![Banc Ceannais na hÉireann / Central Bank of Ireland / Eurosystem]

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Contents

Climate change and the financial sector: introducing the new ESCB analytical indicators of carbon emissions

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Abstract

In July 2021, the ECB Governing Council committed to including climate change considerations in its monetary policy framework. This commitment involved, amongst other deliverables, new climate-related statistical indicators. The focus of this *Article* is on describing the new analytical indicators of carbon emissions for financial institutions resident in Ireland. The Irish values are broadly in line with the euro area responses although the headline statistics mask considerable heterogeneity. For some of the indicators, the highly globalised nature of the Irish economy makes it difficult to establish a link between the new analytical indicators of carbon emissions and the ongoing efforts of indigenous firms to transition towards a more carbon neutral production process. More disaggregated macroeconomic data in the coming years as input into the indicators combined with separate improvements planned to the estimation of these indicators will further assist policy makers in this regard.

1. Introduction

Climate change – as evidenced by the growing incidence of more extreme weather events - is recognised as one of the greatest challenges facing humanity. Efforts to coordinate policy at a global level to reduce, stop, and reverse the release of atmospheric greenhouse gases have intensified in recent years. The 2015 Paris Agreement aimed to limit the average global temperature rise to below 2^oC compared to pre-industrial levels. Consistent with the Paris Agreement, both the European Commission and the Irish government have separately announced plans to reach net zero emissions by 2050. The European Commission has adopted a series of legislative proposals as part of the 'European Green Deal' outlining its ambition for Europe to become the world's first climate neutral continent by 2050. The Irish government, in addition to its European commitments, published the *Climate Action Plan 2021* three years ago. The main goals of the plan are to reduce greenhouse gas emissions to 51 per cent of 2018 levels by 2030 before attaining net zero emissions by 2050.

As the incidence of extreme weather events intensify, the implications of climate change for short-term economic fluctuations have come into focus. In a detailed literature review, Ciccarelli et al (2023) outlines how the adverse impact of climate change on economic growth is widely documented, while the relationship between climate change and inflation is expected to be non-linear as climate change intensifies. In earlier research, Ciccarelli (2021) outlined the main channels through which climate change could influence activity and prices. The immediate impact of climate change on short-run economic developments is on physical capital, land, as well as agriculture and labour inputs as more extreme weather conditions disrupt economies' supply side. At the same time that these disruptive effects occur, households and businesses need to transition to a low carbon economy in order to decouple carbon emissions from economic activity and this is likely to require significant policy interventions.

Against this background of more frequent extreme weather events, the implications of climate change for the financial sector have become a more immediate priority for policy makers. In 2015, finance ministers from the Group of Twenty (G20) asked the Financial Stability Board to consider how the financial sector could take account of the risks that climate change poses to the financial system. In a wide-ranging speech that year, then Bank of England Governor Mark Carney explained the intertemporal trade-off inhibiting measures to reduce climate change as the immediate costs arising from such measures combined with longer-term benefits can disincentivise mitigation

policies. Lane (2019) outlined what challenges arising from climate change imply for the implementation of monetary policy, the efforts required to gauge the risks to financial stability of such change, as well as the challenges that climate change poses for the regulation and supervision of firms and markets.

In 2021, the ECB Governing Council decided on a comprehensive action plan to incorporate climate change considerations into its monetary policy framework in line with its obligation under EU treaties. This action plan included, amongst other deliverables, new statistical collections of climate change that include indicators of sustainable debt securities, the exposure of financial institutions to climate-related physical risks, as well as indicators that can gauge the carbon emissions financed by the financial sector. Sustainable finance indicators encompass four categories of securities: Green bonds where the proceeds are used to finance green projects; Social bonds where the proceeds are used to finance social projects; Sustainability bonds where the proceeds are used to finance a combination of both green and social projects; and Sustainability linked bonds where the issuers are committed to future improvements in sustainability outcomes but with no binding restrictions on how the proceeds may be used. Third party entities such as the International Capital Markets Association or the Climate Bonds Initiative typically provide the sustainability classification. Total issuance of sustainable debt securities has surged in recent years although they still account for a small part of the wider debt securities market with Green bonds accounting for the majority of these securities.

Physical risk indicators gauge financial institutions' exposure to different natural disasters including flooding, windstorms, landslides, and subsidence. The construction of these indicators combines locational and geospatial data, with risk mitigation strategies such as insurance coverage considered. The risks and expected losses are calculated for Non-Financial Corporations (NFCs) that are counterparts to euro area financial institutions.

The sustainable finance indicators were classified as "experimental" as they weren't underpinned by as much rigour compared with official statistics. Nonetheless, experimental indicators are still robust enough for monetary policy analysis. The physical and carbon emission indicators were classified as "analytical" as they were underpinned by less rigour compared with experimental indicators. This in turn reflects the lower coverage rates, reliance on third party data providers, and some limitations with the underlying methodology. However, the second wave of results published in April 2024 addressed many of these limitations.

The indicators of carbon emissions, which are the focus of this article, allow users to evaluate how the financial sector contributes to the funding of carbon related activities and, by extension, to assess the associated risk of carbon-intensive sectors transitioning to a low-carbon economy. The first wave of results was published in January 2023 with the underlying results calculated by country and by sector for 2018 to 2020. The second wave of results was published in April 2024 with the underlying results calculated for 2018 to 2021. Appendix 1 shows the higher coverage rates associated with the second wave of results compared with the first wave. Otherwise, all subsequent charts correspond to the second wave of results.

The remainder of this *Article* is structured as follows: Section 2 reviews two established data sources that were used in the construction of the carbon emission indicators before outlining how the indicators were constructed. Section 3 reviews the main findings that emerge regarding the indicators of carbon emissions for financial institutions resident in Ireland. Section 4 outlines how the carbon indicators are calculated based solely on financial institutions' direct holdings of debt securities and listed shares. This is a limitation inherent in the indicators as some sectors' indirect holdings are a multiple of their direct holdings. Some improvements currently in progress are also discussed. Section 5 concludes.

2. Current Climate Data and Indicators of Carbon Emissions

Before analysing how the indicators of carbon emissions are constructed, it is worth reviewing the main existing sources of data on Greenhouse Gas (GHG) emissions regularly used in economic analysis. One of the two main sources available to researchers to study the volume of economy-wide carbon emissions across the euro area is the EU's Emissions Trading Scheme (ETS). The ETS has been in operation since 2005 and works on the 'cap and trade' principle whereby a limit is set on the total amount of greenhouse gases that can be emitted. Within this cap, companies receive or purchase emissions which they can trade on a secondary market. Over time, the permissible volume of GHG emissions that can be released as part of the ETS has fallen as the EU has intensified its efforts to attain carbon neutrality. SEAI Ireland have detailed how the share of GHG emissions in Ireland from large companies participating in the ETS has decreased gradually from 28 per cent of total GHG emissions in 2005 to 21.5 per cent of total GHG emissions in 2022 or from

19,164ktCO$_2$ in 2005 to 12,614 ktCO$_2$ in 2021[2].   Across all EU member states, participation in the scheme is mandatory for companies in the aviation and maritime sectors as well those NFCs operating above a certain size. Consequently, the data on firms' emissions that are recorded as part of the ETS can be used to gauge the broader efforts of policymakers to attain a more carbon neutral domestic production process.

The other primary source of data on economies' emissions is the European System of Environmental Economic Accounting (SEEA). SEEA records direct emissions from each economic sector as part of the system of environmental accounts. The regulation that established the SEEA accounts includes a module on Air emission Accounts, The module on AEA accounts is the component most relevant to the indicators of carbon emissions as it records the emissions of six greenhouse gases including CO$_2$ as well as seven air pollutants.

Data collected on greenhouse gases as part of the AEA accounts are published on an economy-wide basis making it difficult to disaggregate total emissions by economic sector or industry. However, the Non-Financial Reporting Directive (NFRD) framework, which came into effect in 2014, required NFCs with 500 or more employees to provide a review of their business model policies, outcomes, principal risks, and key performance indicators including environmental matters. To this end, many larger NFCs across the euro area have started to publish data on their Scope 1 and Scope 2 emissions. Data on Scope 3 emissions is more difficult to attain although the Corporate Services Reporting Directive (CSRD), which applies from the 2024 financial year onwards and requires a broader set of euro area NFCs to publish data on their Scope 3 emissions data as part of their climate disclosures. The differences in the emission types are outlined in Table 1 below.

Table 1: Emission Types

Emissions Type	Definitions
Scope 1	Direct company emissions e.g. emissions from a production plant that a company owns.
Scope 2	Indirect emissions generated by businesses as a consequence of their energy consumption
Scope 3	Indirect emissions that occur due to companies' participation in Global Value Chains. This can include emissions released during the production of purchased inputs, employees commuting, etc.

Source: Greenhouse Gas Protocol Corporate Standard

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[2] ktCO2 denotes kilotons of carbon emissions and is a unit of measurement. Carbon dioxide emissions are often calculated and reported as elemental carbon before being converted to actual carbon dioxide mass by multiplying them by 3.667 (the ratio of the mass of carbon to that of carbon dioxide).

The data published as part of the EU's ETS and the AEA accounts detail the total volume of emissions associated with an economy's supply side rather than the end-user demand for carbon intensive sectors or the financing of carbon intensive sectors. In light of the risks associated with climate change, G20 finance ministers and central bank governors asked the Financial Stability Board (FSB) to review how the financial sector can take account of climate-related risks. The FSB established the Task Force on Climate-related Financial Disclosures (TCFD) in 2015[3] to develop recommendations for more effective climate-related financial disclosures that, amongst other things, "enable stakeholders to understand better the concentrations of carbon-related assets in the financial sector and the financial system's exposure to climate-related risks". Using in part, the analysis undertaken by the Partnership for Carbon Accounting Financials[4], the TCFD has outlined a suite of additional exposure metrics that help to gauge the carbon intensity of financial institutions' claims: Financed Emissions (FE), Carbon Intensity (CI), Weighted Average Carbon Intensity (WACI) and Carbon Footprint (CFP).

FE and CI measure the emissions intensity of financial institutions' holdings. These two metrics calculate the amount (share) of carbon emissions by NFCs that can be attributed to financial institutions via their securities and loan portfolios. These indicators measure the financed emissions of a counterparty (either individually or at sector or country level) and as such can be used to understand how the debtors' or issuers' emissions change over time in anticipation of the need to transition to a net zero economy.

Financed Emissions (FE): The FE indicator connects debtors' investments[5] to issuers' GHG emissions. In Equation 1, GHG emissions from creditor/issuer j are assigned to financial institution i proportionate to the holder's share of enterprise value. The emissions metric is calculated using different data sources - and this is discussed in more detail in Box A - for time period t (typically one year) by aggregating emissions across all resident institutions' holdings. The metric is calculated separately for banks, investment funds, and insurance corporations & pension funds (ICPF).

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[3] https://www.fsb-tcfd.org/
[4] https://carbonaccountingfinancials.com/en/standard
[5] Investments are calculated in the form of loan exposures or each sector's direct holdings of debt securities and listed shares.

$$(1) FE_t = \sum_{i=1}^{n} \sum_{j=1}^{n} \left(\frac{Investment\ Value_{i,j,t}}{Enterprise\ Value_{j,t}} * Emissions_{j,t} \right)$$

Carbon Intensity (CI) The CI indicator extends the FE indicator by adjusting emissions for creditor/issuer economic activity, thus giving an estimate of investment emission intensity. The metric is reported in tonnes of CO_2 emissions per million euro revenue. As with FE, this metric is aggregated across resident institutions' holdings by sector.

$$(2)\ CI_t = \frac{FE_{,t}}{\sum_{j=1}^{n} \sum_{i=1}^{n} \left(\frac{Investment\ Value_{i,j,t}}{Enterprise\ Value_{j,t}} * Issuer's\ Revenue_{j,t} \right)}$$

Although FE and CI provide information on how the transition to a net-zero carbon economy can be financed, these two indicators do not provide information on whether the financing is targeted to make businesses greener. Instead, the indicators help in monitoring overall emission reductions in economic activities and the correlation of financing in these developments.

The third and fourth indicators – WACI and CFP – are more closely aligned with financial system exposure to climate risk. Both indicators describe emissions relative to creditor portfolio values and can be used to provide a comparison of climate risks across institutions, countries and over time.

Weighted Average Carbon Intensity (WACI): In the WACI indicator, debtor emission intensity (tonnes of emissions per € million of company revenue) is weighted by its share of the creditor's portfolio. As with the previous indicators, this is generally aggregated across all investment holdings of resident institutions. Moreover, the indicator can also be used to compare transition risk between financial institutions.

$$(3) WACI_t = \sum_{j=1}^{n} \sum_{i=1}^{n} \left(\frac{Investment\ Value_{i,j,t}}{Portfolio\ value_t} * \frac{Issuer's\ emissions_{j,t}}{Issuer's\ revenue_{j,t}} \right)$$

Carbon Footprint (CFP): CFP is derived and interpreted similarly to WACI but instead describes debtor emissions relative to enterprise value (tonnes of emissions per € million of company value).

$$(4)\ CFP_t = \sum_{j=1}^{n} \sum_{i=1}^{n} \left(\frac{Investment\ value_{i,j,t}}{Portfolio\ value_t} * \frac{Issuer's\ emissions_{j,t}}{Issuer's\ enterprise\ value_{j,t}} \right)$$

The four metrics combine data on NFCs' emissions with a selection of financial variables: investment, company value, revenue, and portfolio value. Investment corresponds to banks' total lending to NFCs or the value of a financial institution's holdings of debt securities or listed shares issued by NFCs. Both market capitalisation, which is typically more easily available across NFCs, and enterprise value which is typically less responsive to financial transactions, can be used to approximate company value[6]. The most appropriate financial denominator to relate emissions to production would be value added (or GDP at the macroeconomic level) as this excludes all purchases of goods and services from external suppliers. As value added is typically unavailable at the required level of granularity, firms' revenue is frequently used instead. Although easily available, revenue can pose a risk of bias in the different measures of carbon intensity if large parts of the production process are outsourced to suppliers. Portfolio value is calculated as the sum of all loans and credit lines extended by banks to NFCs or the total market value (excluding short positions) of listed shares and debt securities issued by NFCs and held by euro area financial institutions.

Total FE is an absolute metric and expresses the volume of emissions associated with a financial institution's portfolio in terms of million tons of CO_2 emissions. Carbon Footprint (CFP), Carbon Intensity (CI), and Weighted Average Carbon Intensity (WACI) are relative indicators and the results are more comparable over time, across metric, and amongst institutions. The results from the three relative metrics are calculated in terms of tonnes of CO_2 emissions per million euro.

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[6] Enterprise Value (EVIC) is collected by third party data providers and is typically calculated as the total value of firms' assets excluding cash and other non-operating assets.

3. The Evolution of the Carbon Emission Indicator Values in Ireland and the euro area

Before reviewing the Irish and euro area responses, it is important to distinguish between the indicators related to bank lending to NFCs that are calculated at single-entity level, at group level, as well as the indicators calculated at group-level based on financial institutions' direct holdings of debt securities and listed shares. The indicators calculated at single-entity level combine emissions data from the ETS as well as the AEA accounts with bank lending to NFCs using individual loan-level data from the Eurosystem's AnaCredit dataset[7]. The indicators calculated at group entity level based on bank lending to NFCs combine individual loan data from the AnaCredit dataset – both domestic and cross-border loans – with firms' Scope 1 or Scope 2 emissions that are typically reported on an unconsolidated basis at group level, along with matching financial data. The indicators calculated at group-entity level based on financial institutions' direct holdings of debt securities and listed shares combine security-by-security data from the Security Holding Statistics (SHS) database[8] with published, as well as imputed, data on NFCs' Scope 1 as well as their Scope 2 emissions along with matching climate and financial data. Table 2 lists the different emission sources applied across the single-entity and group-entity approach. Box A provides further details on the differences between the single-entity and group-entity methodology.

Table 2: Emissions Calculated Using Single and Group Entity Approach

	Single-Entity	Group-Entity	
	Bank Lending to NFCs	Bank Lending to NFCs	Financial Institutions' Direct Holdings of Debt Securities and Listed Shares
Scope 1 emissions	✓	✓*	✓
Scope 2 emissions			✓

*Only after the methodological improvements included in the second wave of results

Results at Single and Group Entity Level – Bank Lending

Charts 1 and 2 display at both single and group entity level the WACI Indicator for banks resident in Ireland as well as in the euro area based on a balanced

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[7] AnaCredit is a dataset containing detailed information on individual bank loans above a minimum threshold of €25,000 in the euro area, harmonised across all member states. "AnaCredit" stands for analytical credit datasets.
[8] Securities Holding Statistics (SHSS dataset) provide information on securities held by selected categories of euro area investors, broken down by country of residence.

panel of debtors[9] . A limitation with the relative indicators is that any inference made based on the responses can only analyse the pattern evident in the series rather than the absolute figures. At single entity level, the Irish responses are higher than the comparable euro area responses with the other two relative indicators CI and CFP displaying a similar difference. The indicators aren't calculated by country of counterparty but some noticeable differences emerge when comparing the Scope 1 emissions for borrowers resident in Ireland and those across the euro area. Although the majority of individual borrowers are resident in Ireland many of the borrowers with the highest Scope 1 emissions are resident abroad. For borrowers resident in Ireland much of the emissions can be attributed to the transport sector and are highly concentrated on a firm-by-firm basis reflecting the importance of the aeronautical and aircraft-leasing sector to the Irish economy. For borrowers resident elsewhere in the euro area, much of their emissions can be linked to the manufacturing sector. Furthermore, the reported Scope 1 emissions are also concentrated by individual bank. These differences also reflect the business models of Domestic banks compared to International banks which typically have less exposure to the indigenous sector. However, a full disaggregation of the WACI indicator by lender and counterparty is beyond the scope of this article[10].

The results at group-entity level include many of the same underlying borrowers that feature in the calculations at single-entity level. The indicators calculated at group-entity level don't use data from the ETS or the AEA accounts. Instead, data on firms' Scope 1 or Scope 2 emissions that's reported on an unconsolidated basis at group level for the largest NFCs is utilised. Consequently, the point estimates at a single and group entity level can't be compared directly. Nonetheless, some similarities in both the headline series as well as the underlying influences can be observed. At group entity level, the measure of WACI for Ireland and the euro area diverges from 2019 with the Irish responses higher than the comparable euro area responses. The Irish responses are also higher at group-entity level for the other two relative indicators compared with the euro area responses. Similar to the single entity results, the Scope 1 emissions are also concentrated by lender and by borrower. Although the metrics calculated at group entity level includes

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[9] The results published in April 2024 were reported for both a balanced and an unbalanced sample of debtors. The unbalanced sample arises from two sources: missing emissions or financial data of a debtor or issuer, investments and divestments of holders and creditors, respectively. Firms with matching climate and financial data remain in the (balanced) sample even if they are only present for a selection of the years examined.

[10] The distinction between Domestic banks and International banks is based on the criteria previously used in the Central Bank of Ireland's Financial Stability Review.

borrowers from outside the euro area, the majority of reported emissions are still attributable to borrowers within the euro area. In contrast, the computation of the carbon indicators for some Irish resident financial institutions' holdings of debt securities and listed shares is heavily influenced by their claims on NFCs resident in the United States and this is discussed in more detail below.

WACI at Single-Entity Level – Lending to NFCs by Banks Resident in Ireland and the euro area
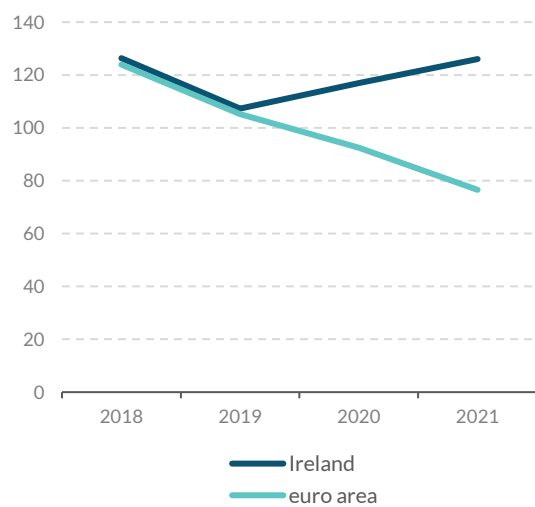
Figure 1
Tons of CO2 emissions per million euro
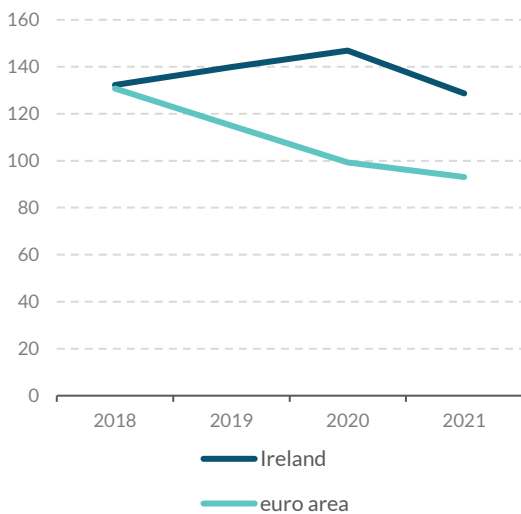
Source: ECB

WACI at Group-Entity Level – Lending to NFCs by Banks Resident in Ireland and the euro area

Figure 2
Tons of CO2 emissions per million euro

Source: ECB

Results at Group Entity Level – Financial Institutions' Holdings of Debt Securities and Listed Shares

Regarding financial institutions' direct holdings of debt securities and listed shares, Charts 3-5 display the WACI indicator from 2018 – 2021 for Ireland and the euro area. Across all three sectors, the Irish responses are broadly in line with the euro area responses. Within the banking sector, domestic banks' holdings of NFC debt has reduced in importance as a source of external funding with retail deposits now their main funding source. The measures of transition risk have decreased steadily from 2018-2021 but remain higher than the corresponding measures for the euro area. The indicators of carbon emissions for the banking sector masks considerable heterogeneity across firms and individual security holdings. Kennedy (2023) outlines how the results from the WACI indicator for banks resident in Ireland is concentrated in a

reduced cohort of securities held by a small number of international banks issued by a small number of non-resident NFCs.

Regarding the investment funds' sector, the majority of securities held are denominated in foreign currency (primarily US dollars) reflecting the highly globalised nature of the funds sector resident in Ireland, which has few linkages to the indigenous sector. The indicators of carbon emissions declined steadily from 2018-2021 even though the investment fund sector experienced heightened levels of volatility. The Central Bank of Ireland's Market Based Finance Monitor (2021) details this volatility which included a surge in the value of assets under management across the investment funds sector between 2020-2021, linked to a stark appreciation of asset values and increasing inflows from investors, notwithstanding the large redemptions at the onset of the COVID-19 pandemic.

The indicators of carbon emissions for the ICPF sectors are combined for all years owing to the issue of market concentration in some countries. For pension funds resident in Ireland, data on their holdings of securities on an ISIN-by-ISIN basis only extends back to 2019 in the SHS[11]. Consequently, the measure of transition risk for the ICPF sector resident in Ireland in 2018 only includes the insurance sector. Between 2018 and 2021, the adjusted measure of WACI for the ICPF sector declined notwithstanding some bounce in 2020. The main asset of insurance corporations resident in Ireland is their claim on investment funds. Regarding pension funds resident in Ireland, their main financial assets are technical reserves as well as their claims on investment funds. In the case of both sectors, their direct holdings of NFC securities represent a small portion of their balance sheet. It needs to be recalled that the indicators of transition risk are based on financial institutions' direct holdings of debt securities and listed shares whereas the indirect holdings of debt securities and listed shares of the ICPF sector are typically a multiple of their direct holdings. A more accurate gauge of the carbon emission indicators for the ICPF sector would use a look-through approach to gauge their holdings of debt securities and listed shares via their claims on money market funds and investment funds. This limitation with the transition risk indicators is discussed in more detail in Section 4.

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[11] An ISIN is a twelve-digit alphanumeric code that uniquely identifies each individual security issued throughout the euro area. ISIN codes are issued by National Numbering Agencies (NNA) recognised by the Association of National Numbering Agencies (ANNA).

WACI – Banks Resident in Ireland and euro area

Figure 3
Tons of CO_2 emissions per million euro
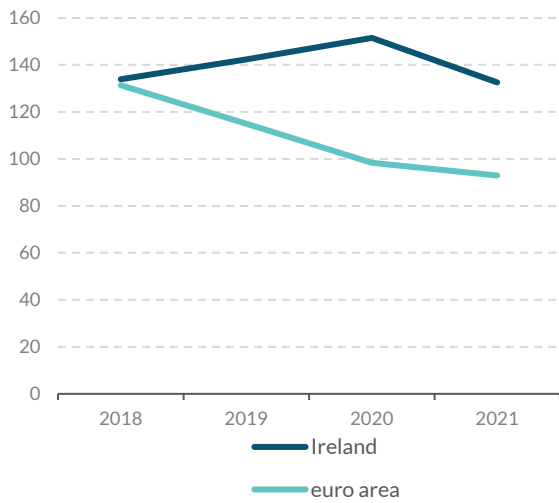
WACI – Investment Funds Resident in Ireland and euro area

Figure 4
Tons of CO_2 emissions per million euro
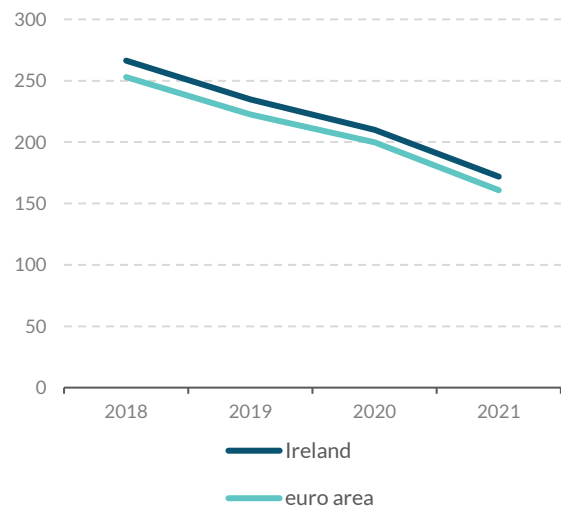
Source: ECB

Source: ECB

WACI –Insurance Corporations & Pension Funds Resident in Ireland and euro area

Figure 5
Tons of CO_2 emissions per million euro
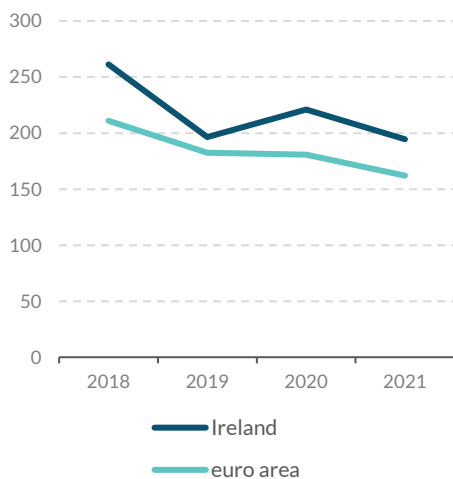
Source: ECB

Only a very small portion of resident financial institutions' direct holdings of debt securities and listed shares correspond to NFCs resident in Ireland. The CSO's Institutional Sector Accounts disaggregate NFCs' liabilities between Foreign-owned and Irish-owned NFCs with a further distinction between Irish

owned and redomiciled PLCs. An important result emerging from this dataset is that only a minority of resident NFCs' liabilities are attributable to Irish owned NFCs and this is outlined in Table 3. Consequently, the link between resident financial institutions' claims on NFCs and the external funding of the indigenous sector is further weakened. This in turn makes it difficult to link Irish resident financial institutions' holdings of debt securities and listed shares with the efforts of indigenous sector to raise external funding to attain a less carbon intensive production process.

Table 3: Financial Liabilities 2018-2021, Non Financial Corporations by ownership

Outstanding amounts €, millions	2018Q4	2019Q4	2020Q4	2021Q4
Debt Securities	23,904	30,434	62,275	80,774
Irish-owned NFCs		15,869	21,692	40,091
of which Redomiclied PLCs		6,845	7,881	
Foreign-owned NFCs		14,565	40,583	40,683
Loans	705,838	673,771	631,441	614,727
Irish-owned NFCs	287,575	261,471	241,302	241,847
of which Redomiclied PLCs	86,340	67,913	48,640	61,242
Foreign-owned NFCs	418,263	412,300	390,139	372,880
Equity and Investment Fund Shares	1,268,132	1,571,973	1,633,492	1,943,057
Irish-owned NFCs	703,007	865,059	832,658	1,098,854
of which Redomiclied PLCs	398,557	522,313	459,160	666,107
Foreign-owned NFCs	565,125	706,914	800,834	844,202
Other	407,038	509,544	416,717	42,830
Total	2,404,912	2,785,722	2,743,925	3,121,388
Irish-owned NFCs	1,119,688	1,268,255	1,206,525	1,506,328
of which Redomiciled PLCs	512,075	625,023	525,639	740,839
Foreign-owned NFCs	1,285,245	1,517,467	1,537,400	1,615,061

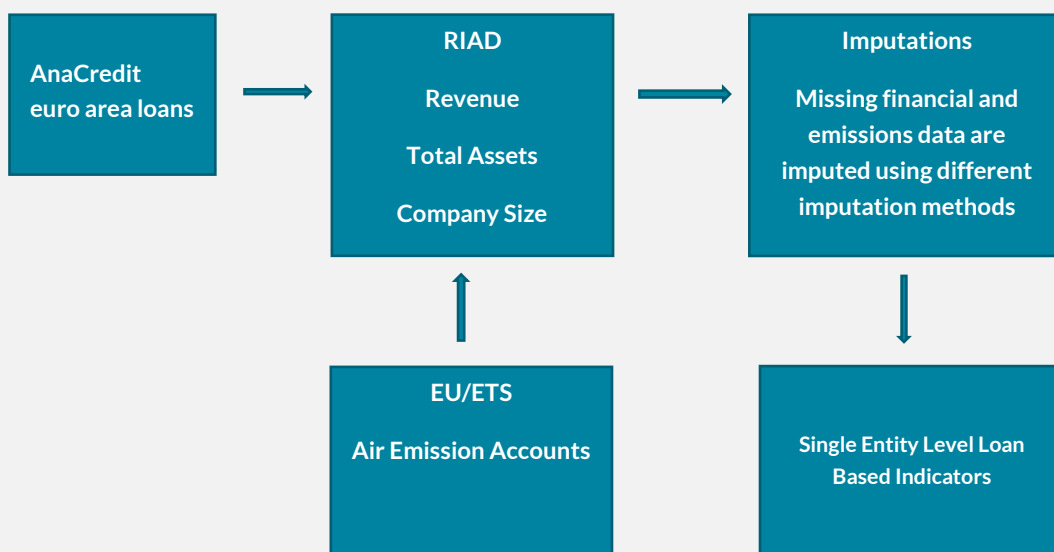Source: Financial Accounts for Ireland, CSO.

Box A: How different datasets were combined to calculate the various measures of Transition Risk

To estimate the carbon intensity of financial institutions' claims, a selection of predominantly granular databases were joined and this combination is depicted in Figures 1 to 3 below. The measures of transition risk are based solely on banks' outstanding loans and credit lines to NFCs and financial institutions' direct holdings of debt securities and listed shares issued by NFCs.

Across the euro area, small and medium enterprises (SME) account for the majority of banks' loan exposures. At the same time, issuance of debt securities and listed shares is confined to much larger NFCs. Larger NFCs typically have substantial disclosure requirements including data on their Scope 1 and Scope 2 emissions owing to the NFRD Directive and the forthcoming CRSD Directive. At the same time, SMEs typically have fewer disclosure requirements and don't always publish data on their Scope 1 and Scope 2 emissions. To allow for this, the carbon intensity of banks' loan exposures was examined at both single entity and group entity level.

The carbon intensity of banks' loan exposures at single entity applies data from the European Union's ETS and in its absence, sector-level AEA data. For NFCs not participating in the ETS, Scope 1 emissions are attributed to a single entity in proportion to the entity's employment share in the given sector. Therefore, the imputation procedure in turn requires the availability of financial information and this data is sourced from the Register of Institutions and Affiliates Data (RIAD).

Figure 1: Single-entity view for banks' loan exposures

AnaCredit euro area loans →
RIAD
Revenue
Total Assets
Company Size
→
Imputations
Missing financial and emissions data are imputed using different imputation methods

EU/ETS
Air Emission Accounts

Single Entity Level Loan Based Indicators

The indicators calculated at group level with respect to banks' loan exposures are particularly beneficial for transition risk analysis, as it fosters the understanding of the global transition risk of the group i.e. beyond the boundaries of the domestic economy. Figure 2 below shows how a combination of datasets were combined. An important difference between the single-entity and group-entity calculations is that data on NFCs' unconsolidated emissions reported at group level is used instead of emissions data from the ETS and AEA.

Figure 2: Group level view of banks' loan exposures

AnaCredit euro area loans → LEI/ RIAD data on group structures → Group level data on NFCs' emissions and matching financial data ↓ Missing financial and emissions data are imputed using different imputation methods → Carbon Metrics: Financed Emission, Carbon Intensity, Weighted Average Carbon Intensity, Carbon Footprint
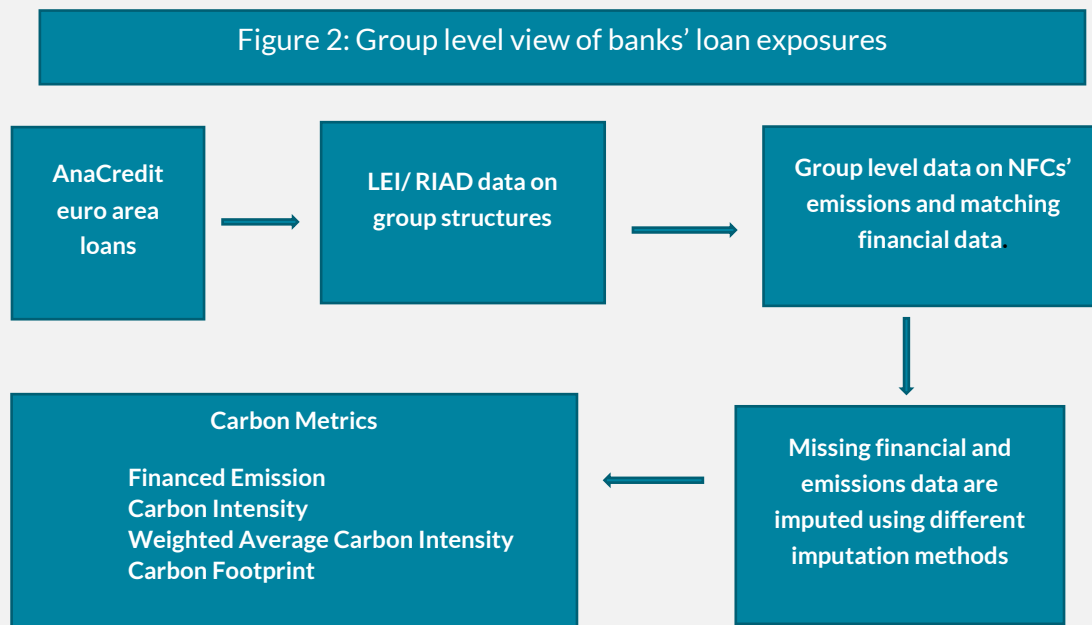
To estimate the carbon intensity of financial institutions' claims on NFCs' securities, Eurosystem granular databases were combined and this is depicted in Figure 3 below. The SHS database and the Centralised Securities Database (CSDB) collects data on holdings and issuance of debt and equity securities for financial institutions resident across the euro area. Crucially, each security has an ISIN. By joining the SHSS and CSDB by ISIN, it is possible to disaggregate each financial sector's holdings of debt securities and listed shares issued by NFCs to the underlying holder and issuer. To distinguis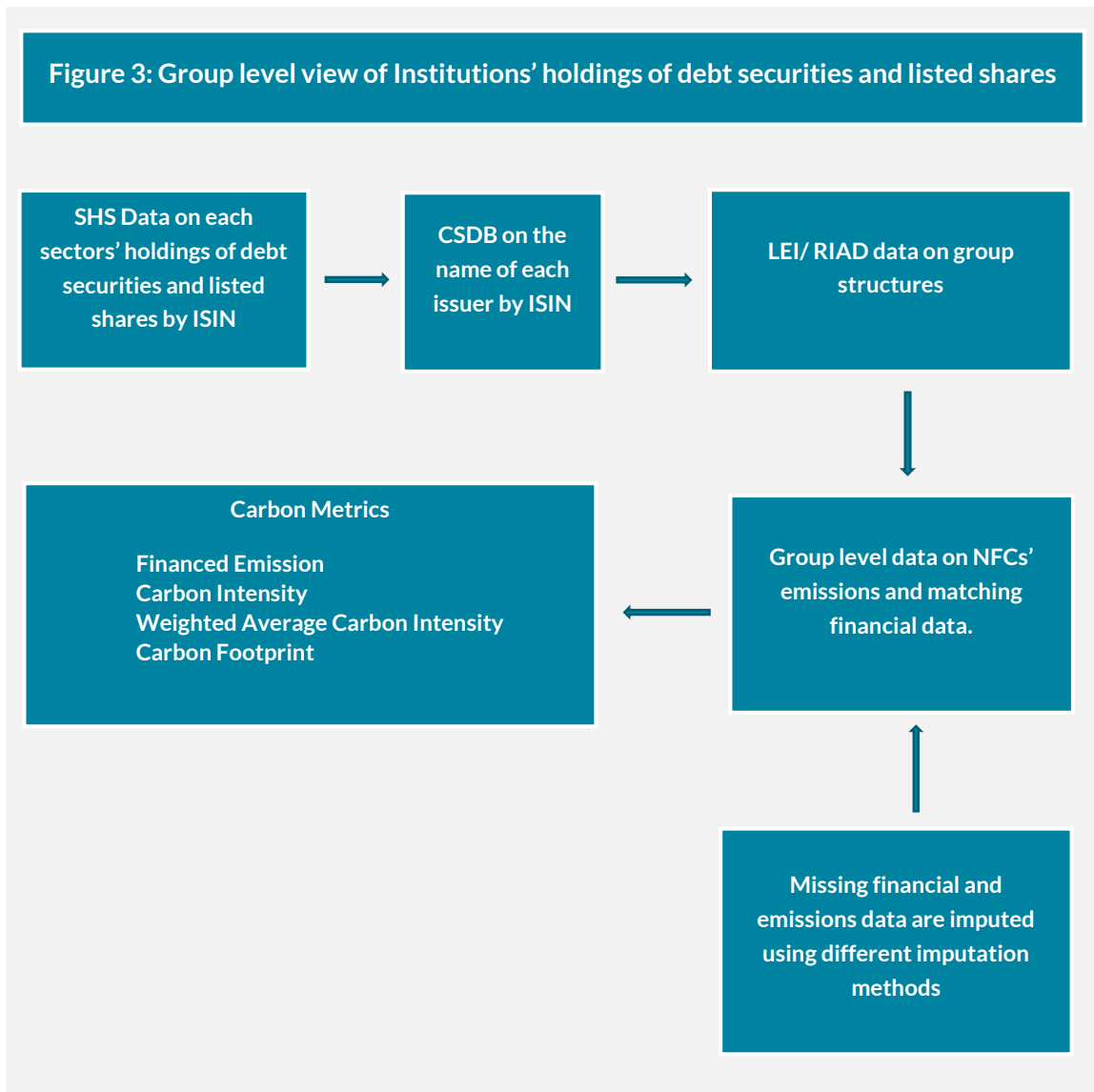h each NFC, the Eurosystem's master database, the Register of Institutions and Affiliates Data (RIAD) provided guidance on NFCs' group structure incorporating within this the global standard Legal Entity Identifier (LEI).

The purpose of such metrics is to understand better the concentrations of carbon-related assets in the financial sector and the financial system's exposure to climate related risks. Data on firms' Scope 1 and Scope 2 emissions along with the corresponding financial data was sourced from Institutional Shareholder Services Group.

Figure 3: Group level view of Institutions' holdings of debt securities and listed shares

SHS Data on each sectors' holdings of debt securities and listed shares by ISIN

→

CSDB on the name of each issuer by ISIN

→

LEI/ RIAD data on group structures

↓

Group level data on NFCs' emissions and matching financial data.

↑

Missing financial and emissions data are imputed using different imputation methods

←

Carbon Metrics

Financed Emission
Carbon Intensity
Weighted Average Carbon Intensity
Carbon Footprint

4. Limitations and Work in Progress

The indicators of carbon emissions represent a best-effort estimate of the carbon emissions associated with a selection of euro area resident financial institutions' claims. Owing to the various limitations associated with the underlying data and the estimation techniques, the indicators are currently categorised as "analytical". As more NFCs disclose data on the environmental impact of their activities owing to the CSRD directive, subsequent releases of these indicators will enjoy greater levels of certainty. At present, the transition risk indicators are only calculated for financial institutions' direct holdings of debt securities and listed shares. In the case of the ICPF sector, the value of their indirect holdings of NFCs' debt securities and listed shares via money market funds and investment funds may be equal to or greater than their direct holdings. Related to this, much of the investment funds' sector direct holdings

of debt securities and listed shares correspond to the indirect holdings of the rest of the financial sector. To improve the accuracy of the indicators, a 'look-through' approach would allow policy-makers to gauge more accurately, the carbon intensity of financial institutions' claims.

ECB (2024) outline three main methodological improvements that the subsequent release of the transition risk indicators are likely to benefit from: the use of input-output tables, a more complex time-series decomposition, and the calculation of Scope 3 emissions. The measure of WACI is underpinned by a decomposition of inflation and exchange rate fluctuations. A more complex decomposition will distinguish more thoroughly between inflation and exchange rate changes from other disturbances. At present, Scope 2 emissions are only reported at group-entity level. To derive a measure of Scope 2 emissions at single-entity level, input-output (I/O) tables may be used to allocate emissions from the energy sector to different debtors. Scope 3 emissions can account for a considerable volume of total emissions in some sectors although their reporting is not yet standardised. For single entity-level indicators, the imputation of Scope 3 emissions is expected to be advanced through I/O modelling. For group level indicators, the carbon emission indicators may in time by expanded to include Scope 3 emissions as NFCs start to publish this data owing to the CSRD directive.

The extension of the current analytical framework to include these improvements over time will provide a more holistic picture of the carbon emissions associated with financial institutions' claims.

5. Conclusions

For many years, economists have studied the climatic implications of economic activity with a particular focus on GHG emissions. Until recently, many of these studies focussed on economies' supply side and the need to de-couple longer-term economic growth from the growth in GHG emissions. The greater urgency across countries to attain carbon neutrality, the need for the financial sector to facilitate this, and the increased evidence linking extreme weather events with short-run fluctuations in activity and prices means that climate change has become a more pressing concern for central banks.

The indicators of carbon emissions reviewed in this *Article* represent the first attempt by the Eurosystem to gauge the financial sector's exposure to counterparties with carbon-intensive business models and the carbon intensity of the same financial institutions' security and loan portfolios. The indicators

encompass banks, investment funds, as well as the ICPF sector resident throughout the euro area from 2018 – 2021.   So far, two waves of data releases have been published in January 2023 and April 2024 with the second wave of indicators benefiting from higher coverage rates and more rigorous estimation techniques.

Regarding financial institutions resident in Ireland, the results indicate that the carbon intensity of their outstanding volumes of loans to NFCs appears to be sensitive to the method of estimation used. So far, the results calculated at single-entity and group-entity level are moving in different directions partially reflecting the differences in the carbon emissions of domestic and cross-border loans.   Regarding Irish resident financial institutions' direct holdings of debt securities and listed shares, the latest results indicate a decline in the carbon intensity of their claims although these headline results mask over a considerable degree of heterogeneity. Finally, much of their holdings of NFC securities relate to non-resident NFCs with debt securities and listed shares issued by Irish owned NFCs typically held by the non-resident sector. More disaggregated macroeconomic data in the coming years will provide further insights on this topic.

Appendix 1

While the second wave of transition risk indicators contain several methodological improvements one important aspect is that they now have much higher coverage rates associated with them owing to the imputation methods employed to increase date coverage. The coverage rates or the proportion of financial institutions' underlying claims that are reported in the first and second release of the transition risk indicators for financial institutions resident in Ireland are documented below. For comparison, the statistics reported in both tables correspond to Scope 1 emissions, and are based on an unbalanced panel. The increased coverage is most pronounced for bank lending to NFCs calculated at single-entity level. A similar increase is also evident in respect of Scope 2 emissions for financial institutions resident in Ireland. A similar increase is also evident in the euro area statistics.

Table 5a: Coverage Rates for Financial Institutions Resident in Ireland (2018-2020)

	Banks	Banks	Investment Funds	Insurance Corporations & Pension Funds
	Single Entity Results	Group Entity Results		
2018	39.7	52	73.8	82.1
2019	43	61.8	76	84.8
2020	34.8	40.5	81.1	86.6

Source: ECB
Note: The results relate to Scope 1 emissions published as part of the first wave of results in January 2023

Table 5b: Coverage Rates for Financial Institutions Resident in Ireland (2018 – 2021)

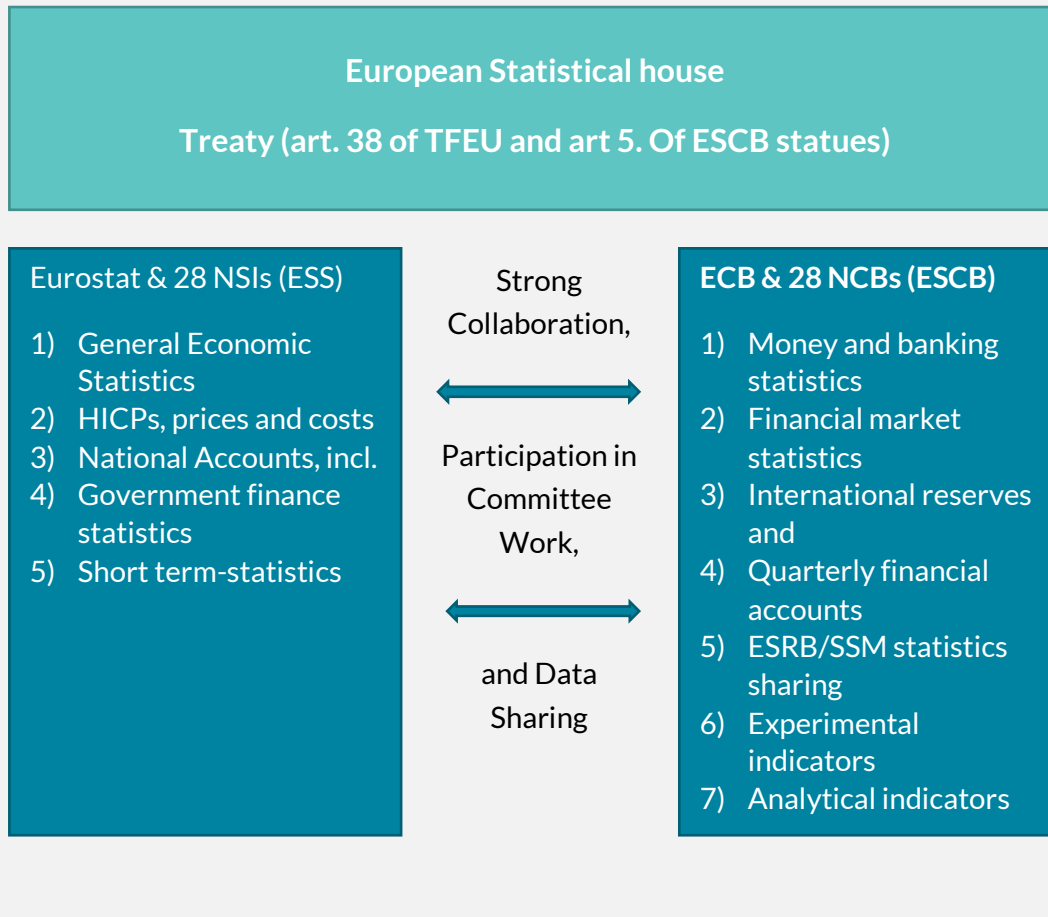|	Banks	Banks	Investment Funds	Insurance Corporations & Pension Funds
	Single Entity Results – bank lending to NFCs	Group Entity Results financial institutions' direct holdings of debt securities and listed shares		
2018	84.3	87.1	91.1	94.3
2019	91.5	92.7	91.8	94.4
2020	91.5	90.8	92.2	93.5
2021	89.7	92.7	94.1	94.5

Source: ECB
Note: The results relate to Scope 1 emissions published as part of the first wave of results in April 2024

Appendix 2

Understanding the different data types

The indicators of carbon emssions constructed by the ECB and the national central banks are one of three categories of climate indicators launched over the past few years, the other two being the physical risk indicators and the sustainable finance indicators. Although the indicators are not underpinned by an ECB regulation, the statistics can still provide important insights to policymakers. In this box, we review the different classifications assigned to Eurosystem statistics.

Article 127 of The Treaty on the Functioning of the European Union (TFEU) provides the ECB with the competence needed to collect all information required to perform the tasks of the European System of Central Banks (ESCB). To attain this, the ECB issues statistical regulations and guidelines to ensure that all reported statistics are underpinned by sufficient rigour. In practice, the collection of macroeconomic statistics is a shared responsibility between the ECB, the national central banks (NCB), as well as Eurostat and national statistical institutes (NSIs) and this collaboration is depicted below.

European Statistical house

Treaty (art. 38 of TFEU and art 5. Of ESCB statues)

Eurostat & 28 NSIs (ESS)	Strong Collaboration, Participation in Committee Work, and Data Sharing	ECB & 28 NCBs (ESCB)
1) General Economic Statistics 2) HICPs, prices and costs 3) National Accounts, incl. 4) Government finance statistics 5) Short term-statistics		1) Money and banking statistics 2) Financial market statistics 3) International reserves and 4) Quarterly financial accounts 5) ESRB/SSM statistics sharing 6) Experimental indicators 7) Analytical indicators

Shared

(i)   Balance of payments statistics

(ii)   International Investment Position statistics

(iii)   Financial and Non-Financial Accounts

To ensure that all economic statistics are underpinned by sufficient rigour, comparability, and harmonisation, all statistics are prepared in accordance with European System of National and Regional Accounts (ESA 2010), the Balance of Payments and International Investment Position Manual (BPM6), and System of National Accounts, 2008 (SNA 2008). SNA 2008 is a statistical framework that provides a comprehensive, consistent, and flexible set of macroeconomic accounts for policymaking, analysis, and research. Furthermore, the SNA 2008 framework is intended for use by all countries. ESA 2010 is broadly consistent with SNA 2008 with regard to accounting rules and classifications. It nevertheless incorporates certain differences, particularly in its presentation, which is more in line with its specific use across the European Union. BPM6 serves as the standard framework for statistics on the transactions and positions between an economy and the rest of the world and is consistent with SNA 2008.

Experimental data including the indicators of sustainable debt securities are economic and financial data, collected and compiled by the ECB, whose quality is somewhat lower than that of other ECB statistics. Experimental indicators typically suffer from one of the following limitations: (i) insufficient harmonisation (ii) incomplete coverage (iii) sub-optimality regarding the statistical concepts and methodologies applied (iv) estimation techniques that are based on substantial assumptions. The experimental datasets are nevertheless regarded as sufficiently reliable to be useful for monetary policy purposes and various ESCB tasks and may therefore also be of interest to users outside the ECB.

Analytical indicators are data that are at a research and/or work-in-progress stage and have not yet reached the quality of experimental statistics due to the inherent limitations associated with the microdata that underlie them and the assumptions made to integrate disparate data sources with distinct characteristics. The indicators can still be relevant and insightful if they are used with care and take into account the characteristics of the underlying data and methodologies.

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