

OVERVIEW OF CENTRAL BANKS' IN-HOUSE CREDIT ASSESSMENT SYSTEMS IN THE EURO AREA

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Abstract

The in-house credit assessment systems (ICASs) developed by euro area national central banks (NCBs) are an important source of credit risk assessment within the Eurosystem collateral framework. They allow counterparties to mobilise as collateral the loans (credit claims) granted to non-financial corporations (NFCs). In this way, ICASs increase the usability of non-marketable credit claims that are normally not accepted as collateral in private market repo transactions, especially for small and medium-sized banks that lend primarily to small and medium-sized enterprises (SMEs). This ultimately leads not only to a widened collateral base and an improved transmission mechanism of monetary policy, but also to a lower reliance on external sources of credit risk assessment such as rating agencies. The importance of ICASs is exemplified by the collateral easing measures adopted in April 2020 in response to the coronavirus (COVID-19) crisis. The measures supported the greater use of credit claim collateral and, indirectly, increased the prevalence of ICASs as a source of collateral assessment.

This paper analyses in detail the role of ICASs in the context of the Eurosystem's credit operations, describing the relevant Eurosystem guidelines and requirements in terms of, among other factors, the estimation of default probabilities, the role of statistical models versus expert analysis, input data, validation analysis and performance monitoring. It then presents the main features of each of the ICASs currently accepted by the Eurosystem as credit assessment systems, highlighting similarities and differences.

Keywords: credit assessments, credit risk models, credit claims, ratings, ICAS.

JEL classification: E58.

Resumen

Los sistemas de evaluación del crédito desarrollados internamente por los bancos centrales nacionales (ICAS) son una fuente importante de valoración del riesgo de crédito dentro del marco de los activos de garantía de política monetaria del Eurosistema. En particular, los ICAS permiten que las entidades financieras aporten los préstamos concedidos a sociedades no financieras como garantía en las operaciones crediticias en las que se instrumenta la política monetaria del Eurosistema. En este sentido, los ICAS contribuyen a que los préstamos puedan ser utilizados como colateral, dado que generalmente no son aceptados como tal en la operativa privada de *repos*, y benefician potencialmente en mayor medida a los bancos de tamaño mediano o pequeño que financian a las pymes. Esto último conduce no solo a una ampliación del conjunto de activos de garantía disponibles en las entidades financieras y a una mejora del mecanismo de transmisión de la política monetaria, sino también a una menor dependencia de fuentes externas de valoración del riesgo de crédito, como las agencias externas de calificación. La importancia de los ICAS se ha puesto de manifiesto en las medidas aprobadas por el Eurosistema en abril de 2020 en respuesta a la crisis del COVID-19. Dichas medidas apoyaron un mayor uso de los préstamos como activos de garantía e, indirectamente, incrementaron la importancia de los ICAS como fuente de valoración del colateral.

Este documento analiza en detalle el papel de los ICAS en el contexto de las operaciones crediticias de política monetaria del Eurosistema, describiendo las guías y los requerimientos más relevantes exigidos a los ICAS en términos, entre otros factores, de la estimación de las probabilidades de impago, el papel de los modelos estadísticos frente al análisis experto, la información utilizada en el proceso de evaluación y la validación periódica de su funcionamiento. Adicionalmente, describe los principales aspectos de cada uno de los ICAS actualmente aceptados como sistema de calificación por el Eurosistema, destacando tanto sus elementos comunes como los diferenciales.

Palabras clave: sistema interno de evaluación del crédito (ICAS), sociedades no financieras, préstamos, activos de garantía, política monetaria.

Códigos JEL: E58.

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Non-technical summary

The ICASs of Eurosystem NCBs are one of three sources of assessments of collateral credit risk within the Eurosystem monetary policy framework. However, they play a special role in that they provide credit quality assessments for NFCs of all sizes and from all industries, which in most cases are not assessed by other credit assessment systems available to the Eurosystem's monetary policy counterparties. ICASs therefore make it easier for banks to mobilise loans to NFCs as collateral.

Since all Eurosystem lending has to be based on adequate collateral, ICASs contribute to the availability of sufficient collateral and a smooth implementation of monetary policy. ICASs therefore help to reduce the Eurosystem's reliance on rating agencies for bank loans and contribute to a more diversified collateral composition.

The acceptance of illiquid bank loans also leads to certain side effects, including operational challenges and risks for the Eurosystem. Various eligibility and use requirements as well as risk control measures aim to ensure that these bank loans are treated in an equivalent manner to other eligible assets from the perspective of the Eurosystem's risk exposure. They thus contribute to a risk-efficient implementation of monetary policy.

The contribution of ICASs to monetary policy implementation becomes even more important in times of market tension, as exemplified by the Eurosystem's response to the COVID-19 crisis. The Eurosystem measures adopted in March and April 2020 in order to support bank funding were followed by a significant increase in the mobilised collateral assessed by ICASs.

ICAS credit quality assessments have also proven useful beyond monetary policy: ICAS ratings are used for financial stability analyses, for economic research and for macroprudential and microprudential supervision. They provide benchmarks for banks' internal ratings-based (IRB) systems and guidance for estimating allowances and provisions for credit risk losses, among other purposes.

The quality and reliability of ICAS credit assessments are ensured through a common set of Eurosystem-wide rules. These have to be followed by any NCB deciding to operate an ICAS, both in the initial acceptance phase and once the system is in regular usage. ICASs have to comply with certain standards in terms of organisation, adequate resources and governance. A key tool for the regular due diligence of ICASs is the annual Eurosystem "performance monitoring process".

The assessment of credit quality has always been important for collateral purposes. This was the case even before the creation of the Economic and Monetary Union (EMU). Four euro area members already had an ICAS before 1999 and kept using it after the adoption of the euro: first in the period in which a two-tier system for collateral was in place, in order to allow a smooth transition from the national frameworks, and subsequently under the unified collateral framework ("single list") adopted in 2007. Other ICASs were set up after the sovereign debt crisis of 2012, in order to increase collateral availability and facilitate the temporary framework for "additional credit claims" (ACCs) adopted by several Eurosystem NCBs at the time. Additional Eurosystem central banks may develop ICASs in the coming years. The

introduction of AnaCredit in 2018 overcame a major obstacle for the development of credit risk models by central banks that previously lacked a credit register.

Although all ICASs must comply with the commonly agreed requirements, they vary slightly in terms of specific procedure and implementation, such as their statistical methodologies. ICASs also differ in terms of (i) “users”, with some central banks additionally using ICAS ratings for macroprudential and microprudential purposes, including in one case microprudential capital requirements; and (ii) internal organisation, with some NCBs conducting their ICAS activity within the scope of market operations and others as part of statistical or other functions.

ICASs already include some relevant and available environmental, social and governance (ESG) indicators in their rating process. The Eurosystem is working towards greater integration of ESG factors, in particular factors related to climate change risks, in the ICAS methodologies.

This paper thus describes in detail the role of ICASs in the context of the Eurosystem’s credit operations. It analyses the Eurosystem guidelines and requirements to which national ICASs must adhere in terms of, among other factors, the measurement of default probabilities, the role of statistical models versus expert analysis, input data, validation analysis and performance monitoring. It also provides a detailed description of each of the seven ICASs currently accepted by the Eurosystem, with an overview of their main features that highlights similarities and differences.

The collateral framework is one of the pillars supporting the Eurosystem's¹ monetary policy implementation. It consists of a set of rules and requirements – eligibility criteria, minimum credit quality, haircuts, etc. – that financial assets have to satisfy in order to be used to secure refinancing operations.² Although once called the “open secret of central banks” (Nyborg, 2016), an increasing number of papers and books have investigated various aspects of the Eurosystem collateral framework.³

Nevertheless, this is the first paper to provide a comprehensive overview of the entities that conduct Eurosystem-internal credit assessments of a non-negligible part of non-marketable collateral: the ICASs operated by NCBs in the euro area.⁴

The collateral framework is meant to protect the Eurosystem's balance sheet against losses related to the default of a monetary policy counterparty. It thus implements the statutory requirement to base all lending on adequate collateral.⁵ At the same time, the collateral framework ensures that sufficient collateral is available to smoothly implement monetary policy and to provide a level playing field, across jurisdictions, for counterparties in need of liquidity when they mobilise financial assets as collateral.

A key requirement of the collateral framework is a high credit quality of the assets to be mobilised. In this context, the Eurosystem credit assessment framework (ECAF) defines the procedures, rules and techniques which ensure that all assets eligible for monetary policy operations meet the Eurosystem's credit quality requirements. The ECAF is thus the basis for the credit quality assessment of assets mobilised as collateral in Eurosystem credit operations and of assets purchased under the current purchase programmes.

At present, to assess the credit quality of eligible assets, the Eurosystem takes into account information from credit assessment systems belonging to three categories: (1) credit rating agencies accepted as external credit assessment institutions (ECAIs), (2) NCBs' ICASs, and (3) counterparties' IRB systems that are accepted for determining banks' regulatory capital requirements.⁶

ICASs play a special role in the ECAF due to the fact that they allow counterparties to mobilise as collateral the loans (also called “credit claims”) granted to NFCs,

¹ The Eurosystem comprises the ECB and the national central banks of those countries that have adopted the euro. The Eurosystem and the European System of Central Banks will co-exist as long as there are EU Member States outside the euro area.

² Guideline (ECB/2014/60) with subsequent amendments lays down the Eurosystem's existing general framework for monetary policy implementation, including also the collateral framework. The Eurosystem also has further non-public specifications and rules for ICASs.

³ These include BIS (2013), Bindseil (2014), Bindseil and Papadia (2006), Bindseil et al. (2009, 2017), Cheun et al. (2009), ECB (2006, 2011, 2015), and Tamura and Tabakis (2013) from the central banking operational perspective, and Calza et al. (2021), and Mésonnier et al. (2017), from a more academic perspective.

⁴ See, for example, Antunes et al. (2016), Deutsche Bundesbank (2015), Giovannelli et al. (2020), Schirmer (2014), Wukovits (2016), for descriptions of individual NCBs' ICASs.

⁵ See Article 18.1 of the Protocol on the Statute of the European System of Central Banks and of the European Central Bank.

⁶ In addition, one NCB still accepts a “rating tool” in its ACC framework. See also footnote 16.

which in many cases are not assessed by other credit assessment systems available to these counterparties. ICASs are used in particular by small and medium-sized banks that lend primarily to SMEs but do not have an IRB system and are not in a position to fund themselves by issuing asset-backed securities (ABSs) or covered bonds. Moreover, ECAI ratings are available only for a small share of NFCs, while they are usually not available for SMEs.

Already in normal times, the acceptance of ICASs thus contributes to sufficient collateral availability for a wide range of counterparties with different business models and operating in different markets, ensuring a smooth implementation of monetary policy. Accepting bank loans as collateral helps avoid the need for counterparties to hold specific marketable assets only for the purpose of collateralising monetary policy operations. Bank loans have relatively low opportunity costs as collateral, whereas marketable assets are increasingly used as collateral in private market repo transactions.

At the same time, the acceptance of illiquid bank loans leads to certain side effects, including operational challenges and risks for the Eurosystem. In general, appropriate risk management enables the achievement of policy objectives with the lowest possible risk for the Eurosystem. Collateral eligibility and use requirements as well as risk control measures aim to ensure that these bank loans are treated in an equivalent manner to other eligible assets from the perspective of the Eurosystem's risk exposure (see, for example, Tamura and Tabakis, 2013, and ECB, 2015).

But ICASs provide an even more important contribution to the transmission mechanism in times of market tension as they allow banks to increase the share of non-marketable collateral (provided that the minimum credit quality requirement is satisfied) when there is a shortage of marketable assets or the latter have lost value. This role is exemplified by the measures adopted by the Eurosystem in April 2020, during the pandemic-related financial and economic crisis, when the Governing Council decided on a set of collateral measures to facilitate an increase in bank funding against loans to corporates and households. This increase was to be achieved by expanding the use of credit claims as collateral, in particular the so-called ACC frameworks that allow NCBs to enlarge the scope of eligible credit claims for counterparties in their jurisdictions. Credit claims and in particular ACCs are typically mobilised by relying on ICAS or IRB assessments. The effectiveness of these measures was demonstrated by the significant increase in such collateral that was observed in several jurisdictions in 2020.

Besides these benefits for counterparties and for the implementation of monetary policy, ICASs offer several further advantages for the Eurosystem. By supporting banks to mobilise loans rather than government bonds or other marketable assets, ICASs help to diversify Eurosystem balance sheet risks. In addition, ICASs provide Eurosystem-internal credit assessments for a large number of European NFCs as an alternative or complement to ratings by rating agencies, thus helping to reduce the Eurosystem's reliance on the latter and contributing to implementing the recommendations of the Financial Stability Board.⁷ Finally, NCBs also use the

⁷ In October 2010, the FSB published *principles for reducing reliance on credit rating agency ratings* and requested that standard setters and regulators consider next steps that should be taken to translate the principles into more specific policy actions.

ratings of ICASs for various other purposes beyond monetary policy operations, such as for macroprudential and microprudential motives.

The rest of this paper is structured as follows. Section 2 describes in detail the role of ICASs in the context of the Eurosystem's credit operations. Section 3 analyses the Eurosystem's guidelines and requirements to which national ICASs must adhere, inter alia in terms of measuring default probabilities, the role of statistical models versus expert analysis, input data, validation analysis and performance monitoring. Section 4 presents the main features of each of the seven ICASs currently accepted within the ECAF, highlighting similarities and differences, while the annex provides a more detailed description of the features of each of the ICASs. Section 5 concludes.

2 ICASs in the context of the Eurosystem's monetary policy operations

2.1 Credit claims as eligible collateral for the Eurosystem's credit operations

The importance of ICASs is closely related to the use of credit claims to NFCs⁸ as collateral in Eurosystem monetary policy operations. The Eurosystem has traditionally used credit operations with financially sound banks as its main tool for steering short-term interest rates in its monetary policy implementation.⁹ Even if asset purchases have become the quantitatively dominant liquidity-providing instrument since 2015, credit operations have remained an important monetary policy tool, in particular in the form of targeted longer-term refinancing operations (TLTROs). At the end of 2020, the Eurosystem lent almost €1.8 trillion to euro area credit institutions, representing 16% of euro area GDP.

All lending in Eurosystem credit operations must be based on adequate collateral. This requirement is included in Article 18.1 of the Protocol on the Statute of the European System of Central Banks and of the European Central Bank. The collateral protects the Eurosystem against financial risks arising from the default of a borrowing bank.

For historical and structural reasons, the Eurosystem has always accepted a wide range of collateral for its credit operations¹⁰, in particular to ensure sufficient collateral availability for a wide range of counterparties with different business models and operating in different markets. Chart 1 shows that the share of credit claims has steadily increased from below 5% towards close to 30% of the total mobilised collateral over the last 15 years, even if marketable assets (mainly bonds) remain the main source of collateral.¹¹

The acceptance of credit claims as collateral provides several benefits, as highlighted for example by the ECB (2006). With the level of bank intermediation and bank-based financing in the euro area still high, credit claims remain the most important asset class on banks' balance sheets, and thus their acceptance contributes to wide collateral availability. Accepting credit claims helps avoid the need for counterparties to hold specific marketable assets only for the purpose of collateralising monetary policy operations. Credit claims have relatively low opportunity costs as collateral because they are rarely traded and counterparties have limited alternative uses for them, other than securitisation or selling them to

⁸ The definition of "non-financial corporations" is the one given in Regulation (EU) No 549/2013 on the European system of national and regional accounts in the European Union.

⁹ See, for example, ECB (2011) for more information on the role of credit operations in the ECB's monetary policy.

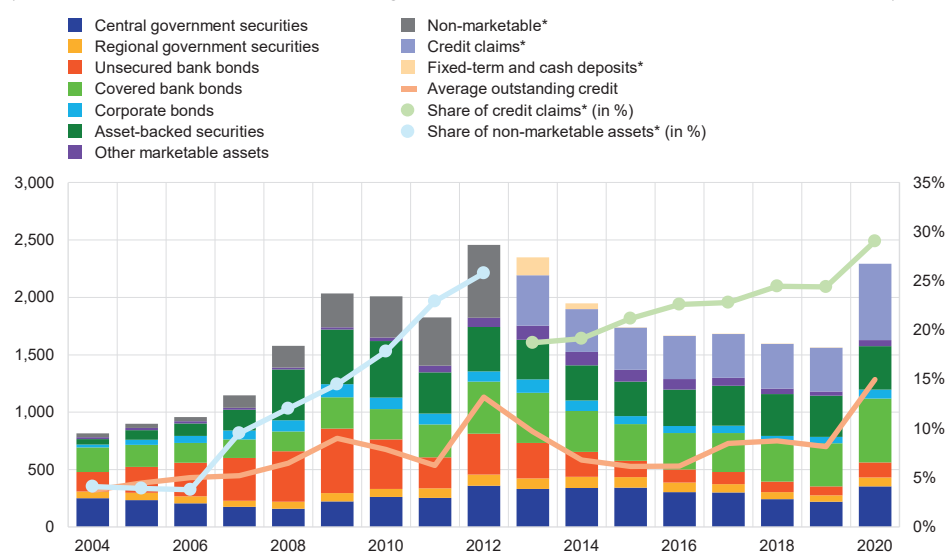
¹⁰ See, for example, Chapter 9 in Bindseil et al. (2009).

¹¹ The jump in 2020 is linked to the ECB's response to the COVID-19 pandemic, as further explained in Box 1.

Chart 1

Increasing use of credit claims as collateral in Eurosystem credit operations

(left scale: EUR billions after valuation and haircuts; right scale: share of total mobilised collateral after valuation and haircuts)



Source: ECB.

Notes: Use of collateral: averages of end-of-month data; credit: based on daily data. * Until 2012, "credit claims" and "fixed-term and cash deposits" were reported jointly in the category "non-marketable assets".

other parties. The acceptance of credit claims as collateral increases the usability of this entire asset class for counterparties, since they can be easily exchanged with central bank money, which is a high-quality liquid asset (HQLA).¹² This can foster the smooth functioning of the euro area financial system and support bank lending to non-financial customers. Moreover, a wide and differentiated collateral framework, also including credit claims, helps diversify risks for the Eurosystem's balance sheet.

At the same time, the acceptance of illiquid bank loans leads to certain operational challenges for the Eurosystem and also additional risks, which could materialise in the event of a counterparty default. Eligibility and use requirements as well as risk control measures aim to ensure that these bank loans are treated in an equivalent manner to other eligible assets from the perspective of the Eurosystem's risk exposure.¹³ For example, the lower liquidity of credit claims compared with marketable assets is compensated by higher valuation haircuts (see ECB, 2015). The acceptance of a broad range of collateral, and if necessary an even broader range during crisis periods (see Box 1), is also part of a risk-efficient implementation of monetary policy in the euro area, in other words the achievement of policy objectives with the lowest possible risk for the Eurosystem. The Eurosystem needs to be able to conduct its monetary policy operations smoothly, even for large operations at very short notice, while taking into account potential side effects¹⁴ and benefiting from adequate protection of its balance sheet.

¹² The liquidity transformation effect of mobilising credit claims on banks' regulatory liquidity coverage ratio requirements is discussed by Grandia et al. (2019), who reflect that credit claims do not belong to so-called high quality liquid assets.

¹³ By aiming at a risk-equivalent treatment across assets, the Eurosystem's risk management seeks to avoid distorting asset prices or overly influencing market processes and market participants' behaviour. This promotes a level playing field across instrument classes and financial markets and ensures a sufficient level of consistency across credit operations from a risk management perspective.

¹⁴ For example, in the context of credit claim collateral, the Eurosystem needs to take into account the financial intermediation role of the central bank and the interaction with commercial banks' regulatory requirements, in particular their regulatory liquidity coverage ratio requirements.

The evolution of the acceptance of credit claims as collateral, the related benefits and challenges for the Eurosystem and other specific issues related to their use have been highlighted and examined on several occasions, for example by Tamura and Tabakis (2013). This paper complements some important milestones for credit claims in the Eurosystem collateral framework with the genesis and the use of ICASs in Section 2.3.

2.2 Evaluating credit quality with the ECAF

The Eurosystem fulfils its statutory requirement of “adequate collateral” with detailed rules on eligibility, valuation and risk control measures – in particular valuation haircuts.¹⁵ Both eligibility and valuation haircuts depend among other criteria on the credit quality of the collateral, which the Eurosystem evaluates using multiple internal and external credit assessment systems, including ICASs. The ECAF defines the related rules, procedures and techniques. The ECAF rules also set forth the framework for credit risk assessment and due diligence in the context of asset purchases.

The ECAF uses information from three types of credit assessment systems to cover the range of accepted marketable assets and credit claims: in addition to seven ICASs for NFCs, there are also four credit rating agencies (ECAIs) and dozens of commercial banks’ IRB systems.¹⁶ The ECAF ensures that the credit ratings from all systems are comparable by mapping each of their rating grades to the appropriate credit quality step (CQS) of the Eurosystem’s harmonised rating scale (see Table 1).

Table 1
The Eurosystem’s harmonised rating scale for the general collateral framework

(probability of default (PD) over a one-year horizon, ECAI rating grades)

Credit quality steps	1	2	3
ICASs and IRBs	Up to 0.10% PD		Up to 0.40% PD
DBRS	AAA/AAH/AA/AAL	AH/A/AL	BBBH/BBB/BBBL
Fitch Ratings	AAA/AA+/AA/AA-	A+/A/A-	BBB+/BBB/BBB-
Moody’s	Aaa/Aa1/Aa2/Aa3	A1/A2/A3	Baa1/Baa2/Baa3
Standard & Poor’s	AAA/AA+/AA/AA-	A+/A/A-	BBB+/BBB/BBB-

Source: ECB.

The Eurosystem conducts extensive due diligence on all the credit assessment systems it uses, before and after their acceptance. The due diligence on accepted credit assessment systems can be complemented with asset-specific due diligence, which is particularly relevant in the context of asset purchases.

The due diligence comprises a vast set of regulatory, operational and information requirements for the acceptance of credit assessment systems in the ECAF. These

¹⁵ See ECB (2015) for a description of the rules and ECB (2014a, 2014b) for the legal acts specifying the general framework (in particular for marketable assets and credit claims) and the temporary framework (in particular for additional credit claims).

¹⁶ In addition, one NCB still accepts a “rating tool” in its ACC framework. The Eurosystem phased out the use of rating tools from its general framework for monetary policy operations owing to cost-benefit considerations in May 2019 (see the related [press release](#)).

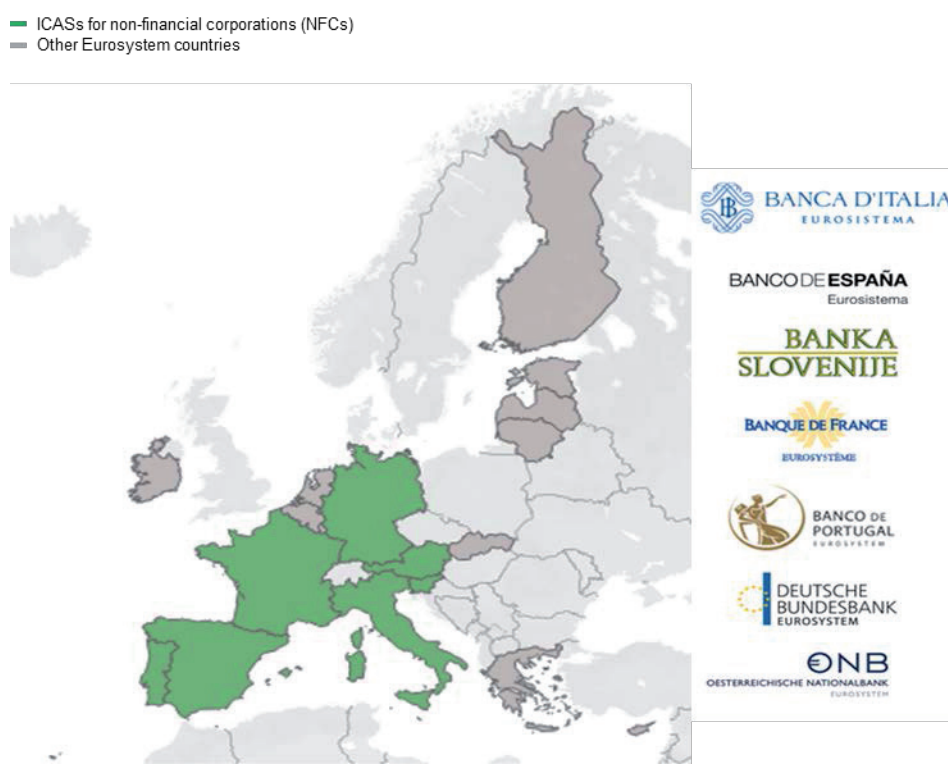
aim to protect the Eurosystem from financial risks and to ensure comparability, accuracy and consistency among the different systems that provide credit assessment information to the Eurosystem, while taking particular account of the respective regulatory situations.¹⁷

The “ECAF performance monitoring process” is the key tool for the annual ECAF due diligence on all accepted systems.¹⁸ It consists of:

1. a quantitative statistical component, to check whether the mapping of the ratings of each credit assessment system to the Eurosystem’s harmonised rating scale is appropriate;
2. a qualitative component, which examines the credit assessment processes and methodologies, taking into account the information provided by the systems themselves as well as by the respective supervisors.

For the seven ICASs for NFCs accepted by the Eurosystem (see Figure 1), the relevant NCBs’ risk management functions and the ECB’s Directorate Risk Management share the ECAF due diligence with clearly assigned responsibilities.

Figure 1
ICASs in the Eurosystem



¹⁷ For example, to be considered for ECAF purposes, it is a necessary but not sufficient condition that ECAs are supervised by the European Securities and Markets Authority (ESMA) as credit rating agencies, while IRB systems have to be authorised for capital requirements purposes by the relevant banking supervisor. For its in-house credit assessment capabilities, in particular its ICASs, the Eurosystem cannot rely on external supervision, and thus these are directly monitored by national risk management functions and the ECB’s Directorate Risk Management.

¹⁸ As part of the harmonised criteria for temporarily eligible ACCs, the requirements for reporting and monitoring under the ECAF are applied to all credit assessment systems used to assess the credit quality of credit claims accepted under the national frameworks for such ACCs.

The ECB's Governing Council decides on the initial acceptance of ICASs, the approval of fundamental changes, and the action points of the annual ECAF performance monitoring process, based on assessments endorsed by the Eurosystem Risk Management Committee, which is comprised of the senior risk managers of all Eurosystem central banks. Section 3 elaborates on the underlying Eurosystem guidelines for ICASs in more detail.

2.3 Historical evolution of ICASs

2.3.1 Use of ICASs before the introduction of the EMU in 1999

The assessment of credit quality has always been important for collateral purposes. Before the introduction of the EMU in 1999, commercial papers were widely used as collateral for refinancing operations in many Member States (including Germany, Spain, France, Italy and Austria). In particular, they were accepted for refinancing operations with the respective NCB in the course of rediscounting operations, provided the issuer had sufficient credit quality.

In addition, some NCBs had their own specific reasons to build up know-how in credit risk assessment. In the 1950s, for example, the Oesterreichische Nationalbank (OeNB) started to assess the credit quality of NFCs applying for subsidised loans financed by grants of the European Recovery Program (Marshall Plan). Due to the exceptional management of the funds granted, their total volume is currently in excess of €1 billion and the OeNB is today still involved in the assessment of credit quality for the purposes of the European Recovery Program. The Banca d'Italia (BdI) developed models and methodologies to assess the credit quality of Italian firms mainly for the purposes of banking supervision. The Banque de France (BdF) has been involved in corporates' credit risk assessment since its creation, more than 200 years ago. Corporate rating activity started in 1987 and was first developed to support monetary policy. Prior to that, credit risk assessment could take the form of classification agreements or instructions given to banks for both monetary policy purposes and for tightening credit regulations. The Banco de España (BdE) began to establish an ICAS at the end of the 1990s to complement the work performed by international rating agencies (ECAIs), as their services were not used widely by Spanish firms. It was therefore considered necessary to assess NFCs in order to expand the credit quality coverage for monetary policy purposes.

2.3.2 Evolution during the first decade of the EMU

Initially, the Eurosystem used a two-tier system for collateral to smoothen the transition for market participants from the previously applicable national frameworks to the EMU. Tier one assets comprised debt instruments that complied with euro area common eligibility criteria (e.g. marketable assets), whereas tier two assets consisted of those assets that were approved by NCBs but did not comply with euro area-wide eligibility criteria at that time. Within this framework, only the NCBs of Germany, Spain, France, the Netherlands and Austria accepted credit claims as tier

two collateral, and only four of them (Germany, Spain, France and Austria) used an ICAS for NFCs.

This set-up was reviewed in the early 2000s, and the ECB (2006), the Deutsche Bundesbank (BBk) (2006) and Tamura and Tabakis (2013) present some of the general issues that were identified. A single list of Eurosystem collateral accepted for credit operations was introduced in 2007 to address these issues and to foster a harmonised collateral framework for all market participants. With this update to the framework, Eurosystem counterparties in all countries gained the possibility to use credit claims as non-marketable collateral. The extension and harmonisation of the framework intensified the cross-border use of credit claims and as well as their overall deployment, especially in times of crisis.

In addition to the original four existing ICASs for NFCs (from Germany, Spain, France and Austria), a credit assessment approach for mortgage-backed promissory notes (MBPNs) issued by Irish credit institutions was applied by the Central Bank of Ireland from 1999, when MBPNs were approved as an eligible asset.¹⁹ The Bdl carried out initial investigations into the possible development of an ICAS at the beginning of the 2000s. These efforts led to the creation of the ValCre statistical model, used since 2006 for the purpose of benchmarking and risk control as well as in the context of measures taken during the 2010-2011 financial crisis. Building on this experience, the ICAS model of the Bdl was subsequently developed in the 2010s.

2.3.3 The importance of ICASs in the ECAF today

During the financial and sovereign debt crises, demand for liquidity within the banking system rose. This resulted in an increased volume of mobilised collateral in monetary policy operations. Since then, non-marketable assets have become more important (see Chart 1 in Section 2.1). To ensure that banks have full access to central bank liquidity even in adverse circumstances, the Eurosystem made it possible for NCBs to temporarily accept additional types of collateral, in particular ACCs.²⁰ From 2012 until the beginning of 2020, the mobilised collateral volume continuously shrank, but the share of regular and ACCs continued to grow. This trend was further strengthened with the collateral easing measures in response to the COVID-19 pandemic in April 2020 (see Box 1).

One reason for the greater use of credit claims is that marketable assets have higher opportunity costs when used as collateral for monetary policy operations. Due to increased risk perception by credit institutions, the scale of unsecured money market transactions between banks has shrunk since the financial crisis. As a result, marketable assets are increasingly used as collateral in the repo market.²¹

¹⁹ The Irish ICAS for MBPNs is largely outside the scope of this paper because it uses a very different approach from the ICASs for NFCs considered in this paper.

²⁰ ACCs are credit claims that do not fulfil all the eligibility criteria applicable under the general collateral framework. For example, ACCs can be of lower credit quality than the generally accepted credit claims or be denominated in currencies other than the euro. To compensate for the associated higher risks, the national central banks impose higher valuation haircuts. See, for example, Box 3 of ECB (2015) and https://www.ecb.europa.eu/explainers/tell-me-more/html/acc_frameworks.en.html.

²¹ See, for example, Deutsche Bundesbank (2013).

Regulatory changes have also played a major role. Since 2015, regulatory authorities have required banks to hold sufficient HQLAs. By using credit claims as collateral for monetary policy operations, HQLAs are gained in the form of unencumbered other (marketable) HQLAs or additional central bank money held in excess of the bank's minimum reserve requirements.²²

While the possibility of pledging credit claims provides banks with additional funding and supports banks in fulfilling the required liquidity coverage ratio, it may also have side effects, such as an increased bank dependency on central bank funding.²³

The importance of ICASs for the Eurosystem has grown in parallel with the greater role of credit claims in the collateral framework. As a consequence, the due diligence for ICASs has also significantly improved. In 2012, the Eurosystem started its first comprehensive review of the four existing ICASs at the time. The ICAS review resulted in the elaboration of best practices and enhanced rules on documentation and operational requirements. The new measures aimed at reducing potential risks by setting best practices for existing and future ICASs. A more detailed description of the Eurosystem's guidelines for ICASs, for example regarding documentation and default definition, follows in Section 3. In addition, new ICASs developed by Banka Slovenije (BS) (in 2012), the Bdl (in 2013) and the Banco de Portugal (BdP) (in 2016) received ECAF acceptance²⁴, increasing the total number to seven.²⁵ As far as loans to NFCs are concerned,²⁶ ICASs are the credit assessment source with the highest mobilised collateral value after haircuts in the regular collateral framework (see Chart 2).²⁷ Since only relatively few NFCs have a credit quality assessment from an external credit rating agency, ICASs and IRB systems help to increase the diversity of available rating sources and broaden the set of eligible credit claims. This applies in particular to SMEs, for which ECAI ratings are generally not available. Today, ICASs and IRB systems are mostly chosen as the rating source for the credit quality assessment of credit claims to NFCs, whereas ECAIs are used for the assessment of credit claims towards public sector entities. IRB systems play a greater role for ACCs as they can also be used to assess loans to private households such as residential mortgages.

The greater availability of ICAS ratings has benefited the Eurosystem, its counterparties and the euro area economy in multiple ways. ICASs assess the credit quality of debtors that may not be assessed by any other system. They help smaller banks which do not have sufficient resources to establish their own IRB system. By promoting credit claims as collateral, ICASs foster all the benefits of this asset class

²² See Grandia et al. (2019) for an analysis of the demand for HQLA due to the LCR and other factors.

²³ With a broad collateral framework, banks may have little incentive to become independent of central bank funding for their liquidity management (due to fixed rate full allotment), mainly because the collateral which is mobilised cannot be used to obtain market funding. While conducting this lender of last resort function during system wide crises is important, it may have side effects during regular times.

²⁴ In addition, the Nationale Bank van België/Banque Nationale de Belgique operated an ICAS from 2013 to 2019.

²⁵ Figure 1 provides an overview of all ICASs in the Eurosystem.

²⁶ Credit claims for public sector entities which do not have a direct ECAI rating as well as pools of credit claims which include loans assessed by both IRB systems and ICASs or via an NCB-specific methodology are not considered.

²⁷ There is also the possibility to use ICASs for marketable assets without an ECAI rating. Since there are very few bonds issued without at least one rating by a credit rating agency, this option has hardly been used in practice. The Governing Council decided in September 2020 to accept such marketable assets only until the go-live of the Eurosystem Collateral Management System, which is currently planned for November 2023.

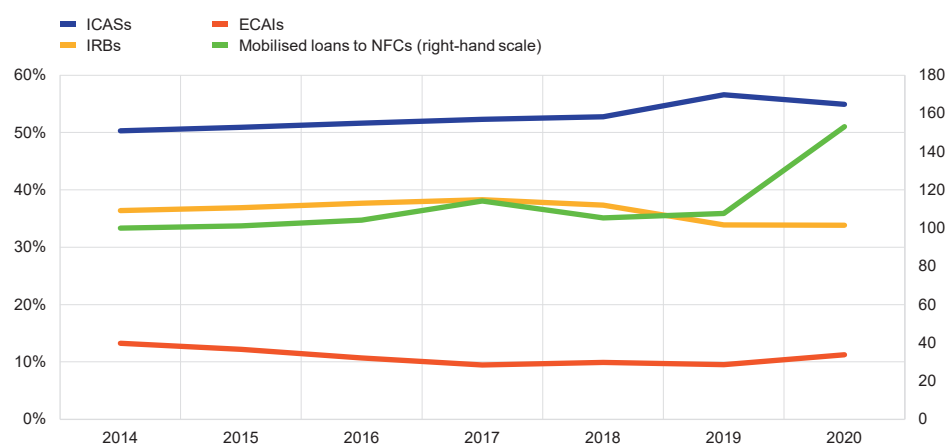
highlighted in Section 2.1. ICASs are an important element in the Eurosystem’s strategy to reduce mechanistic reliance on external ratings, in line with various initiatives by international authorities to lower such reliance in legal, regulatory and other public frameworks.²⁸ The role of ICASs is particularly relevant in crisis times, when sufficient collateral to participate in the Eurosystem’s lending operations becomes paramount. This has been evident most recently during the COVID-19 pandemic (see Box 1). Overall, ICASs thus contribute to the smooth implementation of monetary policy and protect the Eurosystem from financial risks.

More NCBs may decide to develop an ICAS in the coming years. The introduction of AnaCredit²⁹ in 2018 overcame a major obstacle for the development of credit risk models by NCBs that previously lacked a credit register.

Chart 2

Use of credit assessment systems for loans to NFCs mobilised as collateral in Eurosystem credit operations

(left scale: share of mobilised collateral value after haircuts of different credit assessment systems; right scale: 2014 = 100)



Source: ECB.

Note: Only credit claims mobilised under the general collateral framework are included.

Box 1

ICASs and the ECB’s response to the COVID-19 pandemic

When the COVID-19 pandemic hit Europe in the first quarter of 2020, it triggered a human tragedy and an extreme economic downturn. Fiscal and monetary authorities around the globe took unprecedented policy measures to counter the effects on the economy and financial markets.

As of March 2020, the ECB decided in several steps to ease monetary policy and stabilise markets by introducing the pandemic emergency purchase programme (PEPP) and various additional lending operations, which were supported in April 2020 by several significant collateral easing measures as summarised in Table A. The collateral easing measures aimed at improving funding conditions for the real economy during the COVID-19 crisis, not least by facilitating banks’ access to Eurosystem lending operations during the pandemic period. Such measures favoured a greater use of credit claim collateral, in particular ACCs, and thus indirectly the use of ICASs featured

²⁸ See, for example, FSB (2014).

²⁹ See Israël et al. (2017) for a description of the Analytical Credit Dataset “AnaCredit” of the Eurosystem.

prominently.³⁰ The share of credit claims in mobilised collateral thus increased from 24% to 29% in 2020 (see Chart 1), and the volume of loans to NFCs mobilised under the general collateral framework increased by 42% (see Chart 2).

Table A
Overview of the ECB collateral easing measures adopted in April 2020

Category	Collateral easing measure
Expansion of credit claims	ACCs – Increased availability of credit assessment systems
	ACCs – Acceptance of COVID-19-related government/public sector guaranteed loans
	ACCs – Reduced reporting requirements
	Removal of the minimum size threshold for credit claims
Increase of Eurosystem risk tolerance	Increase of Eurosystem risk tolerance by proportionate reduction of all haircuts for all assets by 20%
	Reduction of haircuts for individual credit claims in the general framework, individual ACCs and pools of ACCs
	Increase of the concentration limit for unsecured bank bonds to 10%
Reduced procyclicality of rating downgrades	Collateral eligibility freeze, with a floor of CQS5 (CQS4 for ABSs)
Greek waiver	Acceptance of Greek sovereign bonds as collateral

Source: de Guindos and Schnabel (2020).

Note: The table only lists collateral measures that were introduced in response to the COVID-19 crisis.

The ECB had already created the possibility for NCBs to temporarily accept ACCs in 2011 under specific rules adapted to local needs, provided that certain agreed minimum eligibility and risk management requirements were fulfilled. ACC frameworks mainly allow for the acceptance of loans to smaller non-financial firms and households, as well as debtors with lower credit quality. Following the April 2020 decisions, the nine NCBs with already existing ACC frameworks modified them, and eight additional NCBs created a new ACC framework³¹, often in parallel with government measures such as COVID-19-related guarantee schemes whose guarantees usually cover 70%-80% of the loan amounts. Many of these ACCs are assessed by ICASs, not least for the credit quality of the non-guaranteed part of the COVID-19-related government guarantee schemes. The Eurosystem can thus lend against the full loan amount, minus of course a valuation haircut that depends on the credit quality and other loan characteristics.

The ECB also created the possibility for NCBs to make use of additional credit assessment systems for ACC purposes. In the course of 2020, several NCBs with an ICAS decided to follow the example of the BdI (see Antilici et al., 2020) and started to complement their existing ICASs with more resource-efficient statistical ICASs (S-ICASs), appropriately calibrated to facilitate the assessment of a wider range of debtors while ensuring adequate risk protection. They assess a larger number of SMEs than traditional ICASs, thus widening the scope of potentially eligible credit claims rated within the Eurosystem.

³⁰ See de Guindos and Schnabel (2020) for a more detailed description of the measures and their purpose. The ECB Governing Council decided on 10 December 2020 to extend the pandemic-related collateral easing measures until June 2022.

³¹ See the ECB website for an updated list of the accepted ACC frameworks (https://www.ecb.europa.eu/explainers/tell-me-more/html/acc_frameworks.en.html) and Tamura and Tabakis (2013) for the initially accepted ACC frameworks.

2.3.4 Use of ICASs beyond Eurosystem monetary policy operations

The credit quality assessments for NFCs provided by ICASs have proven useful beyond standard monetary policy operations. In particular, ICAS ratings have been applied for economic studies and financial stability analyses (see, for example, Cahn et al., 2018, and Calza et al., 2021). For macroprudential and microprudential supervision, ICAS ratings provide helpful benchmarks for banks' IRB systems and the estimation of allowances and provisions for credit risk losses, as well as input for stress testing exercises. As an example, the BdF recently used its ICAS rating model for a climate-related stress-testing exercise (see Allen et al., 2020). Finally, ICAS ratings serve statistical purposes. For example, the BBk uses the data collected for its ICAS as an input for its financial statement data pool, which is often used on an anonymised basis for macroprudential and microeconomic studies on topics such as supervision, financial stability, and monetary policy issues (see, for example, von Kalckreuth, 2001). Similarly, ICAS information is used by the Bdl and the BdE for periodic financial stability publications, as well as for research purposes (see, for example, Iannamorelli et al., 2020, De Socio et al. 2020, and Blanco et al., 2020).

Recently, some governments have started to use ICAS ratings in the context of awarding public grants, advances or guarantees in order to monitor the performance of companies that have benefited from public funds, and thus to measure the impact of their policies. In France, for example, access to ICAS ratings has been granted to regional councils (in the context of awarding public grants and advances) and to state agencies involved in the prevention and handling of financial difficulties for firms.

Furthermore, in some jurisdictions ICAS ratings have played a major role in the provision of emergency liquidity assistance (ELA) by NCBs. In this regard, the perimeter of NFCs eligible for ELA is expected to be higher than that for monetary policy operations. Nonetheless, a fast and accurate risk measure of potential collateral is also needed for ELA operations. Additionally, the organisation, infrastructure and skills required to run an ICAS become very valuable in assessing additional asset types accepted as collateral in an ELA.

Apart from NCBs' internal uses, ICAS ratings may also be useful for other economic agents. In particular, both credit institutions and NFCs may potentially benefit from ICAS ratings (see, for example, Schirmer, 2014). To this extent, the existence of an independent qualified opinion on the credit quality of an NFC provided by the ICAS rating and, in particular, the eligibility of the company's credit claims as collateral for monetary policy operations may be important information for both parties in the negotiation process to grant financing and set the terms of loan agreements. The relevance of this use may vary between countries, depending on the NCB's communication policy of its ICAS ratings to credit institutions and NFCs.

Additionally, the BdF's ICAS is the only ICAS whose ratings may be used by credit institutions to calculate their regulatory capital requirements. This is possible because the BdF's ICAS has been recognised as an "external credit assessment institution" by the relevant regulatory authorities.

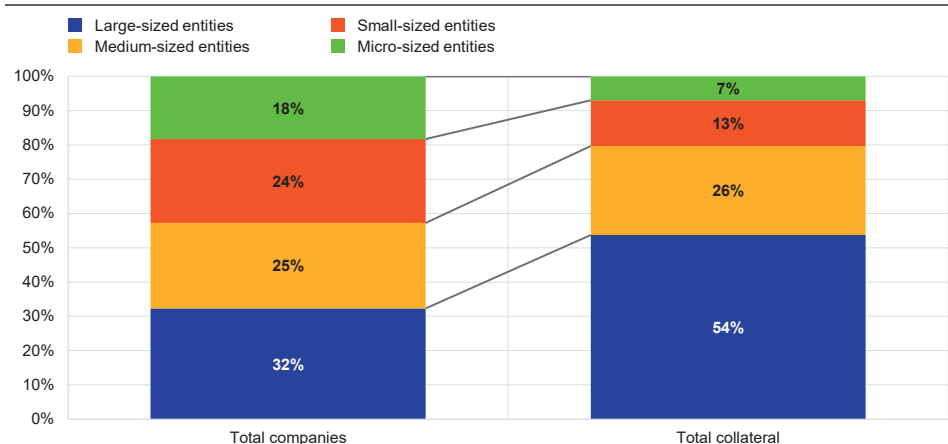
2.4 ICASs' portfolio composition and relative usage

This section³² aims to provide a better understanding of ICASs' portfolio composition (size and sector distribution of rated NFCs) and relative importance for assessing the credit quality of non-marketable collateral in the Eurosystem's credit operations.

On average, one-third of the companies assessed by ICASs are large-sized and two-thirds are SMEs (see Chart 3). Within the SMEs, companies are fairly evenly distributed among the different sizes (medium, small and micro). In terms of collateral mobilised by size, large companies account for the highest share (54%), followed by medium-sized (26%), small-sized (13%) and micro-sized companies (7%).

Chart 3

Size distribution of companies assessed by ICASs compared to collateral mobilised



Notes: Data as at 30 June 2020. Total figures are calculated as a simple average of the percentages of the individual ICASs.

Chart 4 shows the number of companies and collateral mobilised distributed by the company's sector of economic activity. In particular, the ten sectors explicitly represented in the chart are those with a weighting higher than 5% in terms of number of entities or collateral mobilised by all ICASs. The remaining five sectors³³ have been grouped in the category "other activities".

ICASs cover a wide range of sectors with their ratings. A third of the sectors (5 of 15) account for approximately 60% of all companies and collateral mobilised by ICASs. Regarding the number of companies, the sectors "other services", "wholesale trade", "retail trade", "food products" and "real estate" have the highest share. Measured by the collateral mobilised, the most important sectors are "other services", "financial services"³⁴, "real estate", "energy" and "transportation".

³² All the ICAS figures provided in this section include the ratings which rely on a combination of quantitative models with expert assessment (full ICAS ratings) but not the ratings based on a purely statistical assessment (S-ICAS ratings, see Box 1).

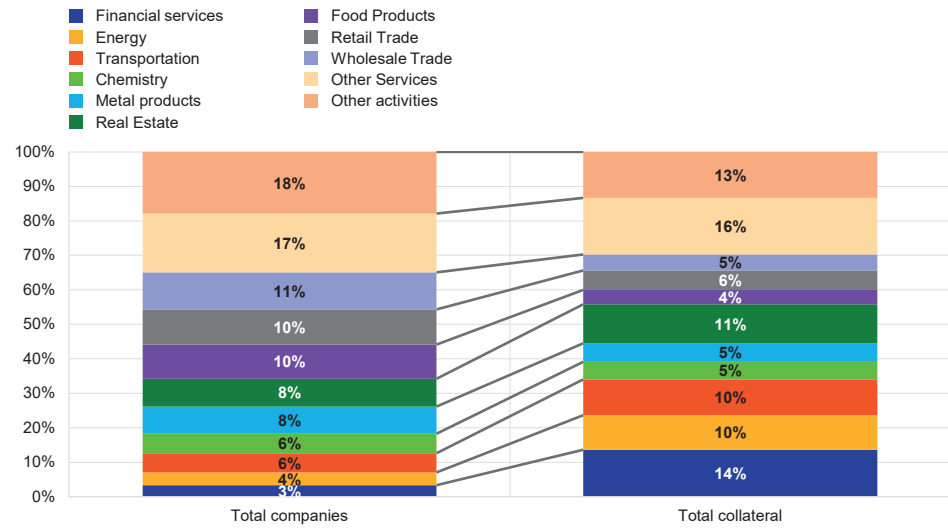
³³ Other manufacturing, machinery and equipment, vehicle manufacturing, construction and information and communication.

³⁴ The European System of Accounts (ESA) sector classification is the relevant one for the definition and therefore eligibility of NFCs, whereas the NACE classification may differ. This explains why certain corporations providing financial services are still part of the corporations rated by ICASs. This sector category corresponds to NACE code 64 "Financial service activities, except insurance and pension funding". Particularly, NFCs classified as holding companies (NACE code 6420) are included in this sector category.

Differences between ICASs in terms of size and sector composition of the rated companies may arise for several reasons. For example, the differences may be due to heterogeneities in the productive structure of the country's economy or the different purposes of each ICAS beyond the Eurosystem's monetary policy operations (see Section 2.3.4).

Chart 4

Sector distribution of companies assessed by ICAS compared to collateral mobilised



Notes: Data as at 30 June 2020. Total figures are calculated as a simple average of the percentages of the individual ICASs.

3 The Eurosystem's guidelines for ICASs

3.1 Overview of the system

A core principle of the ECAF is to ensure consistency, accuracy and comparability with regard to the accepted credit quality assessment systems. For this purpose, the Eurosystem has outlined a series of common rules to be followed by NCBs when operating an ICAS, both in the initial acceptance phase and in the regular usage of the system.

The main aim of credit assessments through ICASs is to evaluate the credit quality of any NFC that is an issuer, debtor or guarantor of eligible collateral.³⁵ This principle does not prevent ICASs from also being used for other purposes, such as banking supervision, assessment of financial stability from a macroprudential perspective, statistical purposes, economic studies and publications (see Section 2.3.4).

Credit ratings issued by ICASs are not subject to the Credit Rating Agencies Regulation³⁶ inasmuch as, in line with its Article 2, they (i) are not paid for by the rated entity³⁷; (ii) are not disclosed to the public; (iii) are issued in accordance with the principles, standards and procedures which ensure the adequate integrity and independence of credit rating activities as provided for by this Regulation; and (iv) do not relate to financial instruments issued by the respective central banks' Member States.

Nonetheless, ICASs have to comply with certain standards which reflect industry best practices in terms of organisation, resources and governance and are aimed at guaranteeing an adequate system structure for the purposes for which it has been designed. These Eurosystem standards/guidelines ensure that ICAS ratings follow principles, standards and procedures that establish at least the same level of integrity and independence that is required by the Capital Requirements Regulation for credit rating agencies and banks' IRB models. In this respect, ICASs should ensure that (i) the development of methodologies, (ii) validation and performance monitoring, and (iii) the rating of entities are allocated to different units managed by different personnel. The number of resources dedicated to the credit assessment should be commensurate with the number of rated entities.

ICASs may assess NFCs of any industry, size and/or legal form; ICAS NCBs should inform the Eurosystem about the criteria used to select the entities to be assessed by the system, for example in terms of sector and size. Monetary policy counterparties can request a rating for a specific NFC upon submission of assets to be potentially mobilised as collateral.

³⁵ Public sector entities may only be assessed by ICASs pursuant to Article 87(2)(c) of Guideline (EU) 2015/510 (ECB/2014/60) (GD) if they

- (a) belong to S.13 according to the ESA 2010 sector classification;
- (b) conduct business that could be done by a non-financial corporation; and
- (c) have at least as comprehensive and quantitative information available as required for the assessment of non-financial corporations by an ICAS.

³⁶ Regulation (EC) No 1060/2009 and its subsequent amendments.

³⁷ There is neither a contractual relationship between the NFCs and the ICAS NCB, nor any legal obligation for these corporations to provide non-public information to the ICAS NCB; any information is provided on a voluntary basis.

A procedure for exchanging rating information between ICASs has been agreed for cases in which there are legal or economic links between NFCs located in different European jurisdictions. All information exchanged between NCBs and that is not in the public domain must be kept confidential.

3.2 Credit risk measures: default probability and risk classes

ICASs measure credit risk as the probability of default (PD) over a one-year horizon, based on a common and harmonised default definition (see Section 3.6 for a detailed description). The output of a credit assessment is the assignment to a rating class that exclusively reflects the underlying risk of default for a given obligor. As described in Section 2.2, the conduct of monetary policy operations requires adequate collateral with high credit standards. These standards are ensured by requiring a minimum rating or its quantitative equivalent in the form of an assigned annual PD, which is mapped to the CQSs on the Eurosystem harmonised rating scale (see Table 1).

In general, the PD is defined as the forward-looking forecast of the likelihood that a particular obligor will default over a fixed assessment horizon. The PD itself is unobservable because the event is stochastic. The only quantity statistically observable is the empirical default frequency.

Depending on the rating philosophy and the modelling choices, the calculated PD can have different properties, i.e. a one-year-default PD can be point-in-time or through-the-cycle.³⁸ The assignment of companies to rating classes is based on an ex ante estimation of the PD.

An ICAS rating scale must have a minimum of seven grades or rating classes for non-defaulted obligors and one for defaulted obligors, but most ICASs actually have around 20 grades.³⁹ Each ICAS has to establish the structure of its rating scale, the granularity and the individual PD intervals associated with each class.

3.3 Rating process

The ICAS rating process consists of a quantitative and a qualitative stage plus the confirmation of the rating proposal by the rating approver. As a result, each credit assessment is characterised by the combination of a quantitative approach and an expert assessment. First, the statistical model that produces the statistical rating is applied. In a second step, the rating analyst typically confirms or overrules the statistical rating to come to a rating proposal. Finally, the rating proposal must be validated by a second analyst, who also ensures the consistency of the ICAS process (four-eyes principle) to yield the final ICAS rating.

The Eurosystem's guidelines for ICASs pay particular attention to the cornerstones of accuracy, consistency and comparability in the rating activity while at the same

³⁸ For a general discussion about these properties, see Basel Committee on Banking Supervision (2005). See also Cesaroni (2015).

³⁹ See Table 2 in Section 4.

time allowing for some flexibility in the implementation. For instance, concerning the statistical model, there is a set of quality criteria that have to be met in terms of discriminatory power and calibration accuracy, but the statistical models employed may vary across the ICASs. Furthermore, the framework describes a minimum set of risk factors to be taken into account, including firm-level financial and risk information derived from financial statements.

The expert analysis takes into account additional quantitative and qualitative information not already considered in the statistical model and follows strict rules and guidelines to ensure the consistency and comparability of rating decisions. Additional financial information, for example, includes payment incidents, default signals and legal proceedings for rating decisions. Any adjustment made on the basis of an expert assessment must be properly documented. Qualitative information impacting the assigned rating (such as press releases or economic prospects of the branch of activity of the company) must be precisely detailed and traced in the different rating tools. In order to avoid any conflict of interest, there are ethics codes that determine the rules to be followed in case of conflicts of interest (such as the submission of the rating file to a rating committee collegiate procedure). A rotation mechanism is also in place so that an analyst does not rate the same company for more than four consecutive years.

A company's rating is reviewed every 12 months and is updated when new material information (such as new financial statement data) becomes available. The rating is valid for up to 24 months after the closing date of the financial statement used for the rating.

3.4 Key risk factors

The main goal of the ICAS rating process is to assess in a standardised and structured way the key risk indicators that affect an enterprise's ability to meet its financial obligations when they fall due. In line with industry standards for credit risk assessment, numerous characteristics are considered when analysing an NFC. The assessment covers a corporation's strengths and weaknesses, such as its market position, its market share or its growth relative to the market. The rating also considers the legal form and size of the enterprise as well as its links with a parent and subsidiary companies, i.e. the group structure. The evaluation of the management may include an opinion on the general quality of management, its future plans and its track record. The assessment of payment behaviour and access to external financing such as bank loans, bond markets and stock markets is reflected in the analysis of financial flexibility. The analysis of the industrial and economic environment includes the nature of competition in the industry and the pattern of business cycles.

A key aspect in the rating process is the analysis of financial ratios, which cover all areas of relevance for analysing financial soundness, i.e. (i) the ability of the enterprise to generate cash from its operations to meet current financial obligations, (ii) the balance between its short-term debt and its liquid assets, (iii) the balance between its total debt and its assets, and (iv) the ability of the enterprise to make profits. The individual ratios of an enterprise may be compared with reference values for its industry and/or a peer group of its competitors, and the evolution over time is

also considered. Furthermore, the rating process is tailored to distinguish national versus international accounting, legal and institutional peculiarities as well as industry-specific factors. While statistical models allow for a standardised assessment of these aspects, the expert analysis serves to identify company-specific extraordinary effects which might otherwise bias the rating.

The risk assessment methodology is generally applied to all enterprises in a uniform way. Nevertheless, differences in the breadth and depth of the analysis of individual enterprises may prevail depending on the size, legal form and/or industry of that corporation as a result of differences in data availability.

3.5 Data sources

The primary data source for financial information on NFCs is the final or interim financial statements. The financial information should cover all relevant activities of the enterprise and, if applicable, additional financial information on groups and affiliated enterprises.

ICASs put strong emphasis on using for their analyses only high-quality data from complete, timely and checked financial statements. To this end, ICASs document in detail the set of data used in the credit quality assessment process, the information sources which provide those data, the timetable and frequency of data collection and the quality control mechanisms in place to ensure on an ongoing basis that the data are of a sufficiently high quality.

Besides financial statement data, information on the NFC from commercial registers and other publicly available sources such as private credit bureaus, data providers and rating assessments from other rating sources is taken into account. In addition, confidential data available to the Eurosystem such as information from the National Credit Register and AnaCredit is considered in the ICAS rating process.

3.6 Default definition

ICASs have to identify the default situation of the rated NFCs for all credit assessment-related tasks (modelling, use and validation). For this purpose, ICASs make use of the information provided by banks via AnaCredit and the National Credit Register, as part of which banks must report defaults according to Regulation (EU) No 575/2013 (CRR). The ICAS default definition relies on Article 178 of the CRR, which sets forth that a default occurs when a bank considers that the obligor is unlikely to pay its credit obligations or the obligor is past due more than 90 days on any material credit obligation to the bank.

The default definition aggregates the whole default information for a given obligor available to an ICAS to a single default indicator reflecting the materiality of the default information. The materiality of the default information is calculated by dividing the aggregated defaulted exposure of a corporation towards banks by the cumulated total credit exposure of that corporation. Information on default events as well as on credit exposures is obtained by the ICASs through AnaCredit and/or the National Credit Register.

Regarding the use of the models, ICASs must monitor their ratings on an ongoing basis. One of the relevant aspects to be considered in the monitoring process is the information on the default signals reported monthly to AnaCredit and/or the National Credit Register. ICASs analyse the updated default information and the potential impact on credit ratings depending on the intensity of the default signal and adjust the rating if needed.

3.7 IT system architecture

The IT system architecture refers to the full range of applications and processes which support the ICAS rating process. This architecture contributes both to improve the speed at which information becomes available and hence rating decisions can be made as well as to reduce the risk of data errors with a high degree of automation. Furthermore, the IT system architecture ensures several aspects such as the continuity of the ICAS business, the confidentiality of data, the regular backup of input and output data of the ICAS and the recording of each step of the credit assessment process.

Overall, to support a reliable process and a good combination of quantitative and qualitative approaches, the IT tools must be flexible, contain consistency checks on qualitative information and ensure the traceability of the analysis conducted by experts.

3.8 Monitoring and internal validation

ICASs should guarantee that their credit assessment systems are adequate for the purposes for which they have been designed. This function must be carried out by a unit independent from those responsible for the development of methodologies and the rating of entities (preferably in the remit of the risk management divisions or departments of each NCB).

The validation unit must issue an independent and qualified opinion on the adequacy of the credit assessment systems both when they are intended to be implemented and on an ongoing basis once they are in place.

The validation encompasses both quantitative and qualitative elements. From a quantitative perspective, the validation of the discriminatory power (the ability of the model to discriminate between good and bad cases, i.e. whether a default will occur or not) and the correct calibration (whether the rating model is assigning correct PD estimates to obligors) of the credit assessment systems are particularly relevant. Regarding the qualitative validation, aspects such as the consistency of methods and data over time, the control procedures in place to ensure the consistency, accuracy and comparability of credit assessments and the unbiasedness of the expert system are periodically validated.

The internal ICAS validation at the NCB level is complemented at the Eurosystem level with an initial one-off validation and the annual performance monitoring exercise applicable for all ECAF-accepted credit assessment systems as described in Section 3.9 below.

3.9 ECAF validation and monitoring

ICASs are subject to both rigorous one-off validation and ongoing performance monitoring within the ECAF, in compliance with a set of principles aimed at ensuring a minimum level of validation and enhancing comparability between credit assessment systems.

The one-off validation is carried out in the context of the initial acceptance of the system or when the NCBs request a significant change or an extension of an already accepted ICAS. It entails a range of quantitative and qualitative analyses aimed at assessing the accuracy of the risk estimates, the validity of the processes used to produce these estimates and the effectiveness of the control procedures in place to ensure the accuracy of the estimates over time.

On an ongoing basis, ICASs are requested to have systematic approaches in place for the early detection of any deficiencies in the system. In this regard, the models/methods used undergo yearly performance monitoring and should be recalibrated once a year if the performance monitoring indicates that this is necessary.

Like all ECAF-accepted credit assessment systems, ICASs are subject to the ECAF performance monitoring process (see Section 2.2). The quantitative component of this performance monitoring consists of a single-period (annual) and a multi-period (five-year) back-testing rule to check if the realised default rate of the assessed credit assessment system is within a tolerable range of each CQS's respective PD threshold. In case of deviations, the mapping of the ICASs' rating grades to the harmonised Eurosystem rating scale is adapted.

To complement the ECAF performance monitoring, ICAS NCBs have to submit to the ECB on an annual basis (i) the results of a minimum level of information on the internal model validation for ICASs (the tests should ideally be conducted for the statistical and final ratings), and (ii) the assessment of the unbiasedness of the expert system that incorporates qualitative information in the overall assessment.

Moreover, in order to ensure transparency and to enable continued monitoring, ICAS NCBs should provide the ECB annually with an updated version of the minimum documentation that they maintain for ECAF purposes, and which describes the rating processes and methodologies of the system. This documentation should be accompanied by a concise summary of any updates to the ICAS's methodologies that took place since the beginning of the year or that are anticipated in the near future, as well as recommendations of possible audits and action plans.

4 National ICASs – features and cross-comparison

This section summarises how all ICASs comply with the set of requirements outlined in Section 3 and how each ICAS differs in terms of its specific implementation, within the bounds set by Eurosystem requirements. More detailed descriptions of the individual ICASs' features are included in the annex.

For all ICASs, the credit rating refers to a PD over a one-year prediction horizon, which is in most cases a point-in-time estimate resulting from the statistical model, with a more forward-looking through-the-cycle perspective after applying the expert analysis.

The PD estimates are categorised into risk classes on the internal rating scale. For monetary policy purposes, the ratings are mapped to the CQSs of the Eurosystem harmonised rating scale.

All ICASs only use timely available data. The balance sheet information used for the assessment must not be older than 18 months.

In addition, all rely on credit register data. Additional credit register information such as credit history and utilisation of credit lines is used by all ICASs in the expert system, while three ICASs (the Bdl, the BdE and BS) also use it as an input for the statistical model. The ICASs using the Common Credit Assessment system (CoCAS; currently the OeNB and the BBk) also take into account rating data from other sources in the calibration process.

The rating process is composed of a statistical model stage as well as an expert analysis stage. Within such boundaries, each ICAS differs in terms of its specific implementation.

In terms of statistical model choice, the logistic regression is a common underlying feature across the different approaches, as well as the use of different sub-models accounting for industry sectors. In particular, ICASs can be divided into two main categories: those following a pure logistic regression approach (the BdE, the BdF, the Bdl, BS and the BdP) and those using a common proprietary approach named CoCAS (the OeNB and the BBk). Overall, the first group of NCBs opted for a logistic regression approach due to its better readability for the analysts in charge of the expert assessment stage. The CoCAS approach of the second group is based on a combination of consensus methodology and linear regression, with a view to ensure that the results are close to the market opinion. Further research is in progress among some NCBs regarding the use of more recent approaches (such as machine learning) for credit risk estimation.

The expert system always encompasses some basic analysis profiles such as financial statement, sector and business risk, and group and third-party analyses; some analysis profiles (trend or benchmarking analysis) are instead assessed by some NCBs only. The integration of ESG factors in the ICAS methodology is in progress among the ICAS NCBs, and some of them have already started to include relevant ESG indicators in the rating process (see Box 2). Based on the four-eyes

principle, a control step carried out by experienced analysts is included in all the ICASs' processes to strengthen the assessment.

The number of ratings produced for ordinary monetary policy operations (including both quantitative and expert analysis) differs significantly across ICASs, spanning from hundreds to several thousands. A few ICASs also produce purely quantitative ratings that can be used, besides economic analysis purposes, for those monetary policy operations foreseen by temporary frameworks or extraordinary monetary policy measures (see Box 1).

From an organisational perspective, the cross-ICAS comparison shows some differences in terms of the functional unit in which the ICAS activity is conducted (market operations, risk control, statistics, etc.). Five ICASs produce ratings from a different operational unit than the one in charge of the development of methodologies. The same applies for the reliance on central banks' local branches, with some ICASs following a decentralised approach and others relying only on the central bank's headquarters only.

The annex presents a detailed description of each of the seven ICASs, highlighting specificities as well as similarities in their approaches. Table 2 summarises the main findings of this comparison.

Table 2
Cross-comparison of the main features of ICASs

		OeNB	BBk	BdE	BdF	Bdl	BdP	BS
Output	Prediction horizon of credit rating	1 year	1 year	1 year	1 year	1 year	1 year	1 year
	Point-in-time/through-the-cycle	PIT	PIT	PIT/TTC	PIT/TTC	PIT/TTC	PIT	PIT/TTC
	Rating scale (number of grades)	20	20	21	21	19	20	14
Methodology	Quantitative assessment approach	Consensus approach	Consensus approach	Fractional logistic regression	Segmentation algorithms and adjusted logistic regression	Logit model	Logit models	Logistic regression
	Number of different sector models	12	12	4	12	6	11	2
	Categories considered in human analysis	8	8	5	15	8	7	4
Production	Number of full ratings	7,000	26,000	500	270,000	4,000	250	500
	Number of statistical ratings	-	-	~950,000	-	350,000	38,000	30,000
Organization	Development of methodologies	Statistics Department - Model Development and Secondary Statistics Unit	Directorate General Markets	Rating Methodologies Unit (Financial Risk Department)	Corporate Methodology Division	Risk Management Directorate	Statistics Department - Sectorial Analysis Unit	Banking Supervision
	Rating of entities	Statistics Department - Statistical Analysis and ICAS Unit	Regional offices	Rating Assessment Unit (Financial Risk Department)	Branches	Branches and Risk Management Directorate	Statistics Department - Credit Assessment Unit	Banking Supervision
	Involved branches	1	9	-	115	15	1	-

Box 2

ESG factors and ICAS ratings

There is a growing general consensus that ESG risk factors may have a relevant impact on credit risk: ESG factors, including climate change risks, can affect borrowers' cash flows and the likelihood that they default on debt obligations.

ESG-based approaches, which assess the performance of a company in relation to ESG criteria, add value by providing information that traditional financial analysis does not take into consideration: these non-financial elements may have a significant impact on the market position or even the solvency of a company, especially in a long-term forward-looking perspective. To this effect, ICASs have already been working on achieving a consistent and adequate measurement and incorporation of ESG factors into credit ratings, and substantial progress is envisaged.

Currently, ICASs have heterogeneous approaches towards the incorporation or consideration of ESG factors within their rating models and methodologies. When environmental factors are included in the rating methodologies, this is usually done within the expert assessment. Incorporating ESG factors into credit ratings and disclosing which factors are relevant and material for a rating assignment may not be straightforward in a context of limited availability of sufficiently harmonised and homogeneous data to be used for a statistical analysis.

To face this challenge, some ICASs have started collecting green finance data, drawing also on financial statements that refer, for example, to CO₂ emissions where available, as well as ad hoc questionnaires. In other cases, information on this topic is collected through interviews with companies, the analysis of their sustainability, corporate governance and audit reports, sector analysis, and the assessment of key performance indicators. The improved information availability expected from the introduction of the Corporate Sustainability Reporting Directive will widen the possibilities to include environmental considerations in the ICAS ratings.

Current efforts by ICASs focus on the selection of ESG indicators to be included in the statistical model or in the expert model; for example, within the latter, ESG factors may be fully incorporated in the system of soft indicators by standing as a category on their own. The ECB will consider developing minimum standards for the incorporation of climate change risks into its internal ratings.⁴⁰

⁴⁰ See the press release in which the ECB presents its action plan to include climate change considerations in its monetary policy strategy (https://www.ecb.europa.eu/press/pr/date/2021/html/ecb.pr210708_1~f104919225.en.html).

5 Conclusion

This paper analyses in detail the role of ICASs in the context of the Eurosystem's monetary policy operations. ICASs are an important tool for the effective credit risk management of loans to NFCs accepted as collateral in Eurosystem credit operations. They contribute to the transmission of monetary policy not least in times of crisis and are used also for other purposes, such as macroprudential and microprudential supervision.

The paper also describes the Eurosystem's guidelines and requirements for ICASs in terms of, *inter alia*, the estimation of default probabilities, the role of statistical models versus expert analysis, input data, validation analysis and performance monitoring. To complete the comprehensive overview on ICASs, the main features of each of the ICASs currently accepted by the Eurosystem as credit assessment systems are explained, and similarities and differences are highlighted. The number and relevance of ICASs for the Eurosystem may further increase in the future, also in the context of the Eurosystem's envisaged work to incorporate climate change in risk assessments.

Annex – Features of national ICASs

A.1 Oesterreichische Nationalbank (OeNB)

A.1.1 Statistical model

Overview

The OeNB uses CoCAS, a joint project with the BBk for its ICAS. CoCAS consists of a novel estimation procedure used to calibrate the statistical models as well as an IT platform to manage the workflow and integrate the expert system. The providers (BBk and OeNB) offer the system to interested Eurosystem NCBs. The BBk and OeNB have fully harmonised the calibration process of the statistical models and pool their data. This leads to a common model for financial statements following the International Financial Reporting Standards (IFRS) and 11 common models for different economic sectors of financial statements according to the national generally accepted accounting principles (nGAAP). After the calculation of the statistical model's rating proposal, which takes into account balance sheet information, an expert analysis is carried out which incorporates additional quantitative as well as qualitative data. The output of the ICAS at each stage is an issuer-specific rating class associated with a point-in-time, one-year PD.

Calibration approach and data

The CoCAS models are estimated on the basis of the proprietary consensus methodology, which, in addition to default data, also takes into account rating data from other rating sources in the calibration process to improve the predictive power of the credit risk model.

In a first step, the biases inherent in the rating data from different sources are corrected via a mixed effects model, leading to a consensus rating for each balance sheet. In a second step, the consensus rating is explained in a linear regression using balance sheet information. In the last step, the predictions from step two are compared with the realised default rates, and the level of the PD estimates is adjusted if needed.

For each model, a five-year rolling window of the data is used and the models are regularly recalibrated. The score produced by the model is mapped to the rating classes and serves as input for the expert system.

Expert assessment

The starting point for the expert analysis is the statistical rating, which is based on the most recent financial statements of the NFC or group. The expert analysis is

structured into eight categories (“company/market”, “balance sheet and income statement”, “statistical model”, “trend analysis”, “benchmarking model”, “ownership/holding structure”, “additional information” and “opinion of third parties”). For each category, the analyst can assign an upgrade by one notch, a downgrade by one notch or no change. The outcomes for each category are summed up and added to the statistical rating, which yields the individual or group rating. For legal entities belonging to a group, the rating of the group is subsequently considered as a rating ceiling for the stand-alone rating, i.e. the individual entity cannot be rated better than the group. In addition, the stand-alone rating is upgraded by up to three notches in case the group rating is better. Following the rating analysis by the analyst, the rating must be approved by a senior analyst in order to comply with the four-eyes principle. If the analyst and the approver come to diverging conclusions or relevant information cannot be sufficiently reflected in the standardised rating process, the rating is forwarded to the rating committee, which takes a decision. As part of the expert system, information on climate change-related risk factors (e.g. CO₂ emissions) is collected.

Model validation

The validation of the OeNB’s ICAS covers the prerequisites set forth in the Eurosystem’s internal requirements plus additional procedures. The validation function assesses the calibration quality and the discriminatory power based on the statistical models as well as on the final ratings in out-of-sample analyses. The validation function is involved in all steps of the calibration process, from data preparation to model selection and model implementation, and advises on further improvements. In addition, the OeNB’s Internal Audit Department performs triannual audits which, as well as comprising an overall assessment also focus on a specific component of the ICAS. For the expert analysis, the OeNB applies a rotation mechanism such that an entity cannot be rated more than four consecutive times by the same analyst. After that, a banning period of one year applies.

A.1.2 Organisation

Scope of rated entities

The OeNB’s ICAS assesses around 4,300 NFCs per year (leading to around 7,000 ratings), and ratings are supplied either at the request of the NFC or a bank, or on the initiative of the OeNB. A prerequisite is the availability of comprehensive high-quality information (e.g. balance sheet data), while the priority for establishing a rating depends on the size of the NFC.

Set-up

The OeNB’s ICAS is part of its risk management function, which is distributed over several organisational units. The responsibility for the OeNB’s ICAS including the collection of financial statement data lies with the Statistics Department in the

Supervisory Statistics, Models and Credit Quality Assessment (SAMBA) Division, while the Statistics – Data Governance, Master Data and Bank Resolution Division supports the ICAS in the collection of credit register and master data. Within the SAMBA Division, a separation of duties between model development, credit assessment and validation is ensured by assigning these tasks to different units. In addition, OeNB West (a branch located in Innsbruck) contributes to the credit assessment as well as the data collection.

A.2 Deutsche Bundesbank (BBk)

A.2.1 Statistical model

Overview

The BBk uses CoCAS, a joint project with the OeNB for its ICAS. CoCAS consists of a novel estimation procedure used to calibrate the statistical models as well as an IT platform to manage the workflow and integrate the expert system. The providers (BBk and OeNB) offer the system to interested Eurosystem NCBs. The BBk and OeNB have fully harmonised the calibration process of the statistical models and pool their data. This leads to a common model for financial statements following the IFRS and 11 common models for different economic sectors of financial statements according to the nGAAP. After the calculation of the statistical model's rating proposal, which takes into account balance sheet information, an expert analysis is carried out which incorporates additional quantitative as well as qualitative data. The output of the ICAS at each stage is an issuer-specific rating class associated with a point-in-time, one-year PD.

Calibration approach and data

The CoCAS models are estimated on the basis of the proprietary consensus methodology, which, in addition to default data, also takes into account rating data from other rating sources in the calibration process to improve the predictive power of the credit risk model.

In a first step, the biases inherent in the rating data from different sources are corrected via a mixed effects model, leading to a consensus rating for each balance sheet. In a second step, the consensus rating is explained in a linear regression using balance sheet information. In the last step, the predictions from step two are compared with the realised default rates, and the level of the PD estimates is adjusted if needed.

For each model, a five-year rolling window of the data is used and the models are regularly recalibrated. The score produced by the model is mapped to the rating classes and serves as input for the expert system.

Expert assessment

In the expert assessment, the analysts of the regional offices of the BBk examine additional information not covered by the models in order to determine the final rating class. A scoring method is used to ensure a consistent approach across all regional offices and to contribute to the greater transparency and comprehensibility of the final credit assessment.

There are eight predefined categories to be taken into account during the expert analysis: (1) quality of corporate management, (2) market and sector information, (3) reliance on third parties, (4) significant ratio-distorting one-off effects and special factors, (5) the relative market position and trends of the enterprise, (6) current developments, (7) other enterprise-specific information and (8) third-party opinions. Besides the eight categories, defaults reported to AnaCredit and the National Credit Register are also considered. In addition, the rating is subject to the overall assessment of any group to which the enterprise belongs. A ninth category considering ESG aspects is currently being developed in order to integrate ESG-related risks and opportunities in the rating assessment process. To date, these aspects have been considered separately in the three categories of management, market and sector information and other enterprise-specific information, wherever they were available. As part of the expert system, information on CO₂ emissions is also collected, with the aim of eventually incorporating this in future models.

The starting point for the expert assessment is the rating class proposal computed by the statistical model. For each of the eight categories to be evaluated, the analyst decides whether the aspects justify a deviation from the proposal. For each category, the analyst can assign an upgrade by one notch, a downgrade by one notch or no change. The outcomes for each category are summed up and added to the statistical rating, which yields the individual or group rating. For legal entities belonging to a group, the rating of the group is subsequently considered as a rating ceiling for the stand-alone rating, i.e. the individual entity cannot be rated better than the group. In addition, the stand-alone rating is upgraded by up to three notches in case the group rating is better. The sum of these deviations and after applying the group and default framework results in the final rating class.

Following the rating analysis by the analyst, the rating must be approved by a senior analyst in order to comply with the four-eyes principle. If the analyst and the approver come to diverging conclusions or relevant information cannot be sufficiently reflected in the standardised rating process, the rating is forwarded to the rating committee, which takes a decision.

A rating committee is involved in particular in the following cases: disagreeing viewpoints about the credit assessment, enterprises of supraregional importance (turnover of more than €1 billion) or a change of the eligible status.

Model validation

The models are validated on a yearly basis as well as occasionally. To this end, the discriminatory power and the calibration quality of both the statistical models and the final ratings (after expert assessment) are assessed. Tests are conducted on an in and out-of-sample basis.

The validation of the BBk's ICAS covers the prerequisites set forth in the Eurosystem's internal requirements plus additional procedures. The validation function assesses the calibration quality and the discriminatory power based on the statistical models as well as on the final ratings in out-of-sample analyses.

In addition, the BBk's Internal Audit Department performs annual to triannual audits which, as well as comprising an overall assessment, also focus on a specific component of the ICAS. For the expert analysis, the BBk applies a rotation mechanism such that an entity cannot be rated more than four consecutive times by the same analyst. After that, a banning period of one year applies.

A.2.2 Organisation

Scope of rated entities

The BBk collects approximately 26,000 financial statements per year, around 800 of which are the leading legal entities of a company group delivering consolidated financial statements according to the IFRS, and around 2,700 of which are the leading legal entities of a company group delivering consolidated financial statements according to the nGAAP. Around 7,000 assessed financial statements are from members of a group.

Of the companies assessed in 2019, around 13,000 were individual companies which had a valid rating from the BBk at the beginning of the year, i.e. they belonged to the non-financial sector, they were not previously in default, they had delivered a full annual financial statement according to the German Commercial Code or IFRS, and they had undergone a complete credit risk assessment procedure and received a final rating.

Set-up

The ICAS of the BBk is located at its central head office as well as its regional offices. Within the central head office, Directorate General Markets, Policy Issues relating to Monetary Policy Implementation Division, the section "Credit Risk Assessment" is responsible for ICAS-related tasks such as model development, definition of the system framework as well as the rules and procedures for the credit risk assessment process.

The credit risk assessment of entities is performed at the BBk's regional offices. Within each of the nine regional offices, there are units responsible for the credit assessment and the securities. The size of the individual units in the regional offices differs according to the size of the respective area of responsibility and the number of corporations assessed.

In December 2016, the Risk Control Division at the central head office took over full responsibility for validation and performance monitoring.

A.3 Banco de España (BdE)

A.3.1 Statistical model

Overview

The BdE's ICAS rating model comprises a statistical and an expert stage. The first provides an automatic rating based on the most recent financial statements of the company. In the second, the analyst incorporates in the final rating of the company all relevant aspects that the statistical model has not been able to capture.

The output of the BdE's ICAS is an issuer-specific rating on a credit rating scale consisting of 21 classes, where each rating class has an associated one-year PD.

The BdE's ICAS estimates fractional logistic regressions to order the firms based on their credit quality using a score calculated as a linear combination of a series of financial ratios. The financial ratio composition and their weights are different depending on the type and the economic sector of the company. Regarding the type of the company, different statistical models are considered for groups and individual companies based on their consolidated or stand-alone financial statements, respectively. Additionally, the statistical model for the construction sector differs from the one developed for other sectors.

Calibration approach and data

In a second phase, the risks associated with the statistical assessments provided by the fractional logistic regressions are quantified to reflect the NFCs' one-year PD. The calibration of the one-year PD uses as its main element the historical annual default rates observed in the five-year time span of the statistical models. The scores are grouped in a finite set of ranges, differentiated by the level of defaults observed in each interval. These levels are used to tie an estimated PD to each set of ranges and assign it to the corresponding rating class in the BdE's ICAS master scale.

Expert assessment

The proposed automated assessment from the statistical model is supplemented with more recent and forward-looking information gathered by the analysts. Economic or business events that are not contained in the financial statements due to a time lag between the date in which the statements were closed and when the events are communicated to the public can thus be taken into account. This is especially relevant when there are significant effects due to a sudden disruption.

Guidelines have been developed for credit analysts to assess each area, aiming at a uniform approach to the analysis, a minimum coverage of all relevant aspects and clear traceability of the final result. This methodological framework is important to have a homogeneous and consistent model among analysts. The BdE's ICAS expert

model involves the analysis of five blocks or areas, and the effect of each area is applied sequentially.

1. Statistical model analysis. This assesses the accuracy and consistency of the financial data used for the ratio calculation and takes into consideration one-off effects as well as comprehensive adjustments to complete the set of financial statements.
2. Financial risk profile. This complements the financial information taken into account in the statistical model. Less easily quantified indicators are assessed, such as trends, financial flexibility and financial contingencies not reflected in the balance sheet.
3. Business risk profile. Some specific characteristics of the sector(s) in which the company operates are assessed in order to determine of the proper development of its industrial activity as well as its competitive position.
4. Management risk profile. The quality of the management and the corporate governance are reviewed. Audit reports or penalties are used by the analysts as evidence for this risk.
5. Other information. This block allows for the review of any additional information (where available and significant) that may be relevant.

The analysis of the five blocks or areas of assessment makes up the stand-alone rating of the companies assessed. The analyst has to determine a risk score for each of the indicators assessed independently, following specific guidelines. Each indicator has a fixed weight, and the risk scores assume different levels of risk for each profile. The final score of the different profiles results in either an upgrade or a downgrade depending on a rating matrix. This assessment covers all ESG indicators with an impact on the credit risk of an NFC. The factors are incorporated in the financial risk profile, business risk profile, management risk profile and other information. It is important to highlight that these ESG factors are considered insofar as they could have an impact on NFCs' financial risk (in this case, credit risk). In this sense, short-term risks will always be more easily identifiable than long-term risks, for which the uncertainty of occurrence increases. This analysis is complemented with an assessment of (i) the interdependencies within the group, including the degree of relationship between an affiliate and its parent company and whether belonging to a group could have a potential impact on a company's credit quality; and (ii) the impact of additional alerts (information received from the National Credit Register, external providers, IRB systems and ECAIs). All the above results in the final rating proposed by the analyst. The credit assessment for each of the companies analysed must be discussed and approved by a supervisor (following the four-eyes principle). Each rating is also discussed and approved by a rating committee.

Model validation

The validation of the BdE's ICAS covers, on an ongoing basis, both the quantitative and the qualitative part of the credit assessment system. Quantitative validation comprises all validation procedures in which statistical indicators for the rating are

calculated and interpreted on the basis of an empirical dataset. Aspects such as discriminatory power and the calibration of the statistical models and final ratings are essential in this part of the validation. Additionally, the analysis of the impact of the expert model on the final ratings is also covered in this part of the validation. In contrast, qualitative validation ensures the applicability and proper application of the quantitative methods in practice and mainly focuses on model design, data quality and the internal use of the rating system.

A.3.2 Organisation

Scope of rated entities

The assessment scope of the BdE's ICAS encompasses large NFCs, both economic groups and individual companies. In order to use its resources more efficiently, the BdE's ICAS assesses NFCs with higher credit quality and higher volumes of credit claims. Upon specific request, the BdE's ICAS also assesses those NFCs whose credit claims are being used, or are likely to be used in the short term, by a counterparty. The BdE's ICAS assesses around 500 NFCs annually. In addition, "purely statistical" PDs are available for around 950,000 NFCs.

Set-up

The BdE's ICAS is currently hosted by the Financial Risk Department, which belongs to the Directorate General Operations, Markets and Payment Systems. The organisational structure of the BdE's ICAS is composed of three units. In particular, the Credit Assessment Unit (CA Unit) is responsible for the assessment of companies, the Rating Methodologies Unit (RM Unit) for the development of rating methodologies and the Validation and Monitoring Unit (VM Unit) for the validation of the rating process. The CA Unit and the RM Unit fall under the same division since they are expected to complement each other in the implementation of the BdE's ICAS. However, the VM Unit has been assigned to a different division within the Financial Risk Department in order to achieve a clear and effective differentiation of functions, as currently required by the ECAF. To that extent, the three units are managed by different personnel, and different staff members have been allocated to the three processes.

The BdE's ICAS is centralised at the bank's main premises, and no branch is involved in the ICAS assessment.

A.4 Banque de France (BdF)

A.4.1 Statistical model

Overview

The BdF's "theme-based catch-up mechanism" underlying its rating model is built on the basis of a statistical and an expert assessment. The statistical rating

methodology assigns a one-year point-in-time PD to a company based on the analysis of firm-level data from the previous accounting period. To obtain a final rating, the expert analysis incorporates an additional through-the-cycle component to the statistical rating by integrating a forward-looking assessment in the analysis. The output of the BdF's ICAS is an issuer-specific rating on a credit rating scale consisting of 21 classes.

The overall model comprises three sub-models ("approaches"): small firms, larger firms and consolidated groups. For the first two sub-models, seven economic sectors are identified, while for the consolidated group sub-model, the BdF identifies only five sectors. Within each sub-model, each sector is assessed separately. The financial ratios used may vary depending on the approach used for rating and the economic sector identified, their discriminatory power vis-à-vis the default indicator and their economic relevance. Specific rules also apply for holdings and real estate promoters.

The entire rating procedure is structured in three core stages that encompass a statistical and an expert assessment.

(i) The first step consists of a quantitative analysis based on a statistical rating model that uses balance sheet data. The model relies on four different steps. The first step is a variable selection process. The second is an optimisation algorithm that clusters the selected financial ratios into four themes and splits each ratio into multiple risk classes. The third step consists of a penalised logistic regression with coefficient adjustments that estimates an unbiased PD of NFCs. The fourth step relates the underlying PD with a rating class (i.e. statistical rating) through the definition of a master scale based on the inverse function of a smoothing cubic spline and an optimisation algorithm.

Financial ratios are selected according to two criteria: high discriminatory power in predicting defaults and financial relevance. The finally selected financial ratios are clustered into four different financial themes (or axes), i.e. profitability, financial autonomy, financial structure and liquidity, with each ratio being assigned to a single theme. For each theme, the ratios are then discretised into (ratio-specific) risk classes based on an algorithm similar to decision trees. At the end of this stage, each company is characterised by its allocation to four classes (one for each theme) according to the position of its financial ratios with respect to the unique combination of thresholds defined to segment the optimal theme-based classes. During the rating procedure, the expert can select a different risk class for a given company than the one automatically obtained with the algorithm.

In the subsequent logistic regression, the dependent variable is the default indicator, which is a binary variable following a Bernoulli distribution. The explanatory variables are the risk classes of the four aforementioned financial themes. These explanatory variables are categorical variables, which are modelled with dummies (i.e. one dummy for each risk class, under each theme) in order to allow the model to adapt to non-linear effects of the explanatory variables. Given the limited sample size of defaulted companies used for the model calibration and the quasi-separation of data in some samples, the BdF's ICAS uses an adjusted logistic regression (i.e. Firth's logistic regression with intercept correction and prudential adjustment), which uses a two-step estimation to ensure unbiased predicted probabilities while leaving unaltered the bias-corrected effect estimates. The first step consists of a logistic regression with Firth-type penalisation to obtain the bias-corrected estimates, and

the second step is an ex post re-estimation of the intercept of the model using an ordinary logistic regression with a constrained maximum likelihood. Between the first and the second step, a prudential adjustment to potential relative risk reversals is applied between two consecutive risk classes within the same financial theme. Finally, a master scale to assign probabilities to rating classes is defined using a smoothing cubic spline. This semi-parametric curve then allows the analysts to determine the PD thresholds required to assign firms to a “financial statistical rating”.

(ii) The second stage consists of a qualitative analysis. Qualitative profiles are defined for each company by means of an expert assessment and allow the financial statistical rating to be confirmed, upgraded or downgraded (see Section 6.4.1.3).

(iii) The last stage consists of a complementary qualitative analysis (based on specific events or the automatically collected characteristics of the company). A list of extra-financial contributions is set up for each company. Their impact is statistically predetermined but grants a degree of flexibility to the expert, who may in some cases modify the rating assigned in the previous steps to produce the global rating, by either upgrading (in the case of group frameworks) or downgrading (if the analyst considers the underlying risk posed by the extra-financial information to be significantly higher).

Calibration approach and data

The statistical models have been calibrated using a five-year rolling window of financial statements and default data. The calibration of the aforementioned statistical models is sector and approach-specific. The extra-financial contributions have been calibrated using qualitative data collected for the same years.

Expert assessment

The expert can intervene at each step if certain information is not properly taken into account. The rating proposed by the rating tool can be adjusted several notches upward or downward. Intervention by the analyst is limited, however. The four-eyes principle applies (and may be extended to six eyes or more according to the complexity of the file or if the expert assessment leads to an upgrade of more than two notches). Moreover, there is a rotation mechanism in place so that an analyst does not rate the same company for more than four consecutive years, with a one-year banning period. The mechanism applies to both the analyst and the manager/individual approving the credit assessments.

The categories used for the qualitative profile are: the environment, the company in itself, transparency, governance, financial flexibility, the company's outlook and strategy and finally corporate social responsibility. This information is gathered through external documentation and interviews conducted by the analysts. Finally, a list of possible extra-financial contributions is considered for each company, including recent start of operations, payment incident on commercial papers, CEO profile, group framework, significant events such as losses of more than half of the equity capital, judicial proceedings and default. This information is collected from the commercial court, the central credit register, the central register for payment

incidents on commercial papers and the BdF's database of financial links between French companies. The impact of each contribution is predetermined, however in some cases the expert is allowed to modify this impact according to a predefined scope of acceptable variations.

There are local rating committees in each region. Moreover, when there are significant discrepancies between the proposed BdF ICAS ratings and credit rating agencies' ratings, the Large Exposures Rating Committee examines groups' ratings to advise the General Director, who makes the final decision.

Model validation

The overall model performances, which include its discriminatory power, the calibration quality of the rating system and the monotonicity of default rates, are monitored using a large set of statistical tools. Concerning the discriminatory power, two main statistics are monitored: the area under the receiving operating characteristic (AUROC) curve and the accuracy ratio. For the calibration quality of the rating system, three tests are implemented: the one-sided Clopper-Pearson exact binomial test, the Hosmer-Lemeshow test, and the min-P multiple testing procedure developed by Westfall and Wolfinger. Finally, for the monotonicity of rating classes, only a Wald test for difference of proportions is used. The above-mentioned tests are carried out both at the aggregate level (Eurosystem credit quality steps) and on a disaggregated basis (by rating class, by sector and by approach).

The final BdF ICAS rating outcome is monitored once a year in two complementary ways:

- an internal annual back-test carried out by the Corporate Methodology Division (the same division that develops and calibrates the model);
- an independent ex post analysis communicated to the ECB that is carried out by the Operations Risk and Compliance Directorate in conformity with the ECAF performance monitoring mechanism.

A.4.2 Organisation

Scope of rated entities

Each year, the BdF's ICAS assesses NFCs with a turnover of €750,000 or more and with available financial documentation. At the end of 2020, this corresponded to 237,971 companies, of which around 4,600 were consolidated groups.

Set-up

The Corporate Methodology Division of the Directorate General Services to the Economy and Network Activities is in charge of defining the overall corporate rating methodology, including the model development and calibration.

Rating decisions are taken by each branch of the BdF network, under the guidance of the general and regional directors who successively delegate their rating responsibilities. Around 1,000 people are involved in the rating process. Consolidated accounts are rated by specialised teams (one per region). All analysts must adhere to professional rules described in detail in a code of conduct.

Validation and performance monitoring are performed by the Operations Risk and Compliance Directorate of the Directorate General Financial Stability and Operations, thus respecting the principle of separation of functions.

A.5 Banca d'Italia (Bdl)

A.5.1 Statistical model

Overview

The Bdl ICAS statistical model predicts an individual PD over a one-year horizon for Italian NFCs having both an exposure to the banking system of at least €30,000 as reported in the National Credit Register and available financial statement data. Due to correlation and data frequency reasons, the general architecture of the Bdl ICAS statistical model has two independent components, providing distinct credit scores and representing partial measures of credit risk:

1. a credit behaviour component, namely a logit regression aimed at modelling data coming from the National Credit Register;
2. a financial component, namely a logit regression based on yearly financial statement data (financial structure, profitability data, etc.).

The credit behaviour component is divided into three different sub-models depending on the size of the firm's financial exposure towards the banking system. The financial component consists of six different sub-models according to their industry sector. The two components are then merged into the final overall model through a further logistic regression and provide the final score. The corresponding PD is finally submitted to the so-called expert system module.

In terms of ESG factors, governance quality is already assessed in the management and corporate governance profile. In the same fashion, environmental and social factors are considered by the analysts when they are deemed to have a significant effect on default probability.

At the same time, work is in progress to deal with ESG factors in a more systematic way by identifying a set of additional ESG indicators to be integrated in the assessment process.

Calibration approach and data

The Bdl ICAS is calibrated using a pooled cross-sectional approach, i.e. default data and estimation data samples refer to different (two-year) time periods. In order to

maximise the discriminatory power between sound and distressed firms against the so-called rare events bias, a balanced sample is used, containing an equal number of defaulted and non-defaulted firms (50% default rate). Credit behaviour and financial models are then calibrated to the default rates prevailing in each sector and credit-size calibration datasets.

Besides “static” data on debtors, the model inputs include credit behaviour data gathered from the National Credit Register and AnaCredit as well as financial statement data. For financial statement data, the Bdl ICAS relies on the Bdl’s financial statements archive, which in turn is based on data collected from Centrale dei Bilanci (CEBI, belonging to Cerved Group). Financial statement data are reclassified according to the CEBI reclassification accounting scheme, which can be applied to both nGAAP and IFRS financial statements. As a consequence, comparability among the financial statements of different companies is ensured.

Expert assessment

Starting from the automatically generated statistical PD, the analyst’s assessment follows a template-guided process spanning eight different profiles. Partial scores resulting from each profile are weighted and aggregated in order to produce a final grade. A decision matrix translating the final grade into the rating decision provides a non-binding guideline for analysts when making the final decision.

The analysis can either confirm the rating derived from the statistical stage or modify it by notching the risk class up or down. The final rating expresses an opinion on whether the data considered improve, confirm or worsen the risk assessment produced by the statistical module. Nonetheless, the final assessment is upper-bounded: analysts can raise the final rating only by one notch.

Profiles include a review of static data, the evaluation of the automatic rating, an analysis of the balance sheet ratios (including at peer group level) and of financial flexibility, an insight on the quality of management and corporate governance, an analysis of the economic environment, an overview of the industrial sector and the geographic location, the group analysis, a review of third-party opinions and a check of recent news on the firm.

For each firm, an independent assessment by at least two analysts is foreseen. If their views diverge or if specific conditions apply, the involvement of the Rating Committee is required. The committee is composed of two members (head and deputy of the Credit Risk Assessment Division), the President (head of the Risk Management Directorate or an alternate) and the Secretary (a senior professional). Analysts involved in the assessment are also required to participate in the meetings. The Rating Committee meets at least once a month. For selected cases, written procedures are adopted. The committee can improve the rating by up to three notches.

Model validation

The aim of the validation process is to check the correctness and accuracy of the methods and processes of the rating system and its time stability (monitoring). The

validation activity, using different statistical tools, calculates a series of indicators on the statistical model and on the expert assessment.

Regarding the statistical model, the validation activity measures the discriminatory power, namely the ability of the system to distinguish ex ante the defaulting from the non-defaulting companies, and the predictive power, i.e. the capacity to estimate PDs reflecting real defaults. The back-test verifies that the number of defaults recorded is in line with the forecast made at the beginning of the year, according to the ECAF methodology.

For the expert assessment validation, the main goal is to quantify the contribution provided by the expert analysis. The role of the analysts in determining the final rating is explained by several statistical indicators related to: (i) the level of activity, (ii) the way the various profiles of analysis are used, and (iii) the correlation among the scores assigned to the profiles. The analysis also measures statistical differences within and among the branches. Outliers and defaults recorded during the year are the subject of special focus.

A.5.2 Organisation

Scope of rated entities

The Bdl ICAS generates on a yearly basis almost 4,000 ratings for NFCs to which banks have granted potentially eligible loans. In addition, “purely statistical” PDs are available for around 350,000 non-financial firms.

Set-up

The system is run by the Financial Risk Management Directorate, which is part of the Directorate General for Markets and Payment Systems. Operations and task coordination are carried out by the Credit Risk Assessment Division (CRA Division), where a dedicated team of analysts works at the expert assessment stage. In order to better exploit a deeper knowledge of the local economic context, additional analysts contribute to the expert assessment from the 15 local branches of the Bdl involved in the ICAS project. Model development is currently carried out within the CRA Division, while model validation is a responsibility of the Financial Risk Control Division, also belonging to the Financial Risk Management Directorate.

A.6 Banco de Portugal (BdP)

A.6.1 Statistical model

Overview

The statistical model produces a point-in-time rating with a prediction horizon of one year through individual PDs.

In the first step (quantitative assessment), the statistical models for both individual and consolidated accounts automatically compute a score and a classification/rating proposal as an average PD and a rating class. The model's prime output is derived from statistically identified and selected purely quantitative characteristics. Logit models are used for both individual and consolidated accounts.

For individual accounts, ten models covering different economic sectors are used, combining size (micro firms; all other firms) and industry (manufacturing, transportation and storage; construction and real estate activities; wholesale and retail trade and the primary sector; utilities and mining and quarrying; and services).

The process starts by considering a large pool of variables, including a small set of macro factors, in order to capture the possible influence of the economy as a whole on a specific firm. Financial ratios are winsorised at the 2nd and 98th percentiles to avoid the inclusion of extreme values. Derived variables are also included in the pool of explanatory variables, either through the calculation of relative ranks for each financial ratio (by year-size-industry), normalised between 0 and 1, or through the transformation into logarithms for the strictly positive variables. For each variable of the initial pool of N variables, a model is estimated with the fixed effects plus that variable. This is a multi-criteria system of variable selection with a large pool of potential variables (based on the methodology of Imbens and Rubin, 2015), through a maximum likelihood estimation. This approach selects the variables in an iterative process based on the explanatory prediction power that each variable is able to provide. The new variable must improve the model's AUROC and Akaike information criterion.

For consolidated accounts, only one model is used since the number of observations in each sector is smaller. Considering the time span for the consolidated accounts model, the macroeconomic variables were removed and the annual ranks were replaced by multiannual ranks (calculated by industry for the complete period), to account for the macroeconomic situation. The econometric model follows, in general, the methodology described in Antunes et al. (2016) used for the individual econometric models, with the necessary adaptations to the information available for economic groups.

After selecting the explanatory variables, the experts from both the Sectoral Analysis Unit and the Credit Assessment Unit evaluate the model and may propose changes to the selected variables or include interactions with industry dummies.

Calibration approach and data

The statistical model calibration requires the annual conduct of the (two-sided) Hosmer-Lemeshow test as an indicator of the quality of the assignment of PDs. It is a joint test for several rating grades and assumes all obligors assigned to a rating grade have the same PD, i.e. each class has a reference value for its PD. The Hosmer-Lemeshow statistic is Chi-square distributed with K degrees of freedom under the hypothesis that all the PD forecasts match the true PDs.

The database used for the calibration of the models combines information from the Central Balance Sheet Office (annual data from 2006 to 2018) and the Central Credit Register (information for the time span 2002-2019) databases, both managed by the

BdP. The database is divided into ten industry and size groups for individual accounts and one dataset for consolidated accounts. Each group is calibrated separately, which results in ten individual models and one consolidated model.

Expert assessment

In the second step, financial analysts check the entity's creditworthiness and determine the final rating. Expert analysis may either confirm the statistical rating proposal or alternatively overrule it by notching the rating up or down on the master scale. In this step, the experts use a set of guidelines to analyse additional data that were not considered by the statistical model or data that represent exceptions to the model's behaviour.

The expert system analysis of the individual company is broken down into seven stages, the first of which is automatically conducted for each company, on a daily basis, according to the most recent information available and regardless of whether a new credit assessment is manually triggered by an analyst. This first stage allows the system to automatically identify whether a company's rating should be revised to a "non-eligible" class for monetary policy purposes or even to default.

The seven stages are: (1) an a priori analysis of credit eligibility, (2) an economic and financial analysis of the company and sector, (3) an analysis of qualitative information and model simulation, (4) an analysis of credit evolution, (5) an analysis of other information, (6) an analysis of other entities' ratings, and (7) an integrated analysis of the group's rating.

Consideration of ESG factors is currently limited and, if any information is available, it is included in Stage 3, in the qualitative analysis of the expert system.

In principle, if an expert analysis is carried out one of three outcomes is expected within each stage:

- the analyst chooses to adjust the statistical model's assigned rating upward by one rating class (upgrade);
- the analyst chooses to adjust the statistical model's assigned rating downward by one rating class (downgrade);
- the analyst finds no reason to adjust the statistical model's assigned rating.

Although the system provides each analyst with suggested changes to the model's rating results (according to the information deemed relevant in each stage of the expert assessment), the analyst has to provide a comment either agreeing with the system's proposal based on the automatic flags or explaining their reasoning to decide on a different outcome. This is valid for every stage of the expert assessment process.

Each stage's intended outcome (one notch – or class in the 20-class master scale considered – up, down or rating unchanged) implies that the company's rating class can deviate from the statistical model's result by at most four notches. However, in exceptional cases (Stage 3), the analyst may choose to upgrade or downgrade a company's rating by more than one notch. In such cases, the analyst must provide

clear justification, and the change must be approved by a second analyst and the Rating Committee. Approval by the Rating Committee is also required whenever the final rating decision differs between the first and second analyst or notch changes deviate significantly from the quantitative assessment.

Following the four-eyes principle, every assessment has to be examined by two analysts, i.e. once the analyst has assigned the final rating, each credit assessment decision is checked by a second analyst (approver).

The members of the Rating Committee are the head of the division, the head of the unit, the head of a different unit and the two analysts involved in the related credit assessment decision. The members of the Rating Committee must discuss and decide on the final rating. All these steps are fully documented and are available at any moment for auditing purposes.

The rating must be evaluated by the Rating Committee if one of the following conditions is met:

- the sum of rating changes from Stages 2 to 5 is more than four notches;
- the rating change in Stage 3 is more than two notches;
- an analyst disagrees with the automatic rating proposal in Stages 6 and 7;
- the second analyst disagrees with the changes proposed in the initial analysis.

Model validation

The Risk Management Department conducts the annual validation tests, which include the following:

- quantitative validation process: (i) discriminatory power (AUROC and accuracy ratio), and (ii) calibration tests (Hosmer-Lemeshow test, Spiegelhalter test and two-sided binomial test);
- qualitative validation process, which consists of an unbiasedness analysis (transition matrix, distribution of changes between statistical and final rating, and distribution of adjustments made in the expert analysis for each category).

Each analyst and approver can assess the same company for a maximum period of four years, after which they are subject to a banning period of at least one year.

A.6.2 Organisation

Scope of rated entities

At full capability, the BdP ICAS can assess around 300 companies with consolidated accounts and around 4,000 companies with individual accounts. However, it is

important to emphasise that although these estimates have been defined, the main goal will always be as a minimum the to fulfil the needs of those counterparties that select the BdP ICAS as a credit assessment system.

Set-up

Model development and calibration are performed by the Sectoral Analysis Unit (Statistics Department) in collaboration with the Economics and Research Department. Credit assessment is carried out by the Credit Assessment Unit (Statistics Department), and validation is performed by the Risk Management Department.

A.7 Banka Slovenije (BS)

A.7.1 Statistical model

Overview

The output of the BS ICAS is a one-year point-in-time PD on an individual basis. The rating scale consists of 13 grades for non-defaulters and one grade for defaulters. There is no differentiation between different types of default.

For the statistical model, a logistic regression is used, based on a time series of six years. The main data sources are the business register, financial statements, the credit register and the transaction accounts register. Defaults are identified on the basis of credit register data and insolvency proceedings reported by the Supreme Court. Two different models are developed for large enterprises and the SME segment, respectively.

In the first phase, the micro model (a model based on individual companies' data) is estimated. A modified Imbens-Rubin method is used in the selection procedure for financial indicators. It is an iterative method that in each step adds the independent variable to optimise the test statistics of the model. In doing so, the final set of independent variables is selected for each segment (large enterprises or SMEs). Based on quarterly default rate data, macroeconomic forecasts for the following year are obtained and included in the next phase of the model assessment. To this end, sectors are categorised into four groups. Due to the COVID-19 pandemic, the method of incorporating macroeconomic forecasts was changed in 2020 and is now based on expert judgement.

ESG indicators have not been systematically addressed yet. Social and governance indicators are partially covered in the expert system within the governance category, while environmental indicators are not considered. The area of ESG indicators has been examined, and a new comprehensive framework may be introduced in the near future.

Calibration approach and data

Each year, the model is recalibrated using the latest data (time series of six years). The process of selecting independent variables is repeated if they are no longer statistically significant. Both models (for large enterprises and SMEs) are assessed based on the new data. In addition, macroeconomic forecasts for the following years are applied.

Expert assessment

For the expert assessment, a simple scoring system is implemented. Four main categories are considered:

1. market position and business model (competition and the company's position in the sector, customers and suppliers, strategy and business model);
2. governance (organisational structure, human resources, processes, technology, leadership);
3. group of connected clients (consolidated financial statements, owners, subsidiaries and affiliates);
4. financial standing and performance of the company.

As a result of the expert analysis, the statistical rating can be upgraded by at most two rating grades and downgraded by an unlimited number of grades.

For each rating, the four-eyes principle must be ensured, i.e. each rating must be validated. If the analyst and the validator do not agree on the rating, the Rating Committee confirms the final rating.

Model validation

The Risk Management Department of BS performs the annual model validation. The following tests are conducted for the statistical model: the AUROC, accuracy ratio, Hosmer-Lemeshow test, Spiegelhalter test and binomial test. The transition matrix and distribution of changes for ratings are reviewed to validate the qualitative assessment.

A.7.2 Organisation

Scope of rated entities

Approximately 30,000 entities are rated each year using the statistical model (valid ICAS population with exposure to at least one Slovenian bank). Approximately 500 entities have a full rating (expert judgement included).

Set-up

The Banking Supervision Department is responsible for the development, recalibration and maintenance of the model. The qualitative assessment is also performed by the Banking Supervision Department. The model validation is conducted by the Risk Management Department. Other departments that are also involved include Banking Operations, Financial Statistics, IT and Systemic Supervision, and Regulation.

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