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A novel high-frequency indicator of financial integration for monitoring the impact of COVID-19

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Contents

Abstract

In early 2020, the rapid spread of the coronavirus (COVID-19) quickly developed into a pandemic. This was followed by a sharp global economic downturn that was extraordinary in its speed, reach and scale. Within days of the first reported COVID-19 cases, the ECB daily Composite Indicator of Systemic Stress soared, and stress in several financial market segments began to flare up. These rapidly emerging financial strains could not be captured by a composite indicator of financial integration at the time because such indicators were low-frequency – principally monthly or even quarterly. The first aim of this paper is to present the steps taken in constructing a novel high-frequency price-based indicator of financial integration (HF-PIFI). Throughout the COVID-19 crisis, this novel indicator was responsive to public health data releases, incoming economic and financial data, and policy announcements. In this sense, it acted as a "thermometer". The second aim of the paper is to use the novel indicator to identify events that were either supportive or damaging with respect to financial integration. This helps to distinguish between the main phases of the pandemic. The third aim of the paper is to review how the novel HF-PIFI indicator performed against the low-frequency indicators of financial integration. Looking back, the signals from the HF-PIFI index were quite accurate: the benefits of daily signals based on market data outweigh those of relying on a more limited set of low-frequency data.

JEL classification: C82, C83, E58, G10.

Keywords: COVID-19, pandemic, systemic risks, financial integration, new statistical indicators, event studies.

Non-technical summary

The COVID-19 pandemic caused an unprecedented type of economic shock, bringing a global downturn that was extraordinary in its speed, reach and scale. Supply was immediately constrained by lockdown measures that resulted in restricted mobility and business closures. The halting of retail activities and disruptions in supply chains were accompanied by a plunge in the demand for intermediate and final goods. Within days of the first reported cases, various indicators of financial stress began to soar.

The ECB has been monitoring the state of financial integration in the euro area since the launch of the euro. However, until 2020, indicators of financial integration were calculated and analysed monthly or even quarterly. Such indicators were not fully capable of monitoring the rapid financial impact of the pandemic and the related policy responses on financial integration. New high-frequency measures of financial disintegration therefore had to be developed. This paper presents the methodological and statistical aspects of constructing a novel high-frequency price-based indicator of financial integration (HF-PIFI).

The methodology for creating such indicators is firmly rooted in the work carried out at the ECB over the years and in other relevant literature. Starting from the well-established low-frequency composite indicators of financial integration, the HF-PIFI was constructed and used to track the unfolding pandemic at a daily frequency.

During the pandemic, the new indicator was highly responsive to new events such as public health data releases, incoming economic data and policy decisions. It proved to be an excellent “thermometer”, flagging events seen as either supportive or damaging with respect to financial integration. The new indicator was able to track in real time some of the steepest declines in financial integration since the launch of these indicators and then to record the fast rebound of financial integration thanks to rapid policy responses and the resilience created by the financial backstops and reforms implemented over the last ten years.

The HF-PIFI’s aggregate dynamics are found to be the result of different patterns displayed by its sub-components, as is the case with the corresponding low-frequency indicators.

Finally, the paper reviews the novel HF-PIFI performed compared with the low-frequency indicators. Looking back, the insights from the novel indicators were timely and accurate, indicating that the benefits of a readily available signal based on recent market data outweigh those of drawing on a more limited set of low-frequency data.

1 Introduction

In early January 2020, the coronavirus (COVID-19) started spreading around the world. By March 2020, the World Health Organisation (WHO) had officially declared a pandemic. COVID-19 brought an unprecedented type of shock, with a sharp global economic downturn that was extraordinary in its speed, reach and scale (see the June 2020 Eurosystem staff macroeconomic projections for the euro area, as well as Altavilla et al., 2020, Schnabel, I., 2021, IMF, 2020a and IMF, 2020b). Supply was immediately constrained by lockdown measures, which brought restricted mobility and business closures. The halting of retail activities and disruptions in supply chains were then accompanied by a plunge in the demand for intermediate and final goods.[1] This period is sometimes referred to as "the great lockdown".

Financial tensions ensued. As COVID-19 cases soared in early 2020[2], the ECB daily Composite Indicator of Systemic Stress (CISS) began surging towards levels last seen during the global financial crisis of 2008-2009 and the euro area sovereign debt crisis of 2011-12 (see Chart 1).

The CISS showed that the COVID-19 crisis was putting financial markets under extraordinary strain (see Borgioli et al., 2020). Stress in several financial market segments began to flare up. Sovereign spreads widened and money market indicators started tightening, while equity markets strongly declined and began to show higher volatility. Concerns about renewed financial fragmentation among euro area countries, last witnessed during the euro area sovereign debt crisis, began to re-emerge (Buti, 2020 and de Guindos, 2020). The ECB has been monitoring the state of financial integration in the euro area since the launch of the single currency, not least because fragmented financial markets impede the smooth and uniform transmission of its monetary policy across member countries.[3]

1 While the cause of these shocks is common to all countries, the size of the economic fallout has differed markedly across countries owing to differences in, among other things, initial macroeconomic and financial conditions, the stringency of public health measures and the strength of domestic fiscal responses.

2 See the European Centre for Disease Prevention and Control's COVID-19 response timeline.

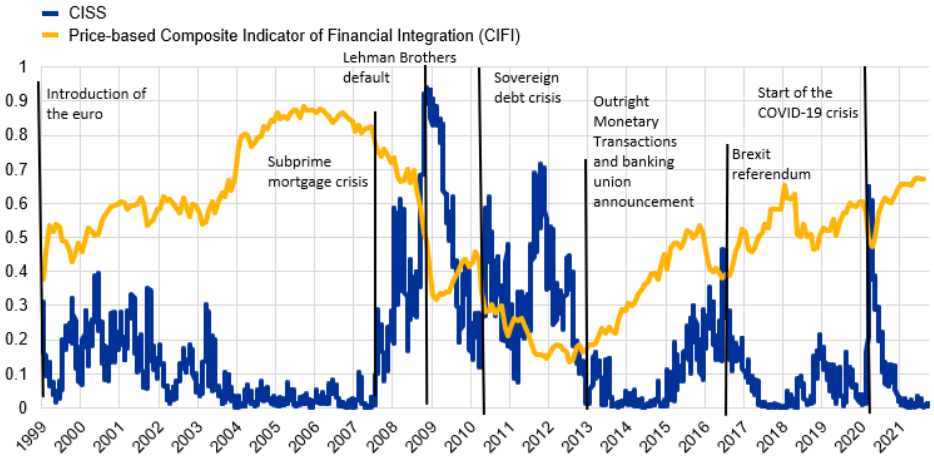
3 For the ECB, the market for a given set of financial instruments and/or services is fully integrated if all potential market participants (i) face a single set of rules when they decide to make transactions, (ii) have equal access to the above-mentioned set of financial instruments and/or services, and (iii) are treated equally when they are active in the market (see Baele et al., 2004).

Chart 1

Financial integration and systemic risk in the euro area

Historical price-based financial integration and systemic risk from January 1995 to August 2021

(January 1995 to August 2021, monthly data)



Sources: ECB and ECB calculations.
Notes: The price-based CIFI in this chart was developed by Hoffmann et al. (2019). For details on the general methodology behind the CISS, see Holló et al. (2012).

At the onset of the COVID-19 pandemic, the low frequency of the financial integration indicators (monthly or even quarterly) posed a challenge for policy analysis. The question then was whether rising financial tensions could be more effectively captured by a high-frequency composite indicator. This proved to be the case, and this paper explains the steps taken and limitations faced in building a novel **high-frequency price-based indicator of financial integration (HF-PIFI)**.[4]

Over the years the ECB has developed two complementary low-frequency **composite indicators of financial integration** (CIFIs; see Hoffmann et al., 2019). The first is a quantity-based CIFI that is updated on a quarterly basis. The second is a price-based CIFI that is calculated at a monthly frequency based on cross-border price differentials in the most important financial markets (money markets, equity, bonds and banking). Both CIFIs are released jointly to the public on a semi-annual basis in the statistical annex of all **ECB financial integration reports** and, more recently, in the **ECB's new biennial report on financial integration and structure in the euro area**. The appeal of both CIFIs is that they are grounded in extensive research.[5]

Within weeks of the first reported COVID-19 cases, the monthly price-based CIFI fell precipitously (see Chart 1). The drop in March 2020 was the fourth-largest month-on-month drop in the level of this indicator since the launch of the euro. The drop in the price-based CIFI between February and April 2020 was comparable to the declines seen at the start of the global financial crisis and the euro area sovereign debt crisis. These signals provided an alarming backdrop to the sharp rises in many other high-

4 On the relevance of real-time data for evidence-based central bank policymaking, see Donnery (2021).

5 See Hoffmann et al. (2019).

frequency financial market indicators (such as sovereign spreads and money market rates).

Particularly alarming was the reappearance of a positive correlation between systemic stress and financial fragmentation in euro area financial markets – a characteristic of previous crises. This was most likely driven by (i) expected large fiscal burdens, (ii) the return of diverse financial premia, and (iii) a concern that differences among countries in their response to the crisis response could distort the competitive environment.[6] The scale of the challenge called for rapid and decisive policy responses by both monetary and fiscal authorities.

The rapid unfolding of the COVID-19 crisis – as well as the deployment of several policy responses, which are discussed below – triggered the need for high-frequency monitoring of financial fragmentation developments across different market segments. A decision was therefore taken to investigate whether the price-based CIFI could be converted into a higher-frequency indicator for monitoring daily dynamics and measuring the impact of events. The investigation would also check whether this new indicator could reflect the effectiveness of the necessary quick responses. To analyse euro area financial integration on a daily basis during the COVID-19 crisis, a toolkit of high-frequency indicators was developed. The starting point was a set of indicators presented in an ECB report on financial integration and structure in the euro area and its statistical annex.[7] Besides the HF-PIFI, the toolkit comprises other high-frequency statistical indicators such as a new dispersion indicator for money markets. For the sovereign and corporate segments of the bond market, the toolkit includes both the level and dispersion of spreads or yields at different maturities. To deepen the cross-country analysis of the government sector, the toolkit additionally includes daily credit default swap premia and a market assessment of redenomination risk premia.

This paper has three main aims. The first is to present the steps taken to construct the novel HF-PIFI (Section 2). During the COVID-19 crisis, this indicator was very responsive to new events such as public health data releases, incoming economic data and policy decisions. In this sense, the HF-PIFI acted as a “thermometer”, flagging events seen as either supportive or adverse with respect to financial integration. The second aim of the paper (Section 3) is to use the novel indicator to identify the main events that marked the COVID-19 crisis as described in Borgioli et al. (2020). The third aim (Section 4) is to review how the novel HF-PIFI performed against the low-frequency indicators such as the traditional quantity-based and price-based indicators of financial integration. Section 5 provides some final remarks and suggests lines for future research.

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6 Note that some indicators do not control for economic fundamentals, which could also explain cross-country divergences, while other indicators take fundamentals into account to differing degrees. At the same time, particularly in crisis situations, financial markets (which often act upon forward-looking expectations) can overreact significantly to news signalling changes in fundamentals.

7 See ECB (2020a) and the accompanying statistical annex.

2 Development of the HF-PIFI

The low-frequency price-based CIFI developed by Hoffmann et al. (2019) merges information from several financial market segments and offers a synthetic measure of financial integration. It is rooted in the "law of one price", which is a cornerstone of financial integration analysis. According to this law, assets that are similar in terms of risk and return are expected to converge to the same price. However, in the wake of the pandemic, the low frequency of the price-based CIFI, the lag in data availability and the small number of observations available each year made it difficult to link trends in financial integration to the rapidly unfolding COVID-19 crisis. The question then was whether a higher-frequency version of the CIFI could be produced to help analyse the impact of the COVID-19 crisis on financial integration. As we explain below, this proved to be the case.

2.1 Background: assembling the HF-PIFI

Starting from the conceptual framework for measuring financial integration within the euro area developed in Hoffmann et al. (2019), it is possible to build a single set of statistics integrating information from the money, bond equity and retail banking markets. Selected **measures of financial integration** are chosen for each market segment to be a component of the CIFI. **Specifically, for money, bond and retail banking markets** these measures, based on cross-country dispersion of returns, are calculated as standard deviations of relevant interest rates in line with the idea that a higher dispersion implies a weaker level of financial integration. Data on unsecured overnight interbank lending rates, sovereign and corporate bond yields, and bank loan and deposit rates are used for the money, bond and banking segments respectively. For the **equity market**, two measures of integration are selected: the segmentation measure based on Bekaert et al. (2011) (**EqM1**) and a metric based on Adjaouté and Danthine (2003) (**EqM2**). EqM1 draws on the notion that in a well-integrated financial market, the earnings yields of the same industries across countries would be similar. EqM2 relies on the idea that in a well-integrated financial market there would be no boundaries to diversification and investors should be able to diversify their portfolios optimally, which would lead to the convergence of country and sector dispersions.

2.2 Availability of high-frequency data

A prerequisite for developing the HF-PIFI was the availability of input data for various market segments. The **money market data** used are the national components of the euro short-term rate (€STR)[8]. The €STR reflects the wholesale euro unsecured

[8] For more information on the €STR and the underlying methodology, see the ECB's website. See also ECB (2019), "Goodbye EONIA, welcome €STR!", Box 1 in *Economic Bulletin*, Issue 7, Frankfurt am Main.

overnight borrowing costs of banks located in the euro area (see also Shin (2021), Corradin et al (2020) and Duffie et al (2016)). The high-frequency input data are available and published on each TARGET2 business day based on transactions conducted and settled on the previous TARGET2 business day.[9] The input measure for the HF-PIFI is calculated as the 30-day moving average of the standard deviations of the unweighted interbank lending rates reflected in the €STR ("€STR average rates"; see Chart 2).

Chart 2

HF-PIFI input measures for money market

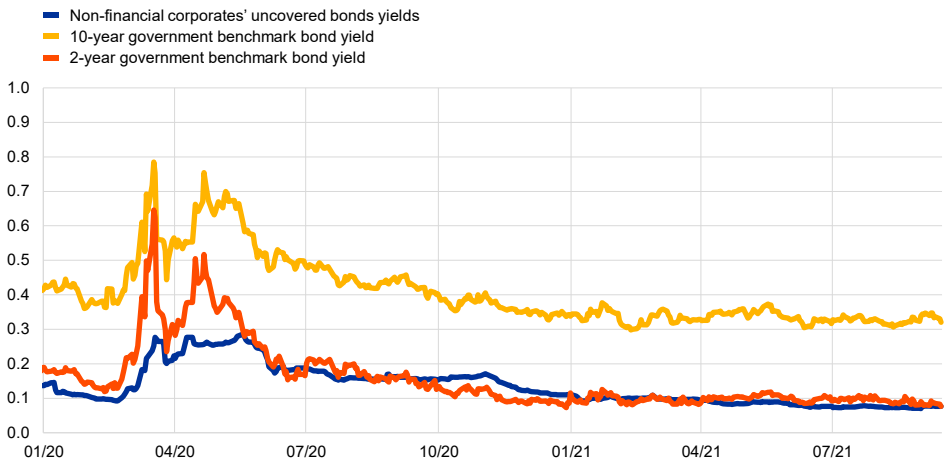
(30-day moving averages of standard deviations)

Sources: ECB and ECB calculations.

Chart 3

HF-PIFI input measures for bond market

(daily standard deviations)



Sources: Refinitiv and ECB calculations.

Meanwhile, the **bond market data** capture both sovereign and corporate bond yields.[10] Specifically, ten-year and two-year benchmark bond yields, as well as non-

9 For a detailed description of the €STR see the ECB's website.

10 The euro area "fixed composition" is used in order to maintain consistency throughout the whole analysis period.

financial corporate uncovered bond yields, available daily and sourced from Refinitiv and Bloomberg, are taken as input (see Table 1). Standard deviations of these yields to maturity across euro area countries are the input measure for the bond market component (see Chart 3).[11]

Table 1

Country and indicator coverage of input data for bond market

(● (included), ○ (not available)

Indicator and country	BE	FR	NL	AT	FI	IE	ES	IT	PT	DE	LU
Daily ten-year Government benchmark bond yield	●	●	●	●	●	●	●	●	●	●	●
Daily two-year Government benchmark bond yield	●	●	●	●	●	●	●	●	●	●	●
Daily non-financial corporate uncovered bond yields (Bloomberg Barclays fixed income indices[12])	○	●	●	●	●	○	●	●	○	●	○

Source: ECB.

Turning to **equity market data**, the two underlying indicators EqM1 and EqM2 need to be converted into high-frequency indicators. Data input into the first component, **EqM1**, covers average equity earning yields in various sectors of economic activity in the euro area countries. The average earnings yield is measured by the inverse of the price/earnings (PE) ratio based on analyst forecasts for country and sector-specific MSCI equity indices[13] (see Table 2). Each country is seen as a portfolio of sectors weighted by their respective forecast market capitalisation.[14] Input data on forecast P/E ratios and market capitalisation of the MSCI equity indices are only available weekly. This represents the weekly input measure of the segmentation indicators (EqM1) feeding into the HF-PIFI (see Chart 4, panel a).

Table 2

Country and sector coverage of input data for EqM1 of equity market

(● (included), ○ (not available)

Sector and country	AT	BE	FI	FR	DE	GR	IE	IT	NL	PT	ES
Consumer discretionary	○	●	●	●	●	●	●	●	●	●	●
Consumer staples	○	●	●	●	●	●	●	●	●	●	●
Energy	●	○	●	●	○	●	○	●	●	●	●
Financials	●	●	●	●	●	●	●	●	●	●	●
Healthcare	○	●	●	●	●	○	●	●	○	○	●
Information technology	○	○	●	●	●	●	○	●	●	○	●
Industrials	●	●	●	●	●	●	●	●	●	●	●
Materials	●	●	●	●	●	●	●	●	●	●	●

11 Spreads were not used because the standard deviation is invariant to translations. This means that if a value (in this case, for instance, the German rate) were added to or subtracted from all the others, the algebraic result would be exactly the same.

12 Rebranded in August 2021 as the “Bloomberg Indices”; see the press announcement on Bloomberg's website.

13 See the MSCI website.

14 The underlying data in the original methodology for CIFI are the forecast variables, so we cannot plug in actual prices.

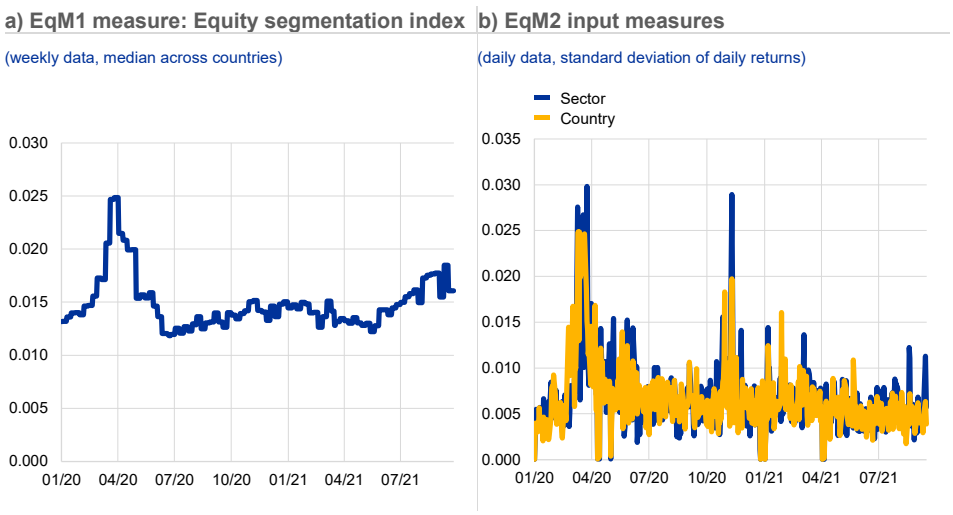
Sector and country	AT	BE	FI	FR	DE	GR	IE	IT	NL	PT	ES
Communication services	•	•	•	•	•	•	•	•	•	•	•
Utilities	•	○	•	•	•	•	○	•	○	•	•

Source: ECB.

The second equity market component (**EqM2**) is constructed as the absolute value of the difference between the cross-sectional dispersions in sector and country equity index returns. The data input is covered by the Refinitiv Datastream total return equity indices[15]. Country indices cover Belgium, Ireland, Spain, France, Germany, Greece, Italy, Luxemburg, Netherlands, Austria, Portugal and Finland. The sectoral indices for the euro area cover the following industries: materials, consumer discretionary, consumer staples, industrials, information technology, healthcare, telecommunications, energy, financials and utilities. The raw input data are available daily. Before calculating the absolute difference between the standard deviations in sector and country equity index returns, the standard deviations need to be smoothed by applying the Hodrick-Prescott (HP) filter with λ parameter set to 14400. The daily EqM2 input measures (see Chart 4, panel b) are derived by looping and substituting end-of-month standard deviations with those of a particular day while keeping all other observations on a monthly basis and applying the filter. This transformation allows the daily and monthly (end-of-month) input measures to be aligned, although it still results in some volatility, which is dealt with by a second application of the HP filter.

Chart 4

HF-PIFI input measures for equity market (2 January 2020-14 September 2021)



Sources: MSCI global equity indices, Refinitiv and ECB calculations.

Finally, the **retail banking market** data used include both the assets (loans) and liabilities (deposits) sides of aggregate bank balance sheets with respect to two counterparties, namely households and non-financial corporations (see Chart 5). The aggregate indicator includes the interest rates on new loans to households (for consumer credit) and on new loans to non-financial corporations (up to one year,

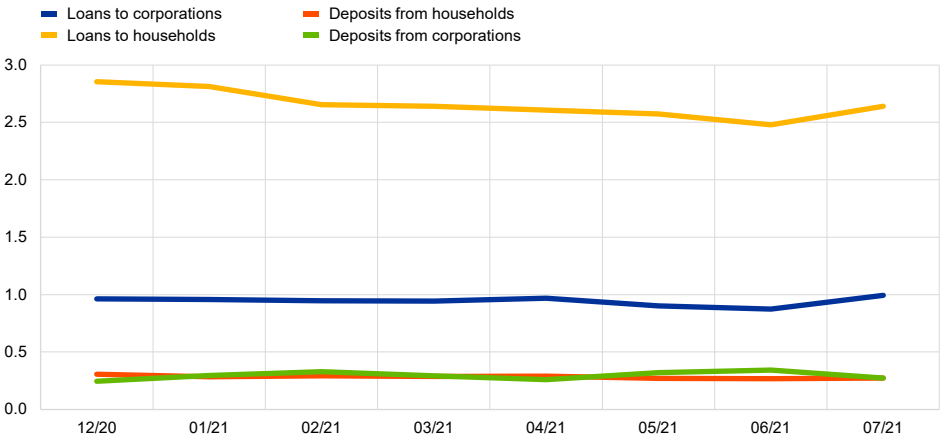
15 See the Refinitiv website.

and up to and including €1 million), as well as rates for households and non-financial corporations on deposits with agreed maturity.[16] The underlying data have monthly frequency and are available around two months after the reporting date.[17]

Chart 5

HF-PIFI input measures for retail banking market (January 2020-July 2021)

(monthly data, standard deviation across countries)



Sources: ECB monetary financial institution interest rate (MIR) statistics and ECB calculations.

In summary, high-frequency input data are available for all market segments with the exception of the retail banking market (see Table 3). Specifically, daily data are available for the money and bond markets and for the sub-index (EqM2) of the equity market component. Data for the other sub-index of the equity market (EqM1) are instead available weekly. Input data for retail banking markets, the fourth component of the composite price indicator, are available monthly. For all the data with frequency lower than daily, the derived sub-indices are aggregated into a daily price-based composite indicator carrying forward the last available records.

16 See also the ECB Statistical Data Warehouse.

17 See the ECB statistical calendars.

Table 3

Overview of input data and measures for the HF-PIFI

Market segment	Input measure	Coverage	Frequency	Raw data
Money market (MM)	Standard deviation (SD) of unweighted interbank lending rates	EMU2021	Daily	€STR; source: ECB
Bond market (BM)	SD of ten and two-year sovereign bond yields to maturity	EMU2021-	Daily	Ten-year and two-year government benchmark bond yields; source: Refinitiv
	SD of non-financial corporate uncovered bond yields	Available euro area countries	Daily	Bloomberg Barclays euro-aggregate indices; source: Bloomberg
Equity market (EM)	EqM1 – median equity market segmentation index Data input: forecast one-year-ahead market capitalisation and P/E ratios of the sectoral equity indices	EMU2011 excl. LU	Weekly	Country and sector MSCI equity indices; source: Refinitiv
	EqM2 – Country and sector dispersion absolute difference Data input: country equity indices, equity sectoral indices for the euro area indices	EMU2011 excl. LU	Daily	Refinitiv Datastream global equity indices, source: Refinitiv
Retail banking market (BKM)	SD of bank interest rates on (i) loans to households for consumption, (ii) loans to corporations of up to €1 million with a floating rate and an interest rate fixation period of up to one year, (iii) deposits from households with an agreed maturity, and (iv) deposits from corporations with an agreed maturity Bank loan and deposit rates refer to new business	EMU2011-	Monthly	MIR statistics; source: ECB

Source: Table 1 Hoffmann et al. (2019).
Notes: EMU2021 is composed of the following countries: Belgium, Germany, Estonia, Ireland, Greece, Spain, France, Italy, Luxembourg, Netherlands, Austria, Portugal and Finland. EMU2011 additionally includes Cyprus, Malta, Slovenia and Slovakia. EMU2011- denotes EMU2011 excluding Estonia, Greece, Cyprus, Luxembourg, Malta and Slovenia.

2.3 The high-frequency transformation

This section elaborates on the steps taken for the transformation into daily frequency of the HF-PIFI, applying the approach developed in Hoffmann et al. (2019) and aiming to achieve the maximum possible alignment between the high-frequency and low-frequency indicators (the HF-PIFI and the price-based CIFI respectively). Annex 2 contains the pseudocodes for documenting calculations undertaken in each step to derive the high-frequency measures.

Before aggregating the above inputs into the novel HF-PIFI, additional steps are needed to solve the issue of standardisation and further transformation. First, the input measures are homogenised in such a way that the state of integration is measured relative to a benchmark of perfect integration. The input measures are standardised in terms of both scale and distributional properties by applying the probability integral transform. Specifically, as adapted based on Hoffmann et al. (2019), given a vector of daily observations for the raw indicator $x^d = \left(x_1^d, x_2^d, \ldots, x_{T_d}^d\right)$ from x^d a subseries with end-of-the-month observations $x^m = \left(x_1^m, x_2^m, \ldots, x_{T_m}^m\right)$ is extracted and will be used to compute the cumulative distribution function $F(x)$ to ensure consistency at different frequencies. In order to compute the cumulative frequency density (CFD), the series of observations x^m are first ranked in

ascending order $x^m_{[1]} \leq x^m_{[2]} \leq \cdots \leq x^m_{[T_m]}$ where $x^m_{[1]}$ and $x^m_{[T_m]}$ are, respectively, the minimum and maximum of the time series. The CFD is then derived as

$$\mathrm{F}(x) = \begin{cases} \dfrac{r}{T_m} & x^m_{[r]} \leq x \leq x^m_{[r+1]} \\ 1 & x \geq x^m_{[T_m]} \end{cases}$$

We evaluate the CFD $F(x)$ in each of the daily observations x^d to obtain daily indicators $F(x^d)$ that are unit-free and approximately distributed uniformly in the interval $(0,1]$. The transformed indicators are thus homogeneous in terms of scale and distribution at the cost of losing the extra information contained in the cardinal scale of the original data.

In the second step, the data need to be benchmarked to an unobserved state of perfect integration to make them comparable and aggregable. As higher indicator values should reflect a higher level of financial integration, the measures are converted using $1 - F(x^d)$. We then multiply those values by a sample-dependent scaling factor $\theta^d(x^d)$ that relates the series to a benchmark of full financial integration. We can assume that all the indicators relying on cross-country price dispersions have 0 as a theoretical benchmark. Therefore, the scaling factor $\theta^d(x^d)$ can be defined as:

$$\theta^d(x^d) = \frac{max(x^d) - \min(x^d)}{max(x^d) - 0}$$

The factor scales down each transformed measure by the percentage share of the realised range of dispersion (the historical maximum minus the minimum dispersion) to the ideal dispersion range (the historical maximum minus the theoretical benchmark of zero). Because there is no theoretical upper bound on price dispersion, its highest observed value is set as the benchmark for the lowest degree of financial integration.

$$z^p = [1 - F(x^d)]\theta^d(x^d)$$

This operation yields series z^p, which can be used as the final input variables to compute the segment sub-indices as the arithmetic means of the constituent series of z^p and eventually to compute the HF-PIFI, applying weights corresponding to the segment sizes.[18] The observations of constituent series only available at a lower frequency (monthly for retail banking market and weekly for the EqM1 component) are carried over the aggregation period.

[18] Hoffmann et al. (2019) calculate the weights using the relative average amounts outstanding from the aggregated euro area financial accounts for the base period 1997-2013, with the following results: money markets 17%, bond markets 36%, equity markets 15% and banking markets 32%.

3 The phases of the COVID-19 crisis identified by the HF-PIFI and its sub-indices

The HF-PIFI and its sub-indices, together with the CISS and various pandemic indicators, have allowed various phases of the crisis to be identified (see Charts 6 and 7) and have connected them to the relevant events that unfolded (see Table 4). Several events stand out, such as the initial dips in price-based euro area financial integration on 17 March and 25 March 2020 and rises in three periods running to 16 June 2020, 17 August 2020 and 4 February 2021. Based on the analysis, Borgioli et al. (2020) identified five distinct phases of financial integration in the euro area during the COVID-19 crisis.

Chart 6

Financial integration and systemic risk in the euro area

Price-based financial integration and systemic risk during the COVID-19 crisis

(daily data, 1 January 2020 -14 September 2021)

Sources: ECB and ECB calculations.
Notes: Please see Table 1 for the labels description of the main financial and institutional events.

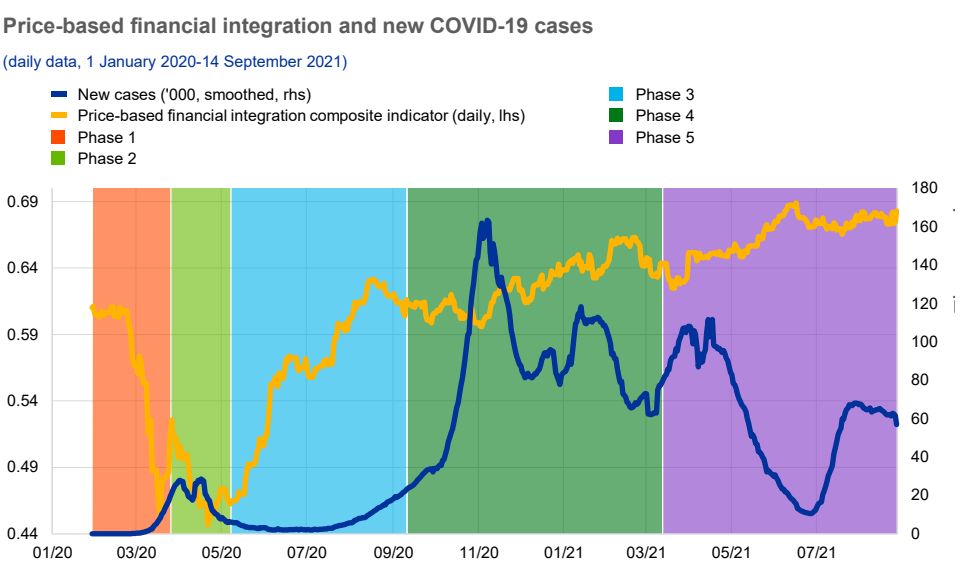
The first phase of the crisis ran from 30 January to 25 March 2020 and was characterised by the outbreak of COVID-19, which rapidly became a global pandemic. Signs of financial fragmentation in the euro area emerged in February and gained pace in early March. The CISS for the euro area increased rapidly, driven by bonds and equities. In addition, the price-based financial integration composite indicator displayed signs of refragmentation in the euro area during this initial phase (see also Hailing et al (2021) and Igan et al (2021)).

In the earliest stages of the crisis, national fiscal responses were deployed in all euro area countries, and spread dynamics were consistent with flight-to-quality capital

flows into German safe assets which pushed German yields down.[19] A comprehensive set of monetary policy measures was announced between mid-March and April 2020, including temporary capital and operational relief for banks. A total of €1.3 billion was lent to European banks at negative interest rates, and the pandemic emergency asset purchase programme (PEPP) was launched (Lane (2021)). The PEPP initially provided for €750 billion of securities purchases by the end of 2020 (see also EBA (2020), ESRB (2021) and FSB (2020)).

Chart 7

Financial integration and systemic risk in the euro area



Sources: ECB, Our World in Data, and ECB calculations.

The second phase of the crisis spanned the period from 26 March until 7 May 2020. It was characterised by the emergence of extensive economic and financial damage. This phase was also marked by a debate about the joint European fiscal response to the shock. The debate was initially dominated by a lack of consensus on the modalities of a potential European Stability Mechanism (ESM) credit line, or on whether to introduce "coronabonds", i.e. bonds issued jointly by all members of the euro area to finance economic relief measures during the pandemic.

Despite continuing ample monetary policy support, the third European Council meeting on the European response to the pandemic, which took place on 26 March 2020, highlighted disagreements among euro area countries on possible joint debt issuance. The fourth European Council meeting on the European response, held on 23 April 2020, led to an agreement on a €540 billion safety net consisting of (i) a €100 billion instrument providing Member States with temporary support to mitigate unemployment risks in an emergency (SURE), (ii) a €200 billion pan-European guarantee fund for loans to companies by the European Investment Bank, and (iii) a €240 billion pandemic crisis support credit line by the ESM. During this meeting, the European Council also tasked the European Commission with developing a proposal

[19] The crisis also led to the re-emergence of material redenomination risk – a stark manifestation of financial fragmentation reflecting market expectations of a country's exit from the euro area.

for a European crisis recovery fund, although views on the potential proportion of grants and loans in such a fund continued to differ. Towards the end of this phase, the positive signals pointing to a common European fiscal response to the pandemic raised confidence and marked a turning point by reviving overall financial reintegration. At that point monetary policy was no longer "the only game in town".[20]

The third phase of the crisis, spanning the period from 8 May to 10 September 2020, was characterised by several events that were supportive of financial integration. These events included the proposals by Germany and France and by the European Commission for a European recovery fund, a gradual relaxation of lockdowns, a larger-than-expected expansion of the PEPP purchase envelope and the eventual agreement on the Next Generation EU recovery instrument. There was a contrast between the improving public health situation and the sharp decline in economic activity (as indicated by negative GDP growth releases), while financial integration improved across market segments. Contrasting incoming data showed, on the one hand, declining COVID-19 infections and slowing death rates, which led to the gradual relaxation of containment measures across countries, and, on the other hand, historically negative economic growth and downward forecast revisions.

In this environment, both the Franco-German proposal on 18 May for €500 billion of grants and the European Commission's Next Generation EU proposal on 27 May for €750 billion of grants and loans (with both proposals to be funded through the EU budget) led to sizeable improvements in financial integration. These positive developments were further reinforced by the decision of the ECB's Governing Council on 4 June to increase the size of the PEPP by EUR 600 billion (to a total of €1,350 billion) and to extend the programme's reinvestment period until 2022.

The joint European fiscal response was a milestone that also reinforced financial integration. The end of this phase was marked by the agreement on the EU Recovery and Resilience Facility – under the Next Generation EU fund proposal – and the 2021-2027 Multi-year Financial Framework. The agreement resolved part of the uncertainty around a common European fiscal response and had an immediate positive effect on financial integration. It thus reaffirmed the positive integration developments following the Franco-German and the European Commission proposals in May. However, the impact of the agreement itself was modest, partly because it had already been priced in by the markets.

[20] On the monetary and fiscal responses, see also Schnabel (2021).

Table 4

Main financial and institutional events

Date	Event label	Event
04/03/2020	1	Closure of Italian schools and universities
18/03/2020	2	ECB PEPP announcement
25/03/2020	3	PEPP legal documentation published
26/03/2020	4	Third European Council meeting with clash over coronabonds
09/04/2020	5	Eurogroup agreement on comprehensive policy response
23/04/2020	6	ECB collateral rating freeze
23/04/2020	7	Fourth European Council meeting with endorsement of Eurogroup's comprehensive policy response and plans for recovery fund
18/05/2020	8	Franco-German €500 billion European recovery fund proposal
27/05/2020	9	European Commission €750 billion Next Generation EU recovery instrument proposal
04/06/2020	10	ECB PEPP expansion and Germany announces major fiscal stimulus package
29/06/2020	11	Merkel and Macron meeting to discuss recovery fund and EU budget ahead of July summit and German government deems that ECB proportionality assessment meets legal requirements
17/07/2020	12	Start of special European Council meeting on recovery fund (7-21 July 2020)
10/09/2020	13	End of special European Council meeting on recovery fund with final agreement on its structure
10/09/2020		ECB Governing Council meeting
21/10/2020	14	First issuance of European Commission SURE bonds
23/10/2020	15	S&P upgrades the outlook on the Italian sovereign bond rating from negative to stable
28/10/2020	16	Germany adopts toughest health restrictions since first lockdown
29/10/2020		ECB hints at December monetary policy stimulus
09/11/2020	17	Pfizer/BioNTech vaccine announcement
10/11/2020	18	Second issuance of SURE bonds
25/11/2020	19	Third issuance of SURE bonds
10/12/2020	20	ECB expands PEPP envelope and announces measures to "preserve favourable financing conditions"
15/01/2021	21	Announcement of US economic relief package
11/03/2021	22	ECB temporarily increases PEPP purchases
08/06/2021	23	European Commission successfully places €800 billion of bonds under the Next Generation EU recovery instrument
11/06/2021	24	European Union countries agree on an easing of travel restrictions over summer
28/06/2021	25	EU hands out first payments from COVID-19 recovery fund under the Next Generation EU recovery instrument
08/07/2021	26	ECB announces new strategy, reformulates inflation goal to 2%
22/07/2021	27	ECB extends forward guidance on rates
19/08/2021	28	Disbursement of the first tranches of money from the €800 billion EU recovery fund (3-19 July 2021)

Source: ECB.
Note: The events listed in the table are marked in the relevant charts as numbered vertical lines corresponding to dates in the timeline and are also referred to in the text.

The fourth phase of the crisis, spanning the period from 11 September 2020 to 11 March 2021, was characterised by the continuing deployment of fiscal easing that supported households' and firms' incomes, while central bank asset purchases, supervisory easing and liquidity operations eased financing conditions for all economic agents. Confidence in the Recovery and Resilience Facility grew, and progress was made with the Next Generation EU instrument. Together, these measures formed an unprecedented "tetra-policy" package for the euro area. Meanwhile, as the second and third waves of the COVID-19 pandemic unfolded,

confidence in the approval and inoculation of effective vaccines also grew. As a result, financial reintegration continued to increase, and there was a resurgence in economic activity in the winter of 2020-21, especially in low-contact and manufacturing sectors.

The fifth phase of the crisis, spanning the period from 12 March 2021 to the cut-off date of this paper, mid-September 2021, was characterised by a fourth wave of COVID-19 (less pronounced than the previous two, with hospitalisation and morbidity rates continuing to decline). Economic activity was robust thanks to the easing of travel restrictions and the resumption of tourism. The “tetra-policy” package continued to support the economy and financial system.

3.1 High-frequency money market, equity market and bond market integration

The dynamics of HF-PIFI sub-indices are quite distinct at times, and different events have impacted the sub-indices differently. Examining these events helps to draw inferences about the state of financial integration or, conversely, threats of financial fragmentation. Again, these indicators must be interpreted with caution and in conjunction with other financial indicators and statistics.

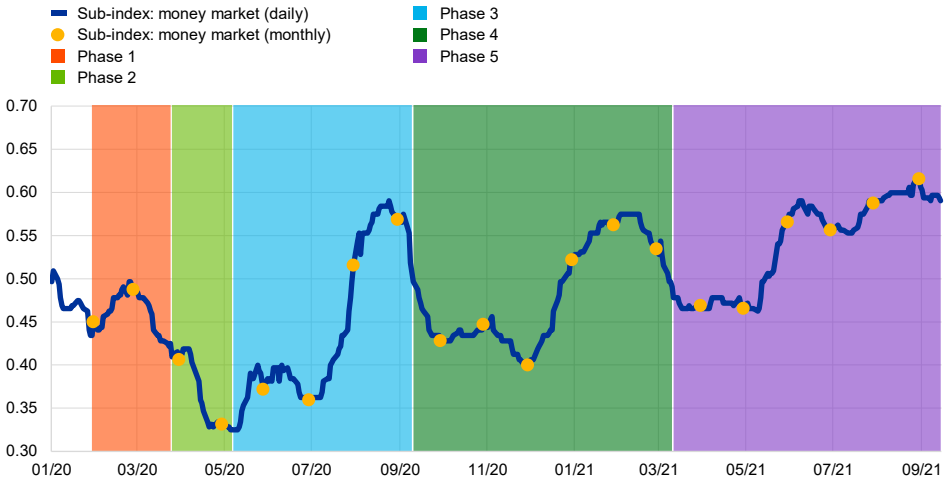
The first sub-index captures the state of money market integration between January 2020 and the end of September 2021 (see Chart 8). In phase 2 of the crisis, specifically in May 2020, this sub-index dives by over 60% to its lowest levels since the 2010-12 euro area sovereign debt crisis. It then gradually recovers, albeit with pronounced declining oscillations that are reabsorbed gradually over time in phases 3 to 5.

The problems in the money market were notably due to illiquid commercial paper (CP) markets. Stressed money market funds holding these CPs were unable to redeem the shares/units they had issued, because they could not sell their assets. By contrast, banks were reported to be in very solid health thanks to their sound capitalisation basis and the COVID-19-related measures enacted by policymakers to support the flow of credit to the real economy.

Chart 8

Money market sub-index (monthly and daily)

(daily and end-of-month data, 2 January 2020-14 September 2021)



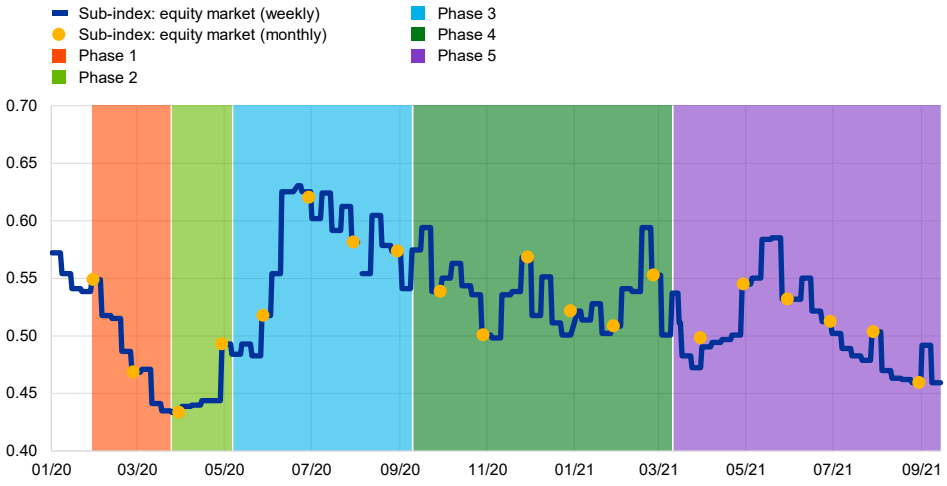
Sources: ECB (€STR) and ECB calculations.

The second sub-index captures the state of equity market integration, which exhibited a rather different dynamic (see Chart 9). In phase 3, this sub-index increased sharply, with both components EqM1 and EqM2 pointing to a substantial reintegration process (see also Charts 4 and 5). These dynamics can be at least partially explained by the presentation in May of both the Franco-German proposal for a fund of grants and the European Commission's €750 billion Next Generation EU proposal, which may have caused a realignment of earnings expectations across EU countries and sectors. In addition, EqM1 was more pronounced in smaller euro area economies with less liquid equity markets than in countries with deeper equity markets.

Chart 9

Equity market sub-index (monthly and weekly)

(daily and end-of-month data, 2 January 2020-14 September 2021)



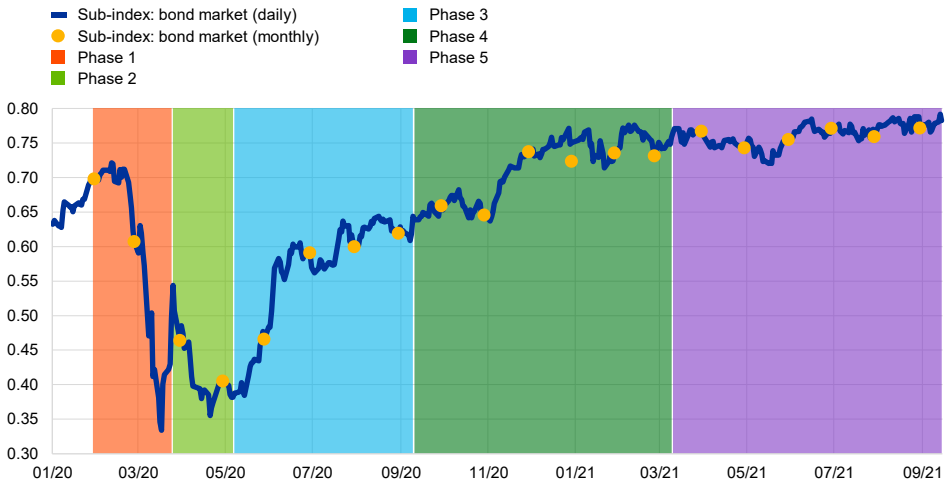
Sources: Refinitiv and ECB calculations.

The third sub-index captures the state of bond market integration and exhibits a wholly different dynamic from that of the previous two indices (see Chart 10). A sharp fall in phase 1, specifically in March 2020, and a second one in phase 2, specifically in May 2020, are followed by an almost steady recovery in integration until mid-June 2021, at which point the index plateaued until the end of September.

Chart 10

Bond market sub-index (monthly and daily)

(daily and end-of-month data, 2 January 2020-14 September 2021)



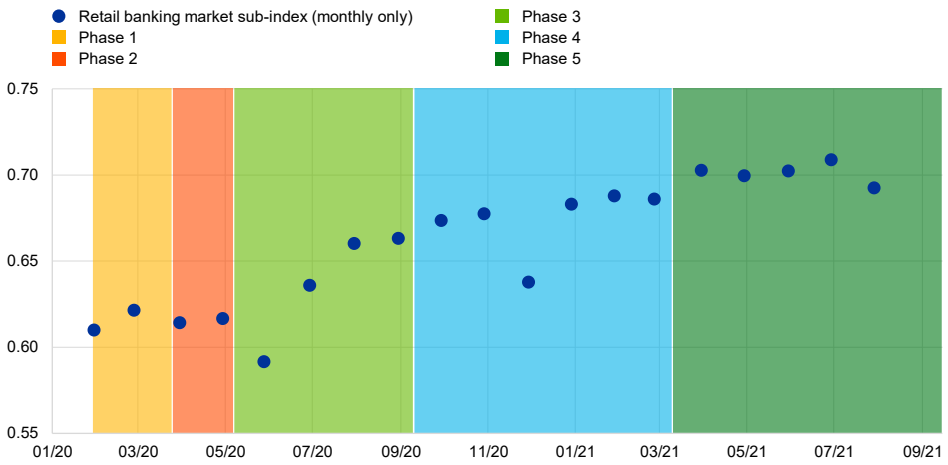
Sources: Refinitiv, Bloomberg and ECB calculations.

The fourth sub-index captures the state of retail banking market integration (see Chart 11). Owing to the monthly frequency of the indicators and the lower variance and higher stickiness of the underlying data, this component moves less than the previous ones. A relative drop is observed at the start of phase 3, with a lag compared with the other components, followed by a quick revival in the same phase. The indicator then moves only slightly for the rest of the period observed.

Chart 11

Retail banking market sub-index (monthly only)

(monthly, January 2020-July 2022)



Sources: ECB and ECB calculations.

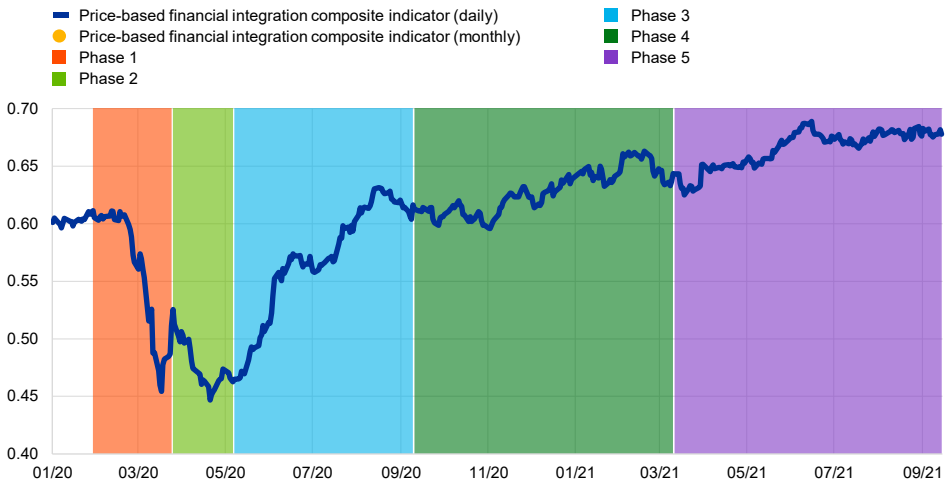
3.2 The new HF-PIFI during the phases of the COVID-19 crisis

The HF-PIFI displayed signs of refragmentation in the euro area during **the first phase** (see Chart 12), with bond markets the segment most affected. In the sovereign bond market segment, the large fiscal burdens expected from the necessary public support to firms and households, potential tax shortfalls and pre-existing differences in public debt levels led to government bond spreads to diverge (and even to double in the case of some vulnerable countries).

Chart 12

Price-based financial integration composite indicator (monthly and daily)

(daily and end-of-month data, 2 January 2020-14 September 2021)



Sources: ECB, Refinitiv, Bloomberg and ECB calculations.

Yet, in terms of levels, sovereign spreads stayed well below the 2011-12 sovereign debt crisis peaks. As mentioned at the start of this section, national fiscal responses were deployed in all euro area countries when the crisis began, and capital flows into German safe assets pushed German bond yields down. The comprehensive set of monetary policy measures announced in phases 1 and 2 contributed to halting and partially reversing the divergence of bond yields in both the corporate and sovereign bond markets.

The pandemic had uneven effects across financial market segments **in the second phase of the crisis.** The development of the sub-components shows that equity markets were the only market segment for which financial integration rebounded, while financial integration receded in the other market segments.[21] The disagreement over coronabonds in phase 3 stoked financial tensions, most visibly in the sovereign bond markets.

The third phase of the crisis was characterised by several events that supported financial integration across market segments.

These led to sizeable reductions in (i) sovereign spreads, with some substantial reconvergence; (ii) redenomination risk; and (iii) corporate yields, notably for vulnerable countries.

In this phase, fragmentation in money markets was smaller than in other financial market segments. After exhibiting signs of fragmentation from the start of phase 1 and well into phase 2, indicators for the money market segment started declining to lower dispersion levels from late-April 2020. The different lending operations and the adjustments of lending criteria and eligible collateral supported a gradual reduction in dispersion for unsecured money market rates (€STR) in particular. The dispersion of secured money market rates spiked around key pandemic dates because of flight-to-quality dynamics and around futures delivery dates because of collateral scarcity. From early May 2020, the money market indicator approached pre-crisis levels and then broadly fluctuated around those levels.

The fourth and fifth phases of the crisis brought continuing financial reintegration, albeit unevenly across financial segments. This was supported by the “tetra-policy” package amidst a resurgence in economic activity along with declining hospitalisation and morbidity rates.

[21] However, the dispersion and volatility of forecast equity index returns, not discussed here, remained heightened. During the initial phases of the COVID-19 crisis, option-implied equity market volatility rose sharply to levels last seen at the height of the global financial crisis.

4 Review of the novel indicator's performance

The new HF-PIFI provided daily evidence on the state of financial integration and made it possible to track – almost in real time – the impact of COVID-19 events and of policy responses from the start of the pandemic. As such, it complemented other types of monetary and financial indicators, such as the daily CISS, thus enriching the set of information available to policymakers and analysts. With hindsight, and benefiting from the most recent observations of the lower-frequency indicators of financial integration (obtained with a lag), we can investigate how the novel high-frequency indicator of price-based financial integration performed against the two long-established low-frequency CIFIs.

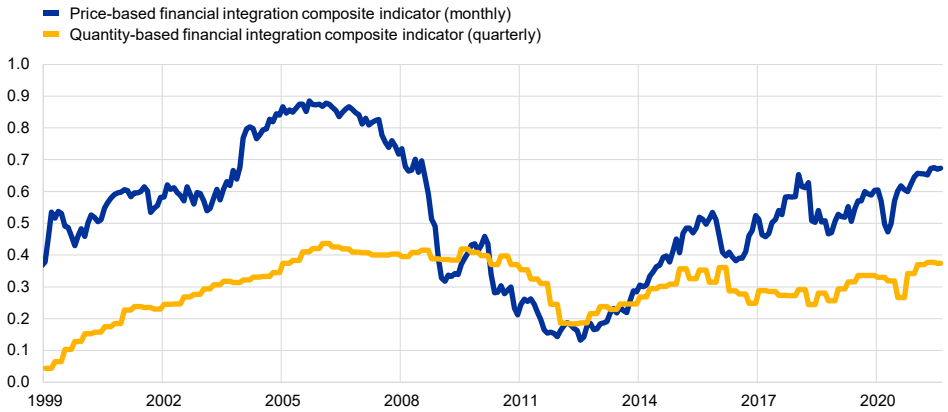
Panel a) of Chart 13 shows the low-frequency price-based and quantity-based CIFIs, originally reported in ECB (2020a), updated to cover the period until October 2021. The high-frequency dimension certainly added depth and details compared with the lower-frequency indicators. For example, the monthly indicator did not point to the deeper drop signalled by the HF-PIFI in both phases 1 and 2. Likewise, the upbeat recovery appears slightly more pronounced when analysing the daily indicators. In line with its objective, the indicator made it possible to analyse the impact of major events on financial integration on a daily basis.

Chart 13

Price-based and quantity-based composite indicators of financial integration: low versus high-frequency

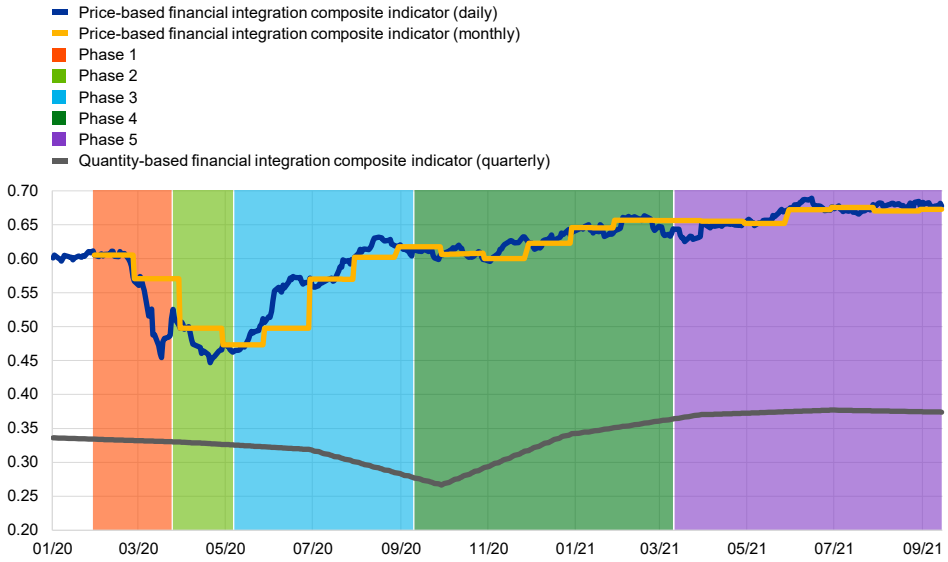
a) Low-frequency price-based and quantity-based composite indicators of financial integration

(January 1999 to September 2021)



b) High-frequency price-based composite indicators of financial integration

(January 1999 to September 2021)



Sources: ECB and ECB calculations.

Chart 14 displays the month-on-month changes in both of the composite indicators. From the joint observation of Charts 13 and 14, it is clear that both low-frequency price and quantity-measured integration plummeted at the start of the pandemic before rebounding sharply (in response to the monetary, supervisory and fiscal policy reaction described above). Looking, for instance, at the quarter-on-quarter changes in quantity-based indicators, the change in the third quarter of 2020 is among the four sharpest drops since the launch of the indicator. What is also noticeable is the greater responsiveness of the price-based integration indicator compared with the quantity-based indicator: i.e., the former exhibits shorter time lags. The higher stickiness of quantities, which are slower to react, was also

observed in previous analyses of financial integration. In fact, asset prices react immediately to incoming news, while portfolio reallocation, as tracked by the quantity measures, is a longer process. The same time lag between prices and quantities is then observed for the sharp upward rebound.

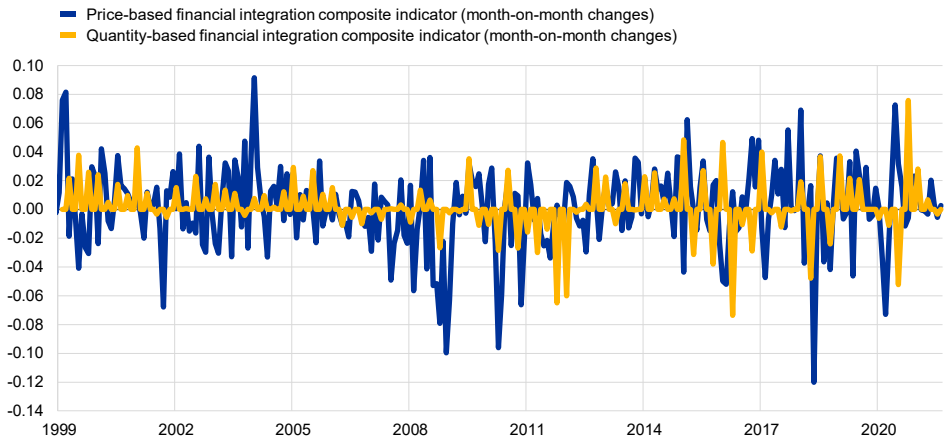
The HF-PIFI shows a drop of around 25% between the end of January 2020 and mid-March 2020. Again, looking at the sub-components of the indicator, it was possible, using the HF-PIFI, to assess the impact on the bond component of an increase in Italian ten-year sovereign spreads from 132 basis points on 17 February to 281 basis points on 17 March. Other compelling examples of the extent to which the set of information available for analysis was increased by the HF-PIFI can be found in Borgioli et al. (2020).

Chart 14

Changes in price-based and quantity-based composite indicators of financial integration

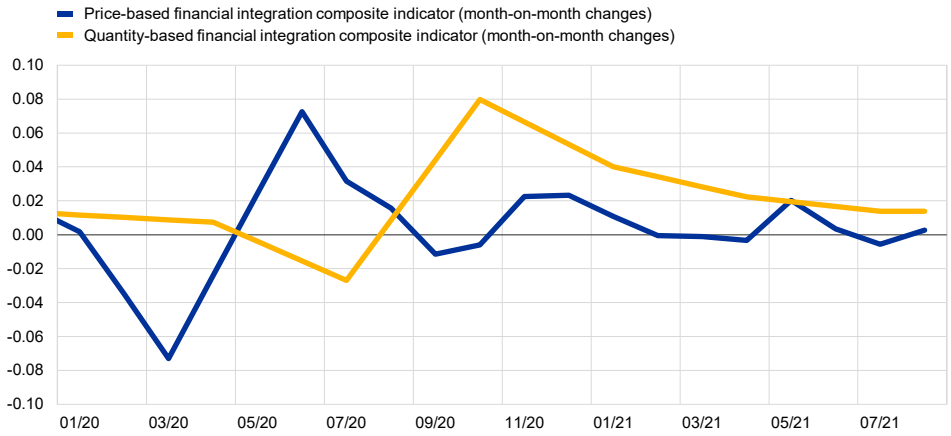
a) Month-on-month changes in price-based and quantity-based composite indicators of financial integration

(1 January 1999-14 September 2022)



b) Month-on-month changes in price-based and quantity-based composite indicators of financial integration

(1 January 1999-14 September 2022)



Sources: ECB and ECB calculations.

The low-frequency price and quantity-based indicators of financial integration are less suitable for tracking the impact of daily events such as the COVID-19 crisis and the related policies reactions. First, the information from the low-frequency indicators is compressed into monthly, typically end-of-period, brackets (or even quarterly brackets for the quantity indicator), and the intra-monthly dynamics are unobservable and impossible to relate to specific events unfolding. Second, data are only available with a time lag, especially for the composite quantity indicator.

By contrast, the new HF-PIFI proved to be an excellent "thermometer" for reading the very short-term evolution of financial integration during the COVID-19 crisis. Chart 15 below (from Hartmann et al., 2021) clearly displays how the new high-frequency indicator can track the short-term changes in aggregate financial integration and connect them to events as they unfold.

Chart 15

Euro area price-based financial integration, COVID-19 pandemic developments and events

(daily data, 17 February 2020-24 May 2021)

Vertical lines and their numbers mark selected significant events (colours refer to country events – Italy red, Spain dark blue, Germany light blue – or events with euro area wide relevance – fiscal light brown, monetary policy and other black):

1. Closure of Italian schools and universities (4 March), 7. ECB PEPP announcement (18 March), 9. PEPP legal documentation published (25 March), 10. Third European Council with divergent views on coronabonds **(26 March),** 12. Eurogroup agreement on comprehensive policy response (9 April), **16. ECB collateral rating freeze (22 April),** 17. Fourth European Council with endorsement of Eurogroup's comprehensive policy response and plans for recovery fund **(23 April),** 24. Franco-German €500 bn. European recovery fund proposal **(18 May),** 25. European Commission €750 bn. "Next Generation EU" recovery instrument proposal **(27 May), 26.**/26. **ECB PEPP expansion and** Germany announces major fiscal stimulus package **(4 June),** 28. Start of special European Council on recovery fund **(17 July),** 29. End of special European Council on recovery fund with final agreement on size and structure **(21 July),** 31. First issuance of EU Commission SURE bonds **(21 October), 32. S&P upgraded the outlook on the Italian sovereign bond rating from negative to stable (23 October),** 33. Germany adopts toughest health restrictions since first lockdown **(28 October), 34. ECB hints at December monetary policy stimulus (29 October), 35. BioNTech/Pfizer vaccine announcement (9 November),** 36.Second issuance of EU Commission SURE bonds **(10 November), 38. ECB expands PEPP envelope and announces to "preserve favourable financing conditions" (10 December), 39. Announcement of US economic relief package (15 January), 40. ECB temporarily increases PEPP purchases (11 March). Omitted numbers are relevant events suppressed for readability.**

Sources: ECB and ECB calculations.

5 Final remarks and further steps

This paper had three aims. The first was to present the steps for constructing a novel high-frequency indicator of financial integration. The work was conducted under pressure during the COVID-19 crisis by adapting and expanding an available instrument (the CIFI). The methodology was flexible and transparent. During the COVID-19 crisis, the novel indicator was highly responsive to new "events" such as public health data releases, incoming economic data and policy decisions. In addition, the HF-PIFI aggregate dynamics are found to be the result of different patterns displayed by its sub-components. As in the case of the corresponding low-frequency indicator, the HF-PIFI adds value by enabling analysis of different sub-components that are largely available daily.

In one sense, the HF-PIFI can be seen as a "thermometer", flagging events seen as supportive or damaging to financial integration. Therefore, the second aim of the paper was to use the novel indicator to flag the main events that marked the COVID-19 crisis. This exercise has shown that rapid joint policy responses have a supportive impact on financial integration. One remarkable feature of the COVID-19 crisis, documented in this paper, has been the fast rebound of financial integration thanks to these speedy policy responses and the resilience created by the financial and fiscal backstops, along with the reforms implemented over the last decade.

The third aim of the paper was to check with hindsight how the HF-PIFI performed against low-frequency instruments such as the price-based and quantity-based indicators of financial integration (which respond with a time lag). Looking back over the COVID-19 crisis, the insights from the novel HF-PIFI have proved accurate. The benefits of a readily available signal based on almost real-time market data make up for the much wider set of available low-frequency indicators.

Therefore, from a policy standpoint the novel HF-PIFI has generated useful information corroborating other evidence available to policymakers in times of crisis and beyond. Conceivably, the HF-PIFI could be put to other uses such as sentiment analysis or impact studies. Further uses of the indicator could be examined, for instance by investigating the feasibility of using high-frequency experimental data for the retail banking market and searching for alternatives to the data input available on a weekly basis. Finally, the historical values of the HF-PIFI can be recalculated, also allowing further analysis of past events.

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Annex

A.1 Pseudocodes

```
# Utility Function of daily projection

def compute_subindex_monthly_daily(ts,ts_eval):

        # monthly observation in ts are used to compute the daily projection

        ts = ts.dropna()

        # COMPUTE CUMULATIVE FUNCTION

        sorted_ts = np.sort(ts)

        p = 1. * np.arange(len(ts)) / (len(ts) - 1)

        f = interp1d(sorted_ts, p, kind='previous',bounds_error=False, fill_value=0.)

        #MAX MIN FACTOR

        theta = 1 - max(ts)/min(ts)

        #return daily projection

        z = pd.Series( (1-f(ts_eval))*theta, index=ts_eval.index)

        return z

# BOND MARKET

## daily standard deviations for each bond group

BM1_dstd = BM1_raw.std(axis=1)

BM2_dstd = BM2_raw.std(axis=1)

BM3_dstd = BM3_raw.std(axis=1)


BM1_dstd = BM1_dstd[BM1_dstd.index>='2020']

BM2_dstd = BM2_dstd[BM2_dstd.index>='2020']

BM3_dstd = BM3_dstd[BM3_dstd.index>='2020']

## montly standard deviations for each bond group

BM1_std = BM1_raw.resample('M').last().std(axis=1)
```

```
BM2_std = BM2_raw.resample('M').last().std(axis=1)

BM3_std = BM3_raw.resample('M').last().std(axis=1)


BM1_std = BM1_std[(BM1_std.index>='1995') &
(BM1_std.index<=last_complete_month)]

BM2_std = BM2_std[(BM2_std.index>='1995') &
(BM2_std.index<=last_complete_month)]

BM3_std = BM3_std[(BM3_std.index>='1995') &
(BM3_std.index<=last_complete_month)]


BM1_dsub = compute_subindex_monthly_daily(BM1_std,BM1_dstd)

BM2_dsub = compute_subindex_monthly_daily(BM2_std,BM2_dstd)

BM3_dsub = compute_subindex_monthly_daily(BM3_std,BM3_dstd)

## Bond Market daily subcomponent

BM_dsub =    pd.concat([BM1_dsub,BM2_dsub,BM3_dsub], axis=1, join='outer',
ignore_index=False).mean(axis=1)


# MONEY MARKET

MM1_em_daily

MM1_em = pd.DataFrame(MM1_em_daily.resample('M').mean())

MM1_em_daily_rolling = MM1_em_daily.rolling(20).mean()


MM_dsub = compute_subindex_monthly_daily( MM1_em, MM1_em_daily_rolling)


# EQUITY MARKET

## EM1

monthly_EM1_median

daily_EM1_median

## EM2

### Monthly
```

```
EM2_country_monthly

EM2_sector_monthly


EM2_country_std_monthly = EM2_country_monthly.std(axis=1)*100

EM2_sector_std_monthly = EM2_sector_monthly.std(axis=1)*100


EM2_country_monthly_filtered =
sm.tsa.filters.hpfilter(EM2_country_std_monthly.dropna(),14400)[1]

EM2_sector_monthly_filtered =
sm.tsa.filters.hpfilter(EM2_sector_std_monthly.dropna(),14400)[1]


EM2_monthly = max((EM2_country_monthly_filtered -
EM2_sector_monthly_filtered),0)

### Daily

EM2_country

EM2_sector


EM2_country_std = EM2_country.pct_change(periods=23).std(axis=1)*100

EM2_sector_std = EM2_sector.pct_change(periods=23).std(axis=1)*100


def fitinmonthly_loop(daily_series,monthly_series):

        tt = daily_series[daily_series.index>='2020'].reset_index()

        ## each observation in the daily series is filtered using the monthly series
        and a new filtered daily series is returned

        for index,dobs in tt.iterrows():

        ref_index = pd.to_datetime(dobs.OBS_DATE +
        pd.tseries.offsets.MonthEnd(0)).strftime('%Y-%m-%d')

        monthly_series.iloc[monthly_series.index==ref_index] = dobs[0]

        monthly_filtered = sm.tsa.filters.hpfilter(monthly_series.dropna(), 14400)[1]

        output[dobs.OBS_DATE] = monthly_filtered[ref_index]
```

```
        return output


EM2_country_daily_filtered = fitinmonthly_loop(daily_series=
EM2_country_std,monthly_series= EM2_country_std_monthly)

EM2_sector_daily_filtered = fitinmonthly_loop(daily_series=
EM2_sector_std,monthly_series= EM2_sector_std_monthly)


EM2_daily = max(EM2_country_daily_filtered - EM2_sector_daily_filtered,0)

EM2_daily_filtered = sm.tsa.filters.hpfilter(EM2_daily, 14400)[1]


## EM

EM1_daily = compute_subindex_monthly_daily(ts = monthly_EM1_median ,ts_eval
= daily_EM1_median)

EM2_daily = compute_subindex_monthly_daily(ts = EM2_monthly, ts_eval =
EM2_daily_filtered)


EM_dsub = pd.concat([EM1_daily,EM2_daily]).mean(axis=1)
```

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