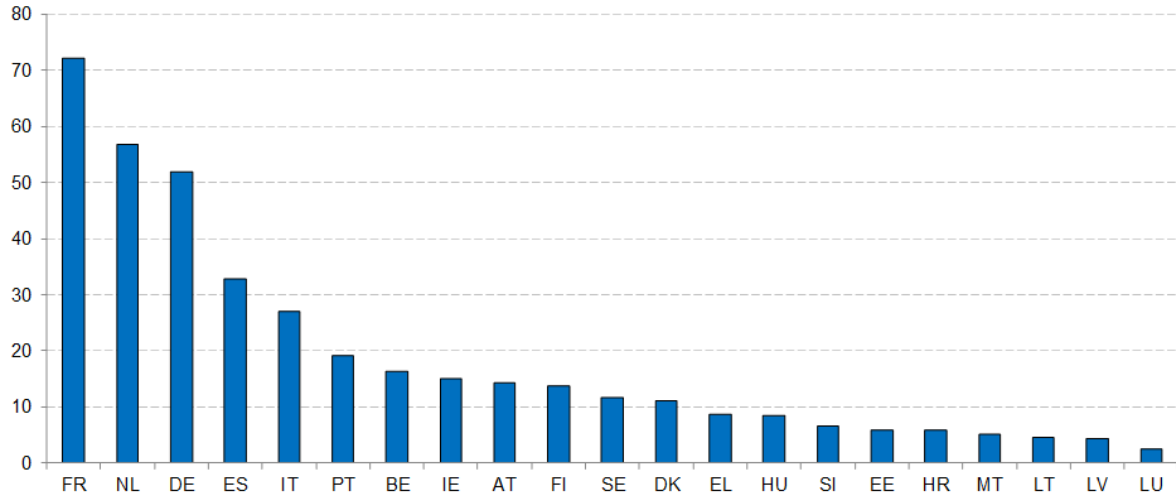
DeFi has become very topical since its rapid growth, which began in December 2020. As of 21 December 2021, about USD 85.2 billion was deposited globally in DeFi smart contracts (commonly referred to as ‘total value locked’), up from a mere USD 8.7 billion on 22 June 2020 (see Chart 3.1)¹⁰³.

Chart 3.1: Total (net) value locked in DeFi smart contracts globally



Source: DeFi pulse.
 Note: Values in USD billion. Daily data.

Chart 3.2: Gross aggregate European transfers to DeFi services by Member State



Source: Chainalysis (2021), *The 2021 geography of cryptocurrency report*, October 2021.
 Note: Values in USD billion. Period covers July 2020 – June 2021.

¹⁰¹ ‘Admin keys’ allow the core project team developing a DeFi application to upgrade its smart contracts and perform emergency shutdowns.

¹⁰² However, this issue increasingly seems to be addressed by the use of decentralised networks of such price feeds instead of a single supplier of truth. Examples of such networks include Chainlink, Band or Teller.

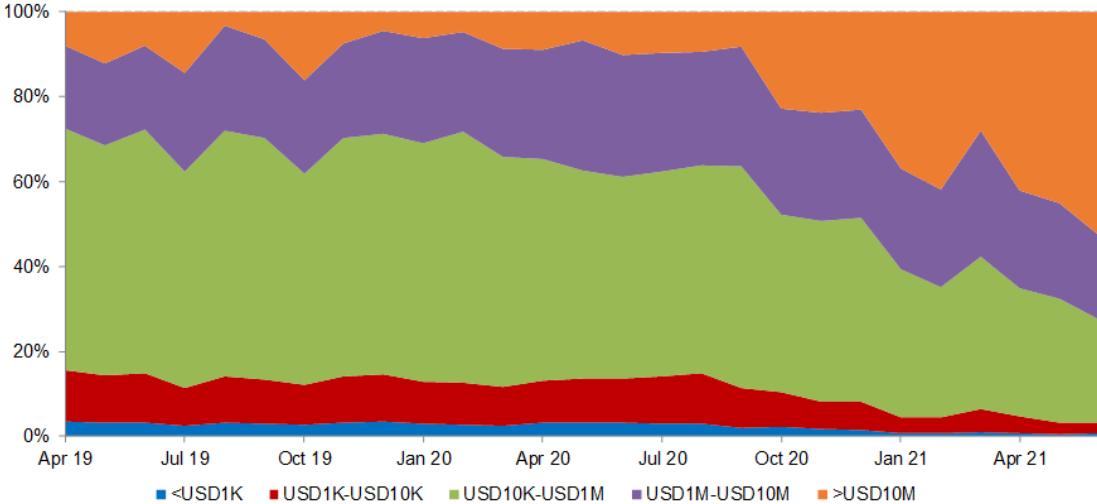
¹⁰³ See [The De Finance Leaderboard of DeFi Pulse](#).

The total USD value locked is strongly affected by price developments of the tokens deposited in smart contracts and the common practice of collateralisation. Nevertheless, the continued growth of DeFi merits closer attention by regulators and supervisors, especially as these DeFi applications replicate or even mimic existing functions in the traditional financial sector.

The crypto asset transaction volume in Europe also grew significantly over the last couple of years, especially in DeFi applications. Chart 3.2 shows aggregate crypto asset value received by DeFi applications in a selection of EU Member States between July 2020 and June 2021. France, the Netherlands and Germany stand out as the top receivers, followed by Spain and Italy.

Chart 3.3 shows that in parts of Europe aggregate crypto asset transactions with a transaction volume above USD 10 million across all services, including DeFi, grew rapidly from USD 1.4 billion in July 2020 to USD 46.3 billion in June 2021. In June 2021, these large transactions represented more than half of all crypto asset transaction volumes across all services. This may indicate that the market is now more mature by pointing to a possibly growing presence of institutional investors.

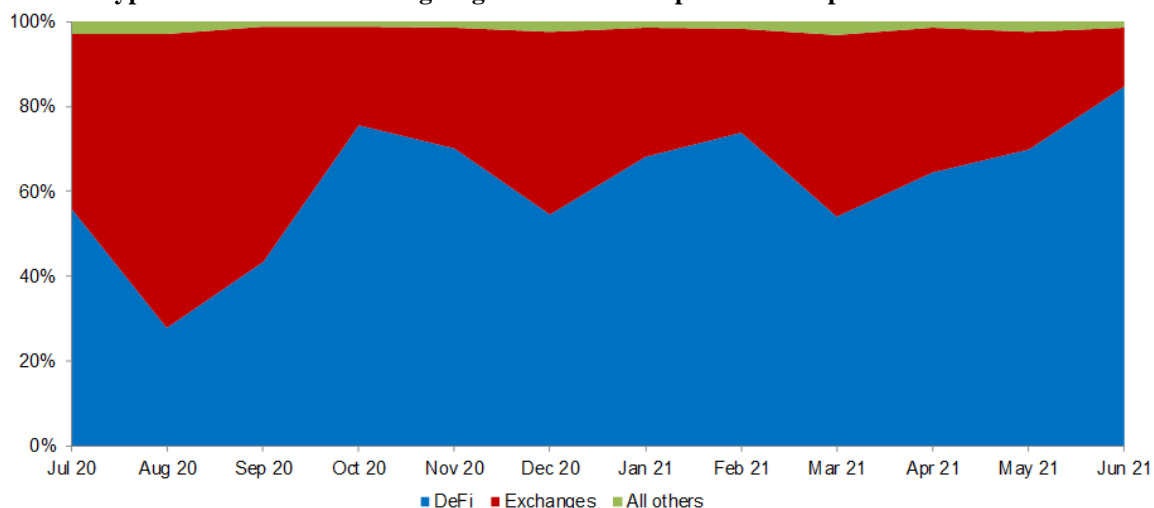
Chart 3.3: Transaction volume by transfer size in parts of Europe



Source: Chainalysis (2021), *The 2021 geography of cryptocurrency report*, October 2021.
 Note: The country sample is composed of AL, AT, BE, BA, CH, DE, DK, EE, EL, ES, FI, FR, HR, HU, IE, IS, IT, LT, LU, MC, MK, ME, MT, NL, NO, PT, SE, SI, and UK.

As depicted in Chart 3.4, the majority of those large transfers increasingly went into DeFi applications.

Chart 3.4: Crypto asset services receiving large transfers from parts of Europe



Source: Chainalysis (2021), *The 2021 geography of cryptocurrency report*, October 2021.

Note: Exchanges denotes centralised cryptocurrency exchanges. All others cover all the other uses, including but not limited to crypto asset mining, gambling, merchant services, peer-to-peer exchanges and illicit activity.

3.3 Current functionalities of DeFi

DeFi seems to replicate key features of the traditional financial system through innovative solutions adapted for the blockchain environment. DeFi essentially uses stablecoins¹⁰⁴ as enablers in a manner similar to traditional deposits and other deposit-like instruments, such as repurchase agreements. Given the decentralised and quasi-anonymous characteristics of DeFi, most of those applications rely on collateral as the basic instrument for smart contract interactions. The value of collateral held in crypto assets other than stablecoins incurs substantial fluctuations vis-à-vis fiat currencies, which necessitates considerable overcollateralisation. This section provides an overview of the relevant DeFi functionalities that are available today, covering payments, trading, lending, derivatives, investment and insurance.

Stablecoins as DeFi enablers

Stablecoins play an important role in the DeFi ecosystem with two basic functions. On the one hand, they serve as a convenient entry and exit vehicle to the DeFi ecosystem for traders that do not want to be constantly exposed to the market risk inherent in other types of tokens without the need to convert their crypto assets into fiat currencies¹⁰⁵. On the other hand, they enable holders of volatile crypto assets to retain their market exposure by pledging them as collateral for loans in stablecoins, which can be used for transactions in various DeFi applications. The use of stablecoins also simplifies the analysis of transactions and the comparison of alternative

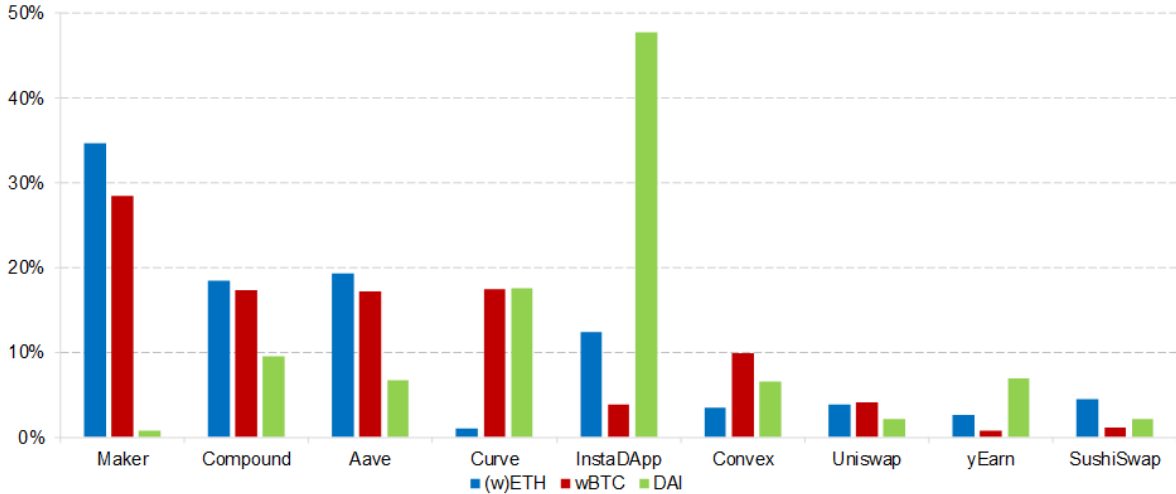
¹⁰⁴ Stablecoins are typically pegged to a fiat currency or sometimes to the price of another asset, such as a commodity. In general, stablecoins can be issued using off-chain collateral that is held in reserve with a custodian (also referred to as custodial stablecoins) or using on-chain collateral that is locked up in a smart contract (also referred to as collateralised stablecoins). Although both types of stablecoins are used in DeFi, only the one using on-chain collateral is true to the nature of DeFi, since the existence of this collateral is easily verifiable. There is also an emerging class of algorithmic stablecoins that are not backed by anything but maintain their value by managing token supply. However, no algorithmic stablecoin has been widely adopted, because fluctuations in quantity are simply substituted for fluctuations in value.

¹⁰⁵ However, the majority of inward transfers to DeFi is actually done in tokens other than stablecoins, notably ETH, which is the native protocol token of Ethereum (see Section 3.4). Some 60% of all large transfers into DeFi above USD 10 million in size were done in ETH. For further details, see Chainalysis (2021), *The 2021 geography of cryptocurrency report*, October 2021.

investment opportunities, as they provide a stable unit of account. For example, DeFi lending is predominantly done in stablecoins. Accordingly, the rise of DeFi has also contributed to a rise in the issuance of stablecoins.

The vast majority of stablecoins used in the DeFi ecosystem are pegged to USD and represent custodial types, such as USDT, USDC and BUSD, dominating in terms of total value in circulation¹⁰⁶. Notably, USDC is backed up and issued by regulated financial institutions and is redeemable at par for USD with these institutions. The most prominent example of a collateralised stablecoin is DAI, which is also USD-pegged and is the fourth most widely used stablecoin in DeFi. For example, the majority of DeFi lending is done using the DAI stablecoin. Two of the most widely used EUR-pegged stablecoins are of custodial nature (EURS and EURT), while a third one (sEUR) is issued by the DeFi application Synthetix. Although growing, the order of magnitude of the EUR-pegged stablecoin supply is negligible compared to that of USD-pegged ones¹⁰⁷. On 23 December 2021, the circulating supply of EURS stood at EUR 98.8 million¹⁰⁸, that of EURT at EUR 103 million¹⁰⁹ and that of sEUR at EUR 73.8 million¹¹⁰.

Chart 3.5: Share of (w)ETH, wBTC and DAI locked as collateral across the 9 largest DeFi applications



Source: DG FISMA calculations based on 21 December 2021 data from <https://defipulse.com>.
 Note: The total value locked across the 9 applications per crypto asset is 100%. (w)ETH refers to wrapped ether (ETH). wBTC refers to wrapped Bitcoin (BTC). DAI refers to the stablecoin DAI.

When it comes to collateral, stablecoins are used in the DeFi ecosystem on equal footing with other types of crypto assets. On 21 December 2021, about half of all collateral locked in DeFi smart contracts was linked to either the Ethereum’s native token Ether (37.7%) or Bitcoin (12.3%)¹¹¹. DAI stablecoin represented 5.7% of the total value locked. Chart 3.5 provides the percentage breakdown of collateral across these three types of crypto assets locked in the smart

¹⁰⁶ For the latest data, see <https://defipulse.com/usd>.
¹⁰⁷ E.g. USDT circulating supply approached USD 92 billion on 23 December 2021. See <https://wallet.tether.to/transparency>.
¹⁰⁸ <https://stasis.net/>
¹⁰⁹ <https://wallet.tether.to/transparency>
¹¹⁰ <https://defimarketcap.10/search.q=sEUR>
¹¹¹ See <https://defipulse.com>. Although Bitcoin cannot be directly used on all public blockchains with DeFi activity, notably Ethereum, wrapped Bitcoin (WBTC) is issued on these blockchains in return for off-chain bitcoin deposits entrusted with a custodian. Wrapped ether (WETH) is also used to facilitate trading against other tokens issued on Ethereum.

contracts of the 9 largest DeFi applications. It emerges that lending applications (Maker, Compound, Aave and InstaDapp) currently represent the widest use in DeFi, followed by decentralised exchanges (Curve, Uniswap, SushiSwap). For example, borrowing DAI from Maker to deposit it in InstaDapp seems to be quite a popular trade.

Payments

Obviously, any crypto asset can theoretically be used for payments. However, DeFi is putting in place globally decentralised instant payment networks, such as Flexa¹¹². Any user can spend a variety of crypto assets in stores and online, including conversion, at zero cost. Such flexibility is made possible through partnerships with leading crypto asset exchanges across the globe. Core to the Flexa network is collateral in the form of a crypto asset- the AMP token, which secures all payments in real-time until the underlying transactions are confirmed and settled on the blockchain. Anyone can provide AMP collateral and, in return, earn a reward in the form of a processing fee that Flexa charges to merchants. Other DeFi applications, such as Sablier¹¹³, enable real-time payments (‘money streaming’) that can be used in various ways¹¹⁴.

Trading and liquidity provision

Trading in DeFi is performed through decentralised crypto asset exchanges, which represents the second most common DeFi functionality. Unlike centralised crypto asset exchanges, the non-custodial nature of decentralised exchanges allows users to remain in control of their assets because no funds have to be deposited with the exchange to trade. Execution of both legs of the trade takes place simultaneously as part of one transaction (i.e. atomically), eliminating counterparty risk. In consequence, there is no need for central counterparty clearing houses or escrow services. Decentralised exchanges have seen substantial growth since 2020, but their share in the overall cryptocurrency transaction volume remained below 10% in December 2021. Although trading costs are higher on decentralised exchanges (partly due to the fact that all transactions are executed on the blockchain, which involves transaction costs), some traders seem to prefer them, possibly due to their quasi-anonymity and interoperability with other DeFi applications¹¹⁵.

In the absence of market makers, DeFi would only allow for trading between individuals with exact opposite interests. These were indeed among the early implementations of decentralised exchanges, referred to as peer-to-peer exchanges. First, the users have to query the network for potential counterparties for a specific pair of crypto assets and then negotiate the price bilaterally, analogous to request-for-quote systems in traditional finance. Once the parties agree on the price, the trade is executed on the blockchain via a smart contract. This excludes the possibility of front-running¹¹⁶, because the trade is only available to the parties who negotiated it. However, early implementations of peer-to-peer protocols did not allow for liquidity sharing with other decentralised exchanges, leading to rather low transaction volumes and high bid/ask

¹¹² <https://flexa.network/>

¹¹³ <https://sablier.finance/>

¹¹⁴ For example, real-time payments allow for continuous salary payments in small increments. Following a deposit, a smart contract starts ‘streaming’ the money to the recipients.

¹¹⁵ For underlying data supporting these statements, see Aramonte, S., Huang, W. and Schrimpf, A. (2021), DeFi risks and the decentralisation illusion, *BIS Quarterly Review*, December 2021.

¹¹⁶ Front-running is trading a financial asset by a broker who has inside knowledge of a future transaction that is about to affect its price substantially.

spreads. Arbitrage opportunities across such exchanges could also not be exploited due to high fees as well as cumbersome and slow transaction processes.

Decentralised order book exchanges is an extension of peer-to-peer exchanges where an order book is added and the exchange itself is open¹¹⁷. Further innovation in the DeFi space has tried to address the inherent liquidity weakness by moving towards more automated exchanges which allow for the use of shared liquidity pools and enable other DeFi applications to use these exchanges without restrictions. Reserve aggregation through a smart contract is one such implementation, whereby users and liquidity providers communicate their bid and ask prices to a smart contract, which accepts the best offer on behalf of a user and executes the trade. This implementation works fine as long as there are many large liquidity providers, which is why such exchanges tend to have in-built control mechanisms with respect to prices and the number of liquidity providers.

The most popular type of decentralised exchanges currently are automated market makers, such as Curve¹¹⁸, also known as a constant function market makers. It is a liquidity pool that holds at least two types of crypto assets in a smart contract and allows anyone to deposit one type in exchange for the other. Contrary to reserve aggregation, the prices are set automatically by the smart contract itself as a function of token availability in the liquidity pool¹¹⁹. The latter cannot be exhausted, as the relative price of the respective token would rise infinitely as its supply approaches zero. This effectively allows for a form of decentralised market making and enables arbitrage. The implicit bid/ask spread and the trading fees accrue to liquidity providers. The novelty of this implementation is that it entirely does away with order book matching, enhancing liquidity for thinly-traded assets. While slippage occurs, the price impact of large orders is generally lower compared to centralised exchanges while transaction fees are higher. Some DeFi applications are tackling the latter drawback as well as the relative low transaction throughput by introducing ‘layer 2 solutions’. In such case, each individual transaction is no longer processed on the blockchain, increasingly resembling approaches employed by centralised crypto asset exchanges, although some notable differences vis-à-vis centralised exchanges remain¹²⁰.

Lending

Crypto asset lending is the most widely used DeFi functionality today. However, unlike in traditional financial systems where credit risk is the key risk facing lenders and requires a thorough creditworthiness assessment of potential borrowers¹²¹, collateralised lending is

¹¹⁷ Order books can be kept both on-chain and off-chain. With on-chain order books, every order is stored in a smart contract, which makes the process costly and rather slow. To avoid this, many protocols use off-chain order books that are hosted and updated by centralised third parties known as relayers. The latter are never in control of user assets though, and they play a purely informational role by providing quotes for a fee. The open nature of protocols ensures that there is competition among relayers. After successfully querying a relayer, the bidder signs and submits a specific order to a smart contract on the exchange, triggering simultaneous (atomic) swap of the respective crypto assets.

¹¹⁸ <https://curve.fi/rootfaq>

¹¹⁹ For instance, the embedded rule can be expressed as $x \cdot y = k$ where k is a constant, hence the name constant function market maker. x and y are the reserves of the two tokens in the liquidity pool. For a more detailed explanation of how automated market makers work, see Aramonte, S., Huang, W. and Schrimpf, A. (2021), DeFi risks and the decentralisation illusion, *BIS Quarterly Review*, December 2021.

¹²⁰ For instance, users trade with smart contracts without any dependence on counterparty matching or restrictions on trading pairs. The exchange also remains non-custodial. For an example, see <https://kwenta.io/>.

¹²¹ In wholesale financial markets though, the main determinant of credit provision is the quantity and quality of collateral provided, thus reducing the need for individual creditworthiness assessment.

prevalent in the DeFi ecosystem, because borrowers are quasi-anonymous. DeFi lending applications are generally used by borrowers to access new crypto assets without having to sell the ones they post as collateral. It also gives them leverage, in the sense that they keep the market exposure to their collateral assets while obtaining an additional liquid asset to transact in.

One type of DeFi lending involves issuance of new crypto assets by a smart contract as part of each lending operation. For example, the application Maker allows anyone who deposits ETH or any other crypto asset issued on Ethereum as collateral to borrow USD-pegged DAI stablecoins that are issued in return¹²². Given the high volatility of the crypto assets used as collateral, however, Maker requires a minimum overcollateralisation ratio¹²³ of 150%, which effectively means that overcollateralisation is higher in practice to avoid the risk of collateral liquidation¹²⁴. In addition to the collateral value falling below the minimum overcollateralisation ratio, collateral is liquidated if the borrower fails to repay the DAI loan and interest. In case of collateral liquidation, the smart contract auctions the collateral to market makers at a discount in exchange for DAI that needs to be withdrawn from the market to defend the USD peg. Interest payments and liquidation fees are partly used to decrease the supply of the Maker governance token (MKR) and thereby support its price. Its holders assume the residual risk in case of insufficient collateral after liquidation. Should such a situation occur, MKR holders would be diluted through automatic issuance of additional MKR tokens.

Another type of DeFi lending takes the form of collateralised debt markets that involve individual liquidity providers (lenders) and borrowers. Such loans are also fully collateralised via smart contracts to mitigate counterparty risk. Matching is performed either on a peer-to-peer basis or through credit pools. As with decentralised exchanges, peer-to-peer matching is rather inefficient. However, it allows for a tailor-made agreement on the lending terms and a fixed interest rate. Credit pools, in turn, use variable interest rates that are adjusted automatically in line with the prevailing supply and demand conditions. When liquidity is abundant, the interest rates will be low and vice versa. Credit pools are more efficient, since they enable maturity and loan size transformation while ensuring high liquidity for lenders who start earning interest as soon as they deposit their tokens in the credit pool.

Some DeFi lending applications are also experimenting with uncollateralised lending, whereby collateral depositors can ‘delegate’ their credit lines to third parties. Interest rate, duration and covenants are agreed bilaterally¹²⁵. Finally, an ingenious DeFi solution for uncollateralised lending relies on particular technological possibilities offered by blockchains. As part of ‘flash loans’, credit is provided on the condition that the loan is received, used and repaid as part of the same set of blockchain transactions (block). In case the borrower cannot return the borrowed funds (including interest), the entire set of transactions is invalid and is not executed. Flash loans are generally used for loan refinancing, collateral swaps and arbitrage. It appears

¹²² In November 2021, DAI accounted for 60% of all DeFi lending, whereas USDC accounted for 30%.

¹²³ Also known as the liquidation ratio.

¹²⁴ In December 2021, the overcollateralisation ratio of DAI was slightly above 200%.

¹²⁵ For example, the DeFi lending application Aave has rolled out such credit delegation between crypto asset funds as collateral depositors and exchanges as borrowers. The stated mid-term goal of Aave is to enable liquidity sourcing into traditional finance, diversifying liquidity sources for money lenders.

that flash loans are also often used in various types of attacks on DeFi applications, including market manipulation¹²⁶.

Synthetic tokens and derivatives

Synthetic DeFi tokens derive their value from an underlying asset just like traditional financial derivatives, such as futures and options. However, some of these synthetic tokens simply track the value of an underlying asset in the same way as traditional exchange-traded products, such as exchange-traded notes. Synthetic DeFi tokens can broadly be divided into asset-based and event-based tokens, both of which require inputs of price information for the underlying asset that cannot be directly observed on the blockchain. Such inputs are provided by ‘price oracles’, which serve as the sources of off-chain information and are susceptible to manipulation. This is why DeFi applications often use oracle networks instead of single oracles.

Asset-based synthetic tokens are effectively an extension of DeFi lending applications, such as Maker described above. As an example, the DeFi application Synthetix was originally conceived for the issuance of USD-pegged stablecoins (sUSD), with other types of derivative tokens added only later. Thus, a user posting collateral in the application’s token SNX would be issued USD debt in return, which can be traded for various Synthetix tokens that track the value of other underlying assets, including other currencies, such as EUR. The peg of Synthetix tokens is largely maintained through arbitrage. Trading fees are distributed to collateral providers, along with rewards in SNX tokens that can be used for further staking¹²⁷. In return, collateral providers assume risk, since their individual debt position is affected by the price fluctuations of all Synthetix tokens in the network¹²⁸. Some DeFi applications even enable investment in tokens that track the value of real-world financial assets, such as stocks and investment funds¹²⁹. There are also DeFi tokens that mimic investment funds and hold a basket of underlying crypto assets, which are locked up in a smart contract and observable in real time. One possibility is to embed into the smart contract a simple passive strategy, such as semi-automatic rebalancing triggered by specific threshold values and time locks. Another possibility is to select an active fund manager¹³⁰.

Event-based synthetic tokens derive their value from any observable event and involve a defined set of potential outcomes over a fixed observation period as well as a defined source of information on the actual outcome. In return for collateral, users can only obtain a full set of tokens, with each token representing one potential outcome of this event. These tokens can then be traded to construct the desired exposure profile. Once a specific outcome materialises, the collateral held in the smart contract is paid out to the holders of tokens that represent this specific outcome. Event-based tokens can also be seen as prediction markets, since the price of each token should theoretically represent the probability of that specific outcome.

¹²⁶ <https://cryptobriefing.com/50-million-lost-the-top-19-defi-cryptocurrency-hacks-2020/>

¹²⁷ <https://staking.synthetix.io/>

¹²⁸ Currently, the Synthetix debt pool is collateralised with its token SNX at a 750% ratio. For further details, see <https://synthetix.io/>

¹²⁹ In addition to the external dependency on price oracles, it appears that there is a substantial tracking error. For an example, see <https://mirrorprotocol.app/#/trade>

¹³⁰ For example, see <https://betoken.fund/>

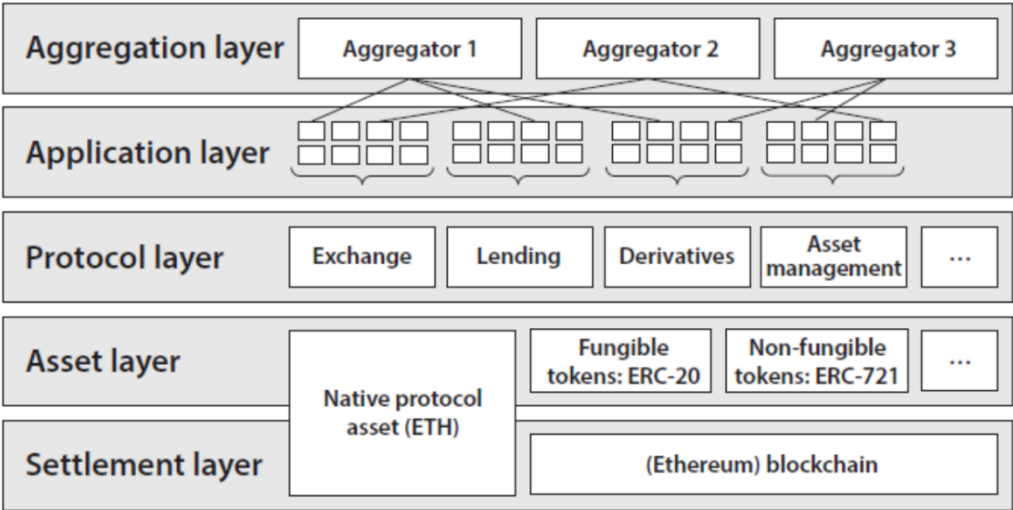
Insurance

The primary focus of insurance in the DeFi ecosystem is risks specific to the decentralised blockchain environment. These include smart contract failures, DeFi application hacks and governance risks. As usual, collateral is provided in return for tokens that entitle holders to a share of the collected insurance premiums. In case of an insurance event, this collateral is used to reimburse the insured users after claims are validated by dedicated assessors of claims. Any surplus usually accrues to collateral providers and governance token holders.

3.4 How DeFi works

DeFi applications are deployed on an open IT infrastructure that is accessible to everyone via the internet. Anyone can also add functionalities by deploying new smart contracts, i.e. software programs stored on a blockchain that run when predetermined conditions are met. DeFi uses a multi-layered IT architecture where every layer has a distinct purpose, commonly referred to as the DeFi stack (see Chart 3.6). It includes a common settlement layer, an asset layer, a protocol layer, an application layer and an aggregation layer. The asset, protocol and application layers together form a specific DeFi functionality as described in the previous section.

Chart 3.6: The DeFi stack



Source: Schaer, F. (2021), Decentralised Finance: On Blockchain- and Smart Contract-Based Financial Markets, Federal Reserve Bank of St. Louis Review, Second Quarter 2021.

Decentralised common settlement layer

The decentralised common settlement layer is a public blockchain that provides for secure storage of ownership information and is a fundamental building block of the system. Any user can freely access decentralised applications (dApps) deployed on the blockchain, and transactions take place every day 24/7. This layer is robust in terms of security, since it can continue to function even if some network nodes are compromised, which is not the case with centralised systems. Another advantage is that the network activity is transparent, given that anyone can verify the validity of transactions and the ruleset of any smart contract that is deployed on the blockchain, including the amount of collateral locked up. A further distinguishing characteristic of DeFi is its non-custodial nature. Unlike in centralised environments, users retain full control by safekeeping their own ‘private key’ that is required to

initiate any transaction involving their assets¹³¹. Importantly, usage of a common settlement layer allows for full interoperability of various DeFi applications that are deployed on the same blockchain.

Most of the DeFi applications today are built on top of the Ethereum blockchain that was the first to introduce the technical possibility of deploying smart contracts. Although other blockchains exist today that provide this functionality, Ethereum enjoys first mover advantages in terms of the number of developers that contribute to its further development¹³². In contrast to the traditional financial system where settlement may take days (for instance, for trading in shares), settlement on the blockchain can be done within seconds¹³³. However, a caveat is that in case of heavy settlement activity, the settlement capacity might become overloaded. As a result, transaction fees can increase substantially and/or the settlement speed can slow down considerably with no real option for users to switch to a different blockchain ecosystem for their existing transactions.

Asset layer

The next layer is composed of tokens issued on the settlement layer, which include the native token embedded in the Blockchain itself for it to function (referred to as the native protocol asset in Chart 3.6) and numerous tokens issued by means of smart contracts deployed on this blockchain. For example, anyone can issue fungible or non-fungible tokens on the Ethereum blockchain using smart contracts. Fungible tokens are identical tokens that are freely interchangeable and are mostly issued via an ERC-20 type smart contract. It is the dominant smart contract type for DeFi applications¹³⁴ and effectively enables tokenisation of any non-Ethereum asset on the Ethereum blockchain, including financial instruments such as shares, real-world assets or tokens from other blockchains such as Bitcoin¹³⁵. As explained in Section 3.3, the smart contract is supposed to ensure that the tokenised asset issued on Ethereum tracks the value of the underlying asset, be it a share or something else. This is usually underpinned by the use of collateral, which aims to eliminate counterparty risk. Beside fungible tokens, there is also the possibility to issue ‘non-fungible’ tokens (NFTs)¹³⁶.

¹³¹ By contrast, users of centralised crypto exchanges are not in control of their assets until they withdraw them from the exchange.

¹³² On 31 October 2020, the Ethereum ecosystem had an average of 2 325 active monthly developers, with about a quarter of all new developers in the crypto asset space choosing to join this ecosystem. See <https://medium.com/electric-capital/electric-capital-developer-report-2021-f37874efea6d>.

¹³³ Currently, Ethereum can ensure a throughput of some 10-20 transactions per second.

¹³⁴ Other smart contract standards also exist, but ERC-20 is the most commonly used, including for the issuance of governance tokens. In November 2021, there were some 469 000 different ERC-20 token contracts on Ethereum, see <https://etherscan.io/tokens> for details.

¹³⁵ For example, Wrapped Bitcoin (WBTC) is an ERC-20 token on Ethereum backed 1:1 with Bitcoin. For more details, see <https://wbtc.network/>.

¹³⁶ NFTs are commonly used for digital collectibles and similar use cases that require unique characteristics for each token. These can either be a digital representation of a real-world object such as a piece of art or a digital collectible in itself. NFTs are typically issued via an ERC-721 type smart contract. In November 2021, there were some 23 300 ERC-721 token contracts on Ethereum (see <https://etherscan.io/tokens-nft> for details). NFTs are not discussed in this chapter, since they do not bear any financial characteristics.

Protocol layer

The protocol¹³⁷ layer contains technical implementations of the various DeFi functionalities such as lending or exchanges¹³⁸ in the form of smart contracts. Smart contracts are lines of code deployed on a blockchain that are immutable¹³⁹ and devoid of any discretion, which simply execute the code in accordance with predetermined and publicly observable rules once the triggering conditions are fulfilled. This open source code means that new functionalities can be created based on existing ones, stimulating innovation and enabling incremental improvements¹⁴⁰. Besides, the individual protocols are interoperable with each other because they are built on top of the same settlement layer, enabling various combinations at the aggregation layer¹⁴¹.

Application and aggregation layers

The application layer provides for a user-friendly web-based interface in order to use a specific DeFi application (protocol). Single user interfaces at aggregation layer enable the combined use of several applications at once. For example, the aggregation layer can serve as a comparison tool of similar DeFi applications to optimise returns or enable more advanced combinations of different kinds of DeFi functionalities to achieve specific investment objectives, such as arbitrage. The considerable advantage of aggregation is that it allows for liquidity pooling across various DeFi applications.

Taking together the application and aggregation layers can be seen as DeFi front-end solutions, whereas the settlement, asset and protocol layers are a sort of DeFi back-end solutions.

3.5 Policy considerations

Against the background of current DeFi functionalities and the way it works, this section discusses the opportunities and risks of DeFi before concluding with an overview of regulatory challenges in a decentralised environment.

Opportunities of DeFi

Compared to the traditional financial system, DeFi claims to increase the security, efficiency, transparency, accessibility, openness and interoperability of financial services. While security is an inherent feature of the settlement layer (see Section 3.4), the security of smart contracts deployed on it depends on their coding quality. Whereas the settlement layer itself has never been compromised, smart contract hacks occur regularly, as explained in the next section on risks. Efficiency largely stems from the use of smart contracts and collateral that can reduce counterparty risk. It also stems from the non-custodial nature of DeFi that makes traditional

¹³⁷ ‘Protocol’ is a computing term that means a common way for unrelated objects to communicate with each other in object-oriented programming. DeFi applications are commonly referred to as protocols.

¹³⁸ See Section 3.3.

¹³⁹ However, modifications to the smart contract ruleset or even their shutdown may be possible, either by means of ‘administrator keys’ held by specific individuals or in case of a favourable vote by governance token holders.

¹⁴⁰ For example, an early implementation of constant function market makers (see Section 3.3) was proposed by a group of people in 2017, a different person simplified the model and yet another group provided a formal proof of concept in 2018. In 2019, the model was adapted for general use with more than two tokens and optimised for stablecoin swaps by two further groups of people.

¹⁴¹ For this reason, DeFi is often referred to as the ‘money Lego system’ where each separate protocol can be seen as one Lego brick.

services such as custody and central clearing redundant. In any case, even though the processing of transactions on a public blockchain is relatively slow, DeFi still offers quicker settlement than traditional securities¹⁴².

Public blockchains offer data transparency by design, which may lay the basis for further innovation. The transparency inherent in DeFi could offer substantial benefits. The fact that all transactions are public means that everyone can have free access to the entire time series of historical and real-time trading data, including researchers and supervisors. It could provide regulators an opportunity to better understand the risks that often remain obscure in the traditional financial system. Transparency could also imply lower audit costs, since auditing of smart contracts involves less effort than the real-life audit of intermediary firms. As already mentioned, DeFi is much more accessible than the traditional financial system, since it operates around the clock and allows both users and developers of additional functionalities uncontrolled access. The non-custodial nature of DeFi also plays a role here, since users do not need to open accounts with any intermediary to start using the available DeFi functionalities – all they need to do is install free software¹⁴³. The open source code promotes innovation by attracting a substantial developer community, which actively contributes to incremental improvements over time. Given the open nature of most DeFi applications as regards copyright protection, anyone can simply copy existing code and improve it further by adding additional features. Interoperability comes from the fact that DeFi applications share the same common settlement layer (see Section 3.4), allowing for unlimited combinations among the various DeFi applications.

Overall, as a result of its accessibility, openness and interoperability, DeFi could provide substantial opportunities for financial integration across borders. In the traditional financial system, intermediaries have historically strived to develop comprehensive financial service offerings under the same brand name, resulting in closed architecture solutions that compete with other financial service providers on similar terms. This has had a constraining effect on competition, since it is very challenging for new entrants to put together a comprehensive service package upon entry. Cross-border service provision has also been challenging due to both strong domestic service providers in banking and insurance, as well as the need for clients to open accounts with intermediaries that are based abroad. In contrast, DeFi applications are limited in scope and rely on interoperability with other applications to add functionalities, with the main objective being to grow in scale at the application level. Given its non-custodial nature, it is also easier to scale DeFi applications across borders than traditional finance. Should DeFi ever go mainstream, it could also positively contribute to financial stability, because of its broader risk-sharing characteristics that go together with decentralised governance and liquidity provision. Geographical diversification would constitute an additional risk-sharing element in case DeFi indeed contributes to financial integration. More generally, the coexistence of traditional finance and decentralised finance as differently organised financial ecosystems could promote broader financial system diversity that may be good from a risk perspective at system-wide level.

¹⁴² For example, whereas any token trade on Ethereum is settled within some 13 seconds, traditional securities settlement still takes 2 days despite all the high frequency trading.

¹⁴³ This statement is true to the extent that users are in possession of some crypto assets. In the contrary case, they would also need to convert their fiat money into crypto assets, which involves intermediaries.

As regards broader economic welfare considerations, an open question is whether the DeFi ecosystem could substitute or complement (parts of) the traditional financial system. Although DeFi seems to replicate many of the functionalities of the traditional financial system, its contribution to the financing of real economic activity is so far minimal, if not fully absent. Thus, there is currently a question mark over its usefulness for the real economy, investments and job creation, also in light of the widespread need for collateral. However, the DeFi ecosystem is at a very early stage in its development, and there is no reason to assume at this point that such a link to the real economy may not develop in the future. In any case, DeFi is already proving to be useful in the virtual economy, e.g. in the context of the ‘metaverse’¹⁴⁴. Plots of virtual land or other real estate¹⁴⁵ and clothing for avatars¹⁴⁶ are traded as NFTs, with established real world companies such as Louis Vuitton, Gucci, Burberry and Nike both investing in such virtual real estate and selling their virtual goods in exchange for crypto assets.

Risks inherent in DeFi

The DeFi ecosystem is also subject to many risks. In 2020, nearly USD 100 million were lost due to bugs and hacks¹⁴⁷. Given the absence of regulation, DeFi is acutely prone to conduct risks such as scams and fraud. The quasi-anonymous transactions may also pose a risk that DeFi is used for tax fraud and money laundering or other illegal activity. ‘Pump-and-dump’ schemes whereby someone would issue tokens, list them on a (decentralised) exchange and then use social media to advertise them to drive up the price and dump the tokens to cash in may occur. Likewise, there have been cases of ‘rug pulls’ where crypto developers abandon a project and run away with investors’ funds, possibly using a deliberately introduced flaw in the code. The inherent transparency of DeFi applications makes it easy for malicious users to inspect the code on the web and exploit unaddressed bugs to steal user funds¹⁴⁸. In case of interconnected DeFi applications, exploiters can also cause them to behave in ways not intended by developers of the individual DeFi applications¹⁴⁹. Furthermore, the existence of ‘admin keys’ may pose a vulnerability in case those with access have malicious intentions¹⁵⁰.

Operational risks are also highly relevant in view of the prominent role played by software. The security of smart contracts can be an issue, in general, largely stemming from flawed coding. Smart contracts are code like any other, which is vulnerable to coding errors (bugs) and hacks. The vast majority of DeFi hacks relate to smart contract vulnerabilities that have an impact on token issuance and the functioning of DeFi applications. The growing combination of applications at aggregation layer also increases the risk of bugs. The irreversibility of blockchain transactions exacerbates the situation, although often teams behind DeFi

¹⁴⁴ Metaverse is a network of virtual worlds focused on social connection. A virtual world is a computer-simulated environment populated by users who explore it, participate in its activities and communicate with each other. In each virtual world, elements including virtual reality, streaming video, mobile gaming, avatars and artificial intelligence are combined into immersive digital experiences.

¹⁴⁵ <https://www.nytimes.com/2021/11/30/business/metaverse-real-estate.html>

¹⁴⁶ <https://www.reuters.com/markets/deals/nike-buys-virtual-sneaker-maker-rtkft-metaverse-push-2021-12-13/>

¹⁴⁷ <https://cryptobriefing.com/50-million-lost-the-top-19-defi-cryptocurrency-hacks-2020/>

¹⁴⁸ This also implies that long-standing DeFi applications enjoy lower risk-premiums, since they are considered ‘safer’ by the market.

¹⁴⁹ Flash loans can also be prone to abuse: four DeFi hacks in 2020 used leverage from flash loans in order to manipulate prices.

¹⁵⁰ Multisignature requirements and timelocks for any administration task attempts to hedge the risk of such admin key abuse.

applications reimburse users out of token reserves or insurance funds¹⁵¹ to safeguard interest in their project. There is also a trade-off between user experience and security at application layer. Some DeFi apps would ask for permissions to transfer an infinite number of tokens on a user's behalf to make the process more convenient. However, any such permission would obviously put the user's funds at risk. This touches upon the non-custodial nature of DeFi, which puts the full responsibility of asset safekeeping on the users themselves. Although wallet services help users in managing their private keys, these wallets are themselves protected by seed phrases¹⁵² that can be lost or forgotten.

At system level, performance of the common settlement layer in severe market conditions has not been sufficiently tested. On past occasions, especially during a crypto asset market panic, the network could not cope with the amount of transactions, leading to stalled transactions and high transaction fees. This raises questions about the true scalability of the network. Another issue is that the actual level of transparency may be significantly lower than expected, notably in cases of complex and opaque interconnections among DeFi applications. Schaer and Nadel (2020)¹⁵³ refer to it as wrapping complexity and find that staking rewards¹⁵⁴ have been a catalyst for the immense growth of the DeFi ecosystem. They believe that such growth is not sustainable, because the token reserves of DeFi applications will either run out or they would be negatively influenced by inflationary effects in case of uncontrolled token growth.

Continued rapid growth of the overall DeFi ecosystem could also have future financial stability implications. In that case, risks until now specific to the DeFi ecosystem could become relevant for the traditional financial system and the real economy. Given that all crypto assets are ultimately owned by someone, adverse price developments in the DeFi ecosystem could negatively affect the real economy, adversely impacting on spending and investment. Conversely, replication of features from the traditional financial system in DeFi could imply that the former's vulnerabilities are also replicated. Thus, DeFi could turn out to be more susceptible to runs than the traditional financial system where capital and liquidity buffers and public support serve a stabilising function¹⁵⁵. In addition, growth in DeFi activity could pose an additional challenge to enforce the EU's anti-money laundering and countering the financing of terrorism (AML/CFT) rules¹⁵⁶ and the EU sanction regime on crypto assets targeting Russia.

Given their peg to the price of other assets or currencies, stablecoins might be most exposed to run-like behaviour. As highlighted in Section 3.3, the vast majority of stablecoins used in the DeFi ecosystem are of a custodial type, i.e. they involve collateral held in off-chain custody. The existence of such collateral is not publicly observable and requires regular audits. Any

¹⁵¹ These are insurance funds internal to the DeFi protocol, which also serve as a kind of reserve pool intended for unforeseen events. Such funds are gradually filled by diverting a percentage of the protocol's income streams.

¹⁵² When wallets are generated, a seed phrase is recorded by the user, so that it can be used to access the wallet and the associated keys when it gets compromised. A seed phrase is usually a 12 to 24-word phrase that is an unencrypted form of the private key in dictionary word format, as it is simpler to remember than an encrypted cryptographic key in alphanumerical string format.

¹⁵³ See Nadler, M. and Schär, F. (2020). *Decentralized finance, centralized ownership? An iterative mapping process to measure protocol token distribution*.

¹⁵⁴ Users that deposit a specific type of token to a smart contract of a DeFi application are generally rewarded with that application's tokens, which can be used further.

¹⁵⁵ This was, for instance, the case during the 2008 financial crisis where public money was used to stabilise the system after investors withdrew their money from short-term money market instruments such as money market funds.

¹⁵⁶ For further details, see https://ec.europa.eu/info/publications/210720-anti-money-laundering-countering-financing-terrorism_en, and <https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32022R0394&from=EN>.

doubts about the adequacy of such collateral could lead to a run. In terms of liquidity risk, the collateral held might be less liquid than desired in case one needs to sell quickly. In terms of solvency risk, collateral fire sales would also drive down its price, compromising the solvency of custodial stablecoin issuers that guarantee redemption at par. In case of run-like events with respect to significant stablecoins, there could also be contagion effects to other stablecoins and the wider DeFi ecosystem. However, the impact of any run on collateralised stablecoins, such as DAI, would be less severe due to their substantial overcollateralisation and the in-built loss absorption mechanism by governance token holders.

The heavy use of collateral in DeFi poses risks of its own. For example, tokens are pledged as collateral in a DeFi application to obtain another type of token, which is then pledged as collateral or staked in yet another DeFi application and so on. Such collateral chains transform credit risk into market risk: a sudden shock to the collateral price may trigger liquidation of the underlying positions, further amplifying market risk. Another vulnerability related to the heavy reliance of custodial stablecoins on collateral is that it might potentially lead to collateral scarcity in the traditional financial system¹⁵⁷. This can become a problem for financial intermediation as the traditional financial system increasingly relies on collateral itself.

Regulatory challenges in a decentralised environment

The opportunities and risks highlighted above are currently bound by the limited size of the DeFi ecosystem. As such, the aim is rather to provide an overview of issues that would become more relevant as the ecosystem continues to grow and that would need to be closely monitored, so that regulators are well-informed and prepared to consider any intervention, if this would prove necessary at a later stage. In this context, one should also reflect on what type of regulatory action would be warranted and most effective in a decentralised environment. Such assessments and discussions are also already taking place across the international regulatory community¹⁵⁸. According to the World Economic Forum (WEF), effective regulatory response is likely to include enforcement of existing financial services regulation where appropriate. However, it is obvious that simply copying traditional regulatory approaches in a decentralised environment may not be an option, since they have traditionally focused on intermediaries that play a central role in the financial system. Adapting the regulatory framework to a decentralised environment may be challenging and would require a rethink of how we approach regulation. Possibly, even more emphasis would need to be put on activity-based regulation as opposed to entity-based one.

The bridging link between traditional finance and the crypto asset ecosystem is obviously the easiest access point for regulation. The most common way to obtain a crypto asset is still by buying it in exchange for fiat currency. Paying for most products and services is also still not possible in crypto assets, requiring regular conversion into fiat currency. However, policing this link alone would not be sufficient to ensure consumer protection and market integrity for users in the DeFi ecosystem. More generally, while regulating access to DeFi applications deployed by regulated financial entities could be feasible, it would be much more challenging to restrict access to a DeFi application that has been transformed into a decentralised autonomous

¹⁵⁷ See e.g. Adachi, M., Cominetta, M., Kaufmann, C. and van der Kraaij, A. (2020), A regulatory and financial stability perspective on global stablecoins, *ECB Macroeprudential Bulletin* 10.

¹⁵⁸ See e.g. the white paper [DeFi Policy-Maker Toolkit](#) published by the World Economic Forum in June 2021.

organisation (DAO). This is exclusively governed by its user community and could be deployed by uncooperative non-regulated actors in third-country jurisdictions. However, past experience with tracking hacked funds and ransoms has demonstrated that the inherent transparency of public blockchains can be used successfully to track down individuals. In this respect, regulatory cooperation with the main jurisdictions relevant to the DeFi ecosystem might prove indispensable.

Furthermore, given the fact that smart contracts are essentially substitutes for regulated intermediaries, it may seem appropriate for regulation to focus on the features of such contracts. However, smart contracts are merely software produced by humans. Thus, one possible approach could be for regulation to target the project team behind the specific DeFi application. Most of the time, these people are not anonymous and even though they may outsource certain tasks to unrelated developers, DeFi projects often have a known founding team behind them¹⁵⁹. Individuals often deploy DeFi applications and actively market them to get users on board. As part of that marketing effort, they reveal their identities and sometimes even personally reimburse users in case of hacks.

To benefit from the inherent data transparency on public blockchains, embedded supervision would seem to be another sensible regulatory approach. Distributed ledger technologies (DLT) have the potential to enable supervisors to monitor transactions in real time and allow them to extract transaction reports directly. Embedded supervision would imply a technological solution that would enable supervisors to automatically monitor compliance with the regulatory framework by reading blockchain transaction data, thus reducing the need for market participants to actively collect, verify and deliver data to supervisory authorities. It would also reduce the administrative burden for firms, while facilitating supervisors' access to transaction data. The DLT pilot regime for market infrastructures¹⁶⁰ will offer an opportunity to assess the benefits of using DLT for reporting purposes and test the technology under controlled conditions. As set out in the Commission's strategy on supervisory data in EU financial services¹⁶¹, the Commission will request ESMA to investigate and prepare a report on new data collection approaches under the DLT pilot regime for market infrastructures. The Commission announced that it would also launch a pilot project¹⁶² on the technical foundations of DeFi supervision embedded in blockchain in 2022. One thing is already clear now, however – supervisors will have to invest considerable amounts of resources in improving their data processing capabilities going forward if they are to stay on top of digital innovation in the financial sector.

To conclude, DeFi presents a new stage in the development of crypto asset ecosystems, although it is still relatively limited in scale. Regulators have to remain vigilant and closely monitor the development of this ecosystem and consider appropriate action, if necessary. A prerequisite in this respect is to enhance the availability and quality of data that enables close

¹⁵⁹ This is because, except for Bitcoin, very few seem to be willing to invest in an anonymous project with no questions asked.

¹⁶⁰ Proposal for a Regulation of the European Parliament and of the Council on a pilot regime for market infrastructures based on distributed ledger technology, COM(2020) 594 final of 24 September 2020.

¹⁶¹ Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions, Strategy on supervisory data in EU financial services, COM/2021/798 final of 15 December 2021.

¹⁶² See Communication from The Commission to the European Parliament, the Council, the European Economic and Social Committee and The Committee of the Regions, Strategy on supervisory data in EU financial services, COM/2021/798 final of 15 December 2021.

monitoring of the DeFi ecosystem. The Commission's 2022 pilot project on embedded supervision is a step in this direction.

REFERENCES

- Asdrubali, P., Sorensen, B., and Yosha, O. (1996), Channels of interstate risk sharing: United States 1963-1990, *Quarterly Journal of Economics* 111: 1081-1110.
- Frost, J. and van Stralen, R. (2018), Macroprudential policy and income inequality, *Journal of International Money and Finance* 85: 278–290.
- Kapan, T. and Minoiu, C. (2018), Balance sheet strength and bank lending: Evidence from the global financial crisis, *Journal of Banking and Finance* 92: 35–50.
- Kim, C. (2014), Macroprudential policies in Korea - Key measures and experiences, *Financial Stability Review* 18: 121-130.
- Kuttner, K.N. and Shim, I. (2016), Can non-interest rate policies stabilise housing markets? Evidence from a panel of 57 economies, *Journal of Financial Stability* 26: 31–44.
- Morgan, P.J., Regis, P.J. and Salike, N. (2019), LTV policy as a macroprudential tool and its effects on residential mortgage loans, *Journal of Financial Intermediation* 37: 89-103.
- Sorensen, B. and O. Yosha (1998), International risk sharing and European monetary unification, *Journal of International Economics* 45: 211–238.
- Thamae, R.I. and Odhiambo, N.M. (2021), The impact of bank regulation on bank lending: a review of international literature, *Journal of Banking Regulation* 22, <https://doi.org/10.1057/s41261-021-00179-9>.

