The Riksbank's Climate Report

February 2025

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Climate change, and the measures taken to mitigate it, may have implications for both price stability and financial stability. They thus affect the Riksbank's core tasks. The Sveriges Riksbank Act (2022:1568) states that the Riksbank shall identify threats to sustainable development that affect the preconditions for its activities. According to the Act, the Riksbank shall also attach particular weight in its asset management to identify how sustainable development can be promoted without waiving other objectives and principles for asset management. The Riksbank shall promote a well-functioning payment system. Sustainability aspects are important for this task as well.

Since 2021, the Riksbank has published climate reports presenting the analysis of, and work on, environmental sustainability and climate change in particular. This is the Riksbank’s third climate report and it mainly covers work carried out in 2023 and 2024. The Riksbank’s internal sustainability work as an authority and employer is an important part of the sustainability work and is described in the Riksbank’s Annual Report.

The Executive Board of the Riksbank adopted the report on 19 February 2025. The report takes into account developments up to 11 February.

The Riksbank and sustainability

The Riksbank is an authority under the Swedish Riksdag whose activities are regulated by the Sveriges Riksbank Act. The overriding objective of the Riksbank is to maintain a low and stable inflation, also known as the price stability target. Without neglecting the price stability target, the Riksbank shall contribute to a balanced development of production and employment (consideration for the real economy).[1] The Riksbank shall also, without neglecting the price stability target, contribute to the stability and efficiency of the financial system, including the ability of the public to make payments.[2]

Climate change, and measures taken to combat it, pose risks to both price stability and financial stability, and may affect the Riksbank's ability to fulfil its objectives. These are mainly jeopardised by *physical risks* and *transition risks*. Physical risks include fires caused by drought, torrential rain and floods that cause injury to people, animals, nature and property. *Transition risks* arise when the world's societies need to take mitigation measures in order to reduce emissions. A further risk is that climate measures are not taken, or are taken too late, and this can be summarised as the risk of a *disorderly transition*.

The Sveriges Riksbank Act states that the Riksbank shall *identify threats to sustainable development that affect the conditions for its activities*.[3] Sustainability refers to long-term economic, social and environmental development.[4]

The Riksbank manages financial assets in order to fulfil its tasks and powers and to generate sufficient income to finance its activities. The assets shall be managed with low risk and taking into account the Riksbank's status as a central bank and the purpose of the asset holdings. The Sveriges Riksbank Act states that in its asset management the Riksbank *shall attach particular weight to how sustainable development can be promoted*, as long as this does not adversely affect the objectives of asset management or the principles of consideration for the Riksbank's tasks and low-risk management.[5] This involves the Riksbank analysing and managing sustainability-related financial risks.

The Riksbank is responsible for promoting a well-functioning payment system.[6] One of the Riksbank's tasks is to ensure that the public can make payments, including during peacetime crisis situations and states of heightened alert.[7] The Riksbank has set the objective that payments in Sweden shall be safe, efficient and accessible. In order for payments to be efficient, the costs to society, including energy consumption, for various methods of payment should be low. The Riksbank is therefore analysing sustainability-related risks and promotes sustainable development in the payment market.

[1] Chapter 2, Section 1 of the Sveriges Riksbank Act.

[2] Chapter 3, Section 1 of the Sveriges Riksbank Act.

[3] Chapter 1, Section 9 of the Sveriges Riksbank Act.

[4] Government Bill 2021/22:41 p. 82 and 246. These aspects of sustainability are also included in the description of Sweden's goals for the implementation of the 2030 Agenda (Government Bill 2019/20:188, Committee report 2020/21:FiU28, Riksdag Communication 2020/21:154).

[5] Chapter 9, Section 1 of the Sveriges Riksbank Act.

[6] Chapter 9, Section 13 of the Instrument of Government.

[7] Chapter 3, Section 1 and Chapter 5, section 1 of the Sveriges Riksbank Act.

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IN BRIEF

The Riksbank needs to identify, analyse and manage climate-related risks, as these affect the Riksbank's ability to achieve its statutory objectives and because it is a requirement under the Sveriges Riksbank Act. The Riksbank helps to increase knowledge about the impact of climate change on the economy. The Riksbank also takes sustainability into account in its asset management and internal work. In this way, the Riksbank contributes to sustainable development within the framework of its mandate.

The consequences of climate change affect the conditions for monetary policy through effects on inflation, economic growth and the neutral interest rate, among other things. For example, recent studies show that inflation can be affected by both transition risks and physical risks related to climate change. To enable the Riksbank to make the best possible monetary policy decisions, further improved knowledge about both the effects and how these are to be incorporated into the formulation of monetary policy.

Climate risks may entail stability risks for the financial system. At present, the transition risks for Swedish banks appear to be limited. However, these may increase if climate mitigation and adaptation measures are not taken and the risk of a disorderly transition increases. The financial system also plays an important role in channelling investment for the transition. Data reporting requirements on exposures to climate-related risks will be strengthened in 2025. This will help to ensure climate risks are priced more accurately and to discourage greenwashing, and thereby facilitating necessary investments.

The Riksbank is expanding reporting of the carbon footprint from the foreign exchange reserves. In its asset management, the Riksbank identifies, analyses and manages sustainability-related financial risks. An important part of this work is to monitor and report on the carbon footprint of the management. The foreign exchange reserves account for a large part of the Riksbank's financial assets and, as of 2025, the Riksbank will expand the reporting of its carbon footprint to promote transparency and increase comparability regarding the climate impact of financial assets.

The climate impact from Swedish payments is very low. The Riksbank's mandate in the area of payments includes making cash available to a satisfactory extent throughout Sweden, and ensuring that the public can make payments during peacetime crisis situations and states of heightened alert. The Riksbank is working continuously to reduce the carbon footprint of payments. Cards and cash are the means of payment that contribute the highest climate impact per payment in Sweden. The total climate impact of all card and cash payments in Sweden is less than the total emissions from 2,000 Swedes in one year.

1 Sustainability for economic development and stability

The Riksbank contributes to favourable long-term economic development by promoting low and stable inflation as well as a stable and efficient financial system, including the ability of the general public to make payments. A sustainable society is also a precondition for stability and favourable long-term economic development. Climate change has implications for the economy through increased costs, uncertainty, financial risks and structural changes. Unsustainable development thus affects the Riksbank's tasks. The Riksbank therefore works systematically for sustainable development by identifying, analysing and managing climate-related risks, contributing to increasing knowledge of the effects of climate change on the economy and by taking sustainability into account in its asset management and internal work.

1.1 Three focus areas for the Riksbank's sustainability work

The Riksbank has divided its sustainability work on climate change into three focus areas. First, the Riksbank is working to *identify, analyse and manage climate-related risks.* This involves the Riksbank continuously analysing the consequences of climate change and the transition to a sustainable economy. This climate analysis is an integral part of day-to-day operations, as threats to sustainable development affect the Riksbank's tasks in the same way as other types of risks and shocks. This work is carried out both as part of ongoing business intelligence and through the in-depth analysis of defined areas where risks can potentially arise. It can be done in the Riksbank's monetary policy drafting process, the financial stability assessment, asset management, the payments area and the Riksbank's own internal sustainability work.

Second, the Riksbank contributes to *increasing knowledge* about the effects of climate change on the economy and the financial system. This is done through the Riksbank's own analyses and through its participation in international working groups. The Riksbank thereby increases its knowledge and contributes to international knowledge. International cooperation is a central element of the work on climate change and is described in the fact box "The Riksbank's international climate work". The Riksbank also contributes to other research on the issue, for example by funding research into sustainability issues related to the Riksbank's activities.

In line with the requirements of the Sveriges Riksbank Act, the Riksbank *takes sustainability into account in its asset management*. This involves, among other things, incorporating sustainability considerations into the management of the foreign exchange reserves and the Riksbank improving its reporting of the carbon footprint of the financial assets on its balance sheet. To the extent that risks related to sustainability arise in the

asset management, these are managed. Knowledge of such risks is particularly important in light of the risks that a disorderly transition would entail, and that the risks arising from the impact of climate change are exacerbated as climate change becomes more evident.

The Riksbank works to continuously cut the greenhouse gas emissions in its own activities and to reduce their negative environmental and climate impact. This work is reported in the Riksbank's Annual Report.

Through these focus areas, *the Riksbank promotes sustainable development* within its mandate.

Figure 1. The Riksbank's focus areas in climate work

FACT BOX – The Riksbank's international climate work

Climate change is a global problem that requires global cooperation. It is therefore an important part of the Riksbank's sustainability work. A key organisation for international cooperation on sustainability is the Network for Greening the Financial System (NGFS), a voluntary network of central banks and supervisors. The network is not responsible for issuing regulations. Within the NGFS, participants work together and within their mandates to promote analysis, develop scenarios and exchange experiences. The Riksbank has participated in the NGFS since 2018 and, in February 2024, the Riksbank became a permanent member of the NGFS Steering Committee. Finansinspektionen (the Swedish financial supervisory authority) has been a permanent member since 2017 and now the Riksbank and Finansinspektionen participate together in the Steering Committee with a single Swedish vote.

The Riksbank participates in three NGFS permanent workstreams. Within the NGFS Monetary policy workstream, the Riksbank has contributed to a report on how society's transition to a sustainable economy affects the macroeconomy. In the Scenario design and analysis workstream, the Riksbank participates in the work of designing scenarios that are used to analyse the impact of climate change on the economy. In the Net zero for central banks workstream, the Riksbank shares experiences of internal sustainability work, as well as the measurement and reporting of climate-related financial risks on central bank balance sheets. In addition, the Riksbank participates in a task force on biodiversity and nature-related risks and in two expert networks for research and legal issues.

Furthermore, the Riksbank participates in the Basel Committee's Task Force on Climate-related Financial Risks (TFCR). The task force focuses on analysing how climate-related risks can create financial risks and developing methodologies to assess climate-related risks. It is currently working to develop harmonised reporting requirements for climate-related risks.[8]

Researchers from the Riksbank also participate in the European System of Central Banks' (ESCB) research network and the Basel Committee's research group, both of which have the climate as one of their focus areas.

The Riksbank also contributes to the work of the European Banking Authority (EBA) on climate-related risks, where the working group on transparency has produced disclosure requirements on climate risks for larger banks. The Riksbank participates in the European Central Bank (ECB) cooperation Network on Climate Change and in the group ECB Green, which works to promote sustainability in internal operations. In the Riksbank's work related to the European Systemic Risk Board (ESRB), climate-related risks are part of the regular risk and policy discussion and the Riksbank participates in the ESRB's meetings with a particular focus on climate risks.

[8] See press release: Basel Committee consults on a disclosure framework for climate-related financial risk.

2 Climate change is becoming increasingly important for monetary policy and financial stability

The consequences of climate change can affect the preconditions for monetary policy. Recent studies show, for example, that inflation can be affected by both transition risks and physical risks, which arise as a result of climate change. To enable the Riksbank to make the best possible monetary policy decisions, knowledge about how inflation is affected by climate change needs to continue to improve. The financial system is also affected. At present, the transition risks appear to be limited for Swedish banks. However, these can increase if action to combat climate change is not taken and the risk of a disorderly transition increases. The financial system plays an important role in channelling investments for the transition. To facilitate this and counteract greenwashing, meaning that financial institutions exaggerate the environmental benefits of their products, it is positive that the requirements for reporting data on exposures to climate-related risks will be strengthened in 2025.

Climate change is caused by excessive greenhouse gas emissions.[9] Greenhouse gas emissions are an example of what economists call a *negative externality*. This means that those who cause the emissions do not bear the full cost of the consequences of the emissions. There is a broad consensus in economic research that the most important factor in reducing greenhouse gas emissions is to make them more expensive, so that those who cause them bear a greater share of the economic costs. One way of achieving this is through various kinds of taxes, on carbon emissions, for example. Another way is through overall quantitative limits, where allocation to companies is made through the purchase of emission rights.

Global emissions are steadily increasing; see Figure 1 on the left. At the same time, Swedish emissions have decreased since the 1990s; see Figure 1 on the right. There are several explanations for this. The heating of homes and premises has become more efficient and shifted to energy sources with lower emissions. There have also been fuel shifts in industry and domestic transport. More efficient vehicles and the reduction obligation have also contributed to the reduction of emissions in domestic transport. A ban on landfilling of organic waste has contributed to reduced emissions related to Swedish waste management. In the energy sector, emissions have decreased as a result of reduced use of oil and coal.

If it is taken into account that Swedish consumption gives rise to emissions in other countries, measured as consumption-based emissions in Figure 1 on the right, Swedish

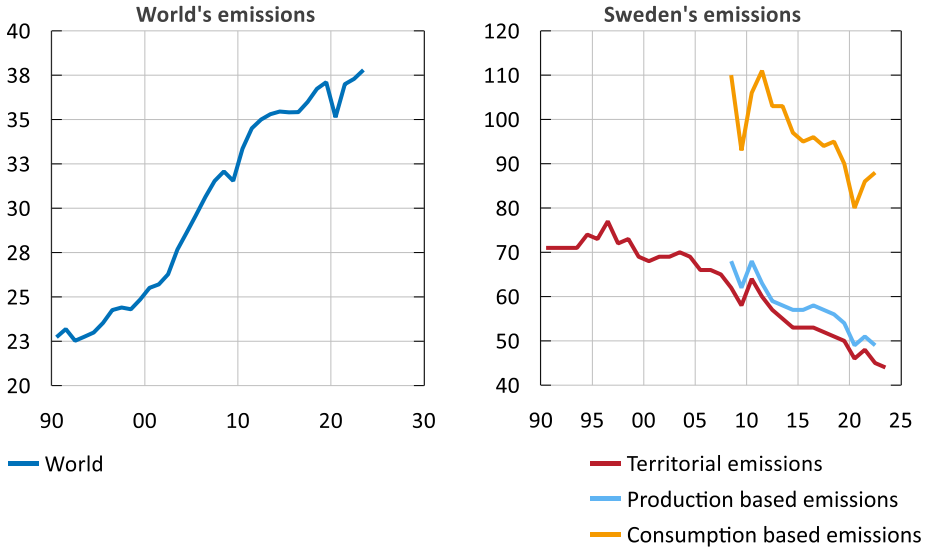
[9] See, for instance, Causes and Effects of Climate Change.

emissions are at a considerably higher level. Furthermore, the declining trend in consumption-based emissions was broken in 2020 and Swedish emissions have increased again according to this calculation method. The territorial and production-based emissions metrics are similar to one another. The difference is that the production-based metric also includes an estimate of international transport caused by Swedish companies and persons.[10]

The Swedish Government's goal is to make Sweden climate neutral by 2045. This involves reducing emissions measured as territorial emissions to zero. Emissions will continue to fall, and at a faster rate than in the last 30 years.[11] In the EU, the goal is to be climate neutral by 2050. Achieving this will require significant investment.[12] Financial market actors thus play a key role in the transition to a sustainable economy, by allocating capital and savings to sustainable investments.

Chart 1. Greenhouse gas emissions in the world and Sweden

Billion tonnes of carbon dioxide equivalents, million tonnes of carbon dioxide equivalents



Note. Territorial emissions are calculated on the basis of detailed data on activities carried out within Sweden's borders. Production-based emissions are calculated based on detailed statistics on fuel use combined with territorial emissions. Consumption-based emissions are calculated on the basis of a model, resulting in greater uncertainty. Climate targets relate to territorial emissions. Data extends to the end of 2023.

Sources: The European Commission (DG EDGAR), the Swedish Environmental Protection Agency.

[10] See Sveriges utsläpp av växthusgaser[Sweden's greenhouse gas emissions] and Tre sätt att beräkna klimatpåverkande utsläpp[Three ways to calculate climate-changing emissions].

[11] See Regeringens klimatpolitik [Government climate policy]. According to assessments, emissions are not falling fast enough to achieve the target; see, for example, Klimatpolitiska rådets rapport 2024[the Climate Policy Council's report 2024] and Naturvårdsverkets underlag till regeringens klimatredovisning 2024[the Swedish Environment Protection Agency's basis for the Government's Climate Report 2024].

[12] There are different estimates of the investment need. One study finds that it may amount to 4 per cent of GDP in the EU every year until 2030; see C. Nerlich, et al. "Investing in Europe's green future - Green investment needs, outlook and obstacles to funding the gap", *ECB Occasional Paper Series* No 367, European Central Bank.

The increased emissions pose several risks. The *physical risks* of climate change are becoming increasingly clear. These include both extensive fires caused by drought, as well as torrential rains and floods that cause injury to people, animals, nature and property. Reduced biodiversity and the risks it may pose to food production are also a physical risk that follows on from climate change. There are also *transition risks* that arise when the world's economies and societies need to take action to adapt to reduce emissions. There is a high risk that these measures are taken to a too small extent, too late or not at all. Then there is the *risk of a disorderly transition*. If international cooperation on climate issues is weakened, the risk of a disorderly transition increases.

2.1 Monetary policy needs to be able to identify climate-related effects on inflation and growth

Physical risks arising from climate events can affect the development of the economy in several ways and on different time horizons. One way to distinguish between different types of climate events is to categorise them as either acute or chronic.[13] Chronic events are of a more long-term nature and can span several decades. These include, for example, sea level rises, water scarcity and loss of biodiversity. The consequences of the chronic physical risks can be large, such as land areas becoming uninhabitable, conflicts arising over resources such as water or arable land, and the fact that many people are forced to migrate. The effects of these changes on monetary policy are of a more indirect nature. They are expected to influence factors that are relevant for the formulation of monetary policy, such as the neutral interest rate and potential output.[14]

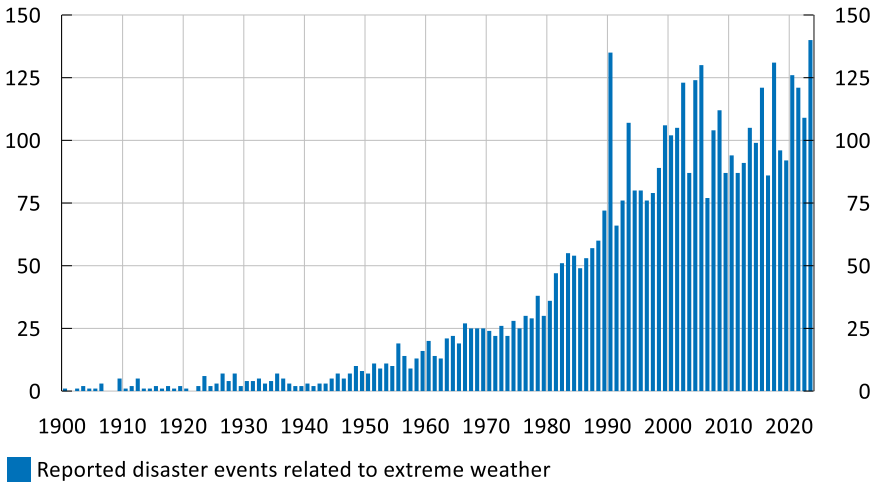
Acute climate events include, for example, extreme weather such as hurricanes or heavy torrential rains, which can cause damage to the economy's production capacity and lead to large price movements on various goods and services. The number of reported natural disasters is at a historically high level and shows great variation between years; see Chart 2. As inflation and economic growth can be directly affected by acute climate events, there can also be a direct impact on monetary policy. It is therefore important to understand the impact on the Swedish economy in order to make informed decisions.

[13] For example, see "Climate change, the macroeconomy and monetary policy", Network for Greening the Financial System, technical document, October 2024.

[14] See the analysis box "The Riksbank's assessment of the long-term neutral interest rate" in the Monetary Policy Report, December 2024, and A. Seim (2024), "Neutral interest rate – significance, limitations and assessment", speech at Sveriges Riksbank, 26 November.

Chart 2. The number of reported natural disasters related to extreme weather

Number



Note. Data for the world from the Emergency Events Database. Last year included is 2023, because full annual data for 2024 is unavailable. The latest observation is from May 2024. Please note that historical data may include systematic error reporting. For more information about the database and access to the data and its documentation, visit the EM-DAT website.

Source: Our World in Data.

Economic developments and thus the conditions for monetary policy are also affected by measures taken by governments and parliaments to combat climate change. They can give rise to transition risks. Measures such as taxes on carbon emissions or subsidies and regulations aim to provide incentives to steer production and consumption away from fossil-based activities. Structural changes are a natural part of all economic development. The transition to a sustainable economy is a structural change that is both expected and, at the same time, highly uncertain.[15]

2.2 Climate change affects inflation and the neutral interest rate

For central banks, the effects of climate change and of the transition to a sustainable economy on inflation are particularly important. While the effects of climate change on the real economy have been relatively well studied, the effects on inflation are somewhat less understood.[16] Price movements that follow climate-related events are examples of *relative price changes*.[17] One example is drought and high temperatures in

[15] For overviews see, for example, J. Hassler, P. Krusell and C. Olovsson (2024), "The Macroeconomics of Climate Change: Starting Points, Tentative Results, and a Way Forward", *Working paper 24-8*, Peterson Institute for International Economics, and J. Pisani-Ferry (2021), "Climate Policy is Macroeconomic Policy, and the Implications Will Be Significant", *Policy Brief*, Peterson Institute for International Economics.

[16] For example, see the review of the research literature in “Acute physical impacts from climate change and monetary policy”, Network for Greening the Financial System, technical document, August 2024.

[17] If prices of some individual products rise, this is not inflation in the real sense. The price of a particular product may increase if it is currently in high demand or if the production or distribution of the product is disturbed, leading to a fall in supply. Such price increases are called relative price changes, which is to say that some individual prices rise relative to others.

southern Europe in the summer of 2022, which led to a drop in production and a sharp rise in the prices of vegetables. Monetary policy cannot control the prices of individual goods but has the task of influencing general price developments. The relevant question for central banks is therefore to what extent relative price changes lead to persistent changes in the general price level. And this in turn largely depends on how monetary policy is formulated.

Research on how society's transition to a sustainable economy can affect monetary policy is under development and staff at the Riksbank have contributed to this growing research literature.[18] An important issue is how the changes in relative prices resulting from either climate events or climate change prevention measures, such as taxes and subsidies, can affect the design of monetary policy. In 2023, researchers at the Riksbank conducted a study of the economic consequences of a rise in the price of fossil-based energy due to the gradual introduction of a carbon tax.[19] The study also examines how the carbon tax affects the optimal formulation of monetary policy. In the model developed in the study, it becomes more relevant for monetary policy to focus on different inflation metrics that remove the effects of energy prices during the transition to a sustainable economy.[20] Another study produced within the framework of the Riksbank's technical assistance analyses how monetary policy should be formulated when a country with a large agricultural sector is affected by extreme weather events. Within the study, one metric of core inflation is defined as CPI inflation adjusted for agricultural prices. The authors show that in the case studied, when the agricultural sector is affected by extreme weather events, monetary policy should stabilise core inflation rather than CPI inflation.[21]

How monetary policy will respond in practice to relative price changes that arise from climate-related actions and events cannot be determined with any certainty in advance. For example, the central bank may not be able to ignore relative price changes and rely on inflation returning to target on its own. In particular, the risk of damaging confidence in the inflation target when inflation deviates significantly from the target needs to be taken into account, as a loss of confidence can lead to and amplify spillover effects in price setting and wage formation.[22]

Another fundamental research question concerns the impact on economic growth in both the short and long term. The transition to a sustainable economy involves major investment in infrastructure and industry, among other things, which has an impact on potential output and the neutral interest rate, for example. The neutral interest rate is defined as the policy rate that has neither a stimulating nor a restrictive effect on the economy and is determined in the long term primarily by global saving and investment

[18] For an overview, see "The green transition and the macroeconomy: a monetary policy perspective", Network for Greening the Financial System, technical document, October 2024

[19] The model is designed to mimic the EU's 'Fit for 55' package, with the price of brown energy gradually increasing by around 50 per cent over a 15-year period.

[20] See C. Olovsson and D. Vestin (2023), "Greenflation?" *Working Paper Series No 420*, Sveriges Riksbank (under publication in the European Economic Review).

[21] See M. Jonsson, C. Kamanzi, P.A. Kwizera and J.C. Niyonsenga (2024), "Adverse weather shocks and monetary policy in Rwanda", Staff memo, November, Sveriges Riksbank.

[22] See, for example, the discussion in E. Thedéen (2023), "Lessons from a turbulent period", speech, 20 December.

patterns. The transition to a sustainable economy may affect the level of the neutral rate, but it is uncertain in which direction. For example, an increased investment puts upward pressure on the neutral interest rate. On the other hand, if growth prospects deteriorate, the neutral interest rate will fall. What the final effect will be is thus uncertain and may vary between countries and over time. More research is needed in this area.[23]

Another area that researchers at the Riksbank have been involved in investigating is how the yield on government bonds is affected by both acute and chronic climate events. An empirical study using data from a large number of countries finds that interest rates rise as a result of transition risk and chronic climate events. The study also shows that acute climate events tend to negatively affect growth, increase public debt and contribute to greater variability in inflation.[24]

2.3 Stability risks due to transition risks are limited but may increase

Both acute and chronic climate events can create risks for financial stability. For example, insurance companies are directly exposed to acute climate events through various types of insurance policies that they provide to companies and households. As the likelihood of natural disasters and extreme weather increases, insurance companies' costs are expected to rise. Internationally, there is a discussion on what measures are needed to deal with the fact that several insurance companies in some countries have stopped offering insurance for such damage, or that the price of the insurance is very high. This means that there is an insurance gap. If insurance covers climate-related damage to a significantly smaller extent, the chances of households and businesses recovering are reduced. This in turn can lead to increased credit risks for banks when the value of collateral for lending deteriorates. In Sweden, insurance protection against natural events is still high.

Transition risks can also give rise to stability risks. A measure leading to a higher price for carbon dioxide emissions or specific regulation for certain products or services may result in increased costs for companies and sectors that are particularly exposed to such decisions. The transition can also lead to some assets becoming unusable or completely losing value, so-called stranded assets. This means an increased risk of poorer profitability for these companies and thereby also increased credit risks for the banks. An orderly transition would strengthen the conditions for limiting such risks. If, on the other hand, the transition is too slow and measures to mitigate climate change are delayed or insufficient, climate risks will increase in the longer term. This can force a disorderly transition that can challenge financial stability and become even more risky.

[23] See, for example, M. Jonsson and C. Nilsson (2025), "The impact of the green transition on the natural interest rate", *Staff memo*, Sveriges Riksbank (forthcoming) and E. Bylund and M. Jonsson (2020), "How does climate change affect the long-run real interest rate?", *Economic Commentaries*, No. 11, Sveriges Riksbank.

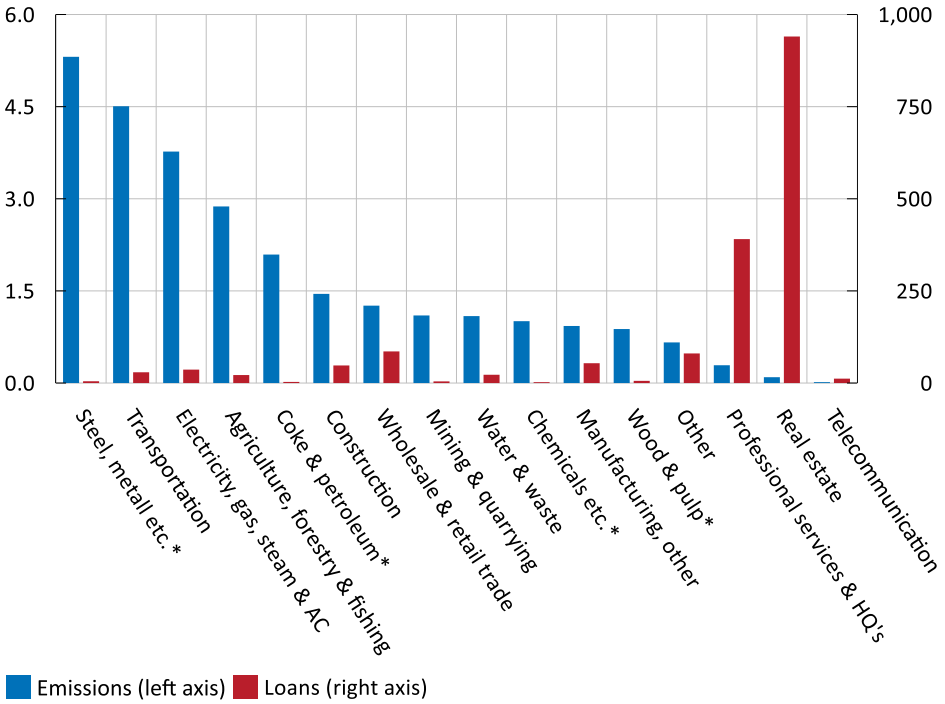
[24] See S. Anyfantaki, M. Blix Grimaldi, C. Maderia, S. Malovaná and G. Papadopoulos (2024), "Climate Risks and Sovereign Risks Nexus", International Banking Research Network.

The Riksbank and other authorities use various forms of climate stress tests and different types of sensitivity analyses to investigate the effects that climate-related risks may have on banks, and ultimately on financial stability. A Staff memo published by the Riksbank contains an analysis of how transition risks in the form of a cost for carbon emissions would affect banks' credit risks based on their loans to different sectors. Chart 3 shows aggregated emissions, measured as production-based emissions, from the companies to which Swedish banks have loans, grouped by sector, and the volume of loans made to these companies.

The figure shows that Swedish banks have relatively small loans to companies with high direct emissions, while they have large loans to companies with low direct emissions. The analysis indicates that the transition risks for Swedish banks are low and manageable. However, it also shows that the profitability of companies that conduct carbon-intensive activities may be affected and that these will need to adapt their operations to be sustainable and profitable in the long term. However, the analysis is based on some simplifications and assumptions, for example, only direct emissions are estimated, which means that the risks are likely to be underestimated. For example, according to the analysis, the property sector has low direct emissions, but it has higher indirect emissions which are not captured in the analysis.

Chart 3. Aggregated emissions and loans by sector

Million tonnes of carbon dioxide equivalents, SEK billion



Note. Based on companies that have loans in the Riksbank's credit register KRITA, which covers approximately 95 per cent of loans from Swedish MFIs to non-households. *Refers to manufacturing. Emissions are calculated as production-based emissions.

Sources: Statistics Sweden, the Riksbank.

A climate scenario analysis by the European supervisory authorities also shows that transition risks do not currently pose a risk to financial stability. At the same time, negative macroeconomic developments can increase the financial sector's losses and thereby limit its ability to finance the climate transition. Even though the financial sector has the resilience to cope with negative scenarios, the analysis therefore shows that it is important to integrate climate-related risks into risk management.[25]

The Riksbank is currently conducting several parallel research projects that deal with the consequences of physical risks for banks and their borrowers. In one project, data on all bank loans to companies in Sweden is used to investigate how weather events affect the banks' requirements for collateral. Another project examines whether the risk of flooding affects profitability and capital levels in banks with mortgages to households in affected areas and whether the banks take a higher risk in their pricing. A third project uses data from the United States to investigate the availability of credit to companies after a natural disaster occurred and whether lending to affected companies influences employment in the area.[26]

2.4 The financial sector is important for the transition to a sustainable economy, but there is a risk of greenwashing

The transition to a more sustainable and climate-neutral society requires both technological innovation and, as mentioned above, large investments. The financial sector plays a key role in making green investments possible. Capital in the financial sector can be used to finance investments in sustainable projects and to ensure that carbon-intensive industries can switch to more sustainable production. To meet this need, capital must come from both the public and the private side. Private capital can be in the form of, for example, bank loans, bond loans, private venture capital or share capital.

Green bonds and environmental funds have become increasingly popular tools in sustainable finance.[27] However, there is a risk that such products are used for greenwashing, which means that financial institutions exaggerate the environmental benefits of their funds, bonds and the projects they finance.

A study of Swedish equity funds that joined the Net Zero Asset Managers Initiative during the period 2019-2021 found that, on average, the funds did not have a lower carbon footprint than others. Nor have these mutual funds reduced their exposure to the most polluting companies in their portfolios. This may be because the funds retain the most polluting shares in their portfolios, because they believe that the companies that issue them are working well enough with their transition or because they want to encourage companies to improve their carbon footprint through active ownership. This may also

[25] See Transition risk losses alone unlikely to threaten EU financial stability, "Fit-For-55" climate stress test shows. The European supervisory authorities the European Banking Authority (EBA), the European Securities and Markets Authority (ESMA) and the European Insurance and Occupational Pensions Authority (EIOPA), together with the European Central Bank (ECB) and the European Systemic Risk Board (ESRB).

[26] See Research News 2024.

[27] Green bonds are fixed-income securities where the capital has been earmarked for environment-related projects. Green bonds contribute to financial stability through diversification effects, reduced climate-related risk and increased transparency.

be due to the fact that the funds do not environmentally adapt their portfolios quickly and efficiently enough. The latter explanation is more problematic both for the climate transition and for the financial system, and it may be a sign of greenwashing.[28]

To ensure that so-called green products really contribute to sustainable development, it is important to have harmonised standards, supervision and sufficient transparency. It is also important that there is structured, transparent and verifiable information that enables better supervision and monitoring of these actors. Otherwise, it is difficult to know what is behind changes in the actors' carbon footprint, which the Riksbank's study of Swedish equity funds gives an indication of.

New reporting requirements improve awareness of climate risks

Reliable climate-related data is also required for actors in the financial system to be able to assess and manage climate-related risks. In the absence of such data, or if data is inadequate, investors can easily get a misleading picture of the exposure of different companies to climate-related risks. The way that climate-related risks are managed and reflected in financial reports has been investigated in a study by the ESRB, which the Riksbank was involved in producing. It shows that incomplete consideration of climate-related risks can lead to overvaluation of assets or underestimation of expected loan losses. The study also concludes that efforts should be made to reinforce reporting requirements for how climate-related risks should be reflected in financial reports. The absence of relevant information on climate-related risks in financial reports could damage financial stability.[29]

Inadequate data can lead investors to invest in unsustainable companies in the belief that they are sustainable, thereby exposing themselves to unwanted risks. It can also counteract and delay the transition, thereby increasing the climate risks in the long term. To counteract these risks, it is necessary to use uniform and standardised frameworks that increase the transparency of climate-related data. In the EU, the Corporate Sustainability Reporting Directive (CSRD) has been implemented.[30] As part of the CSRD, harmonised reporting standards (European Sustainability Reporting Standards, ESRS) will be introduced which will facilitate comparison.[31] In 2025, large companies will start reporting according to the ESRS, and in the following years more companies will start reporting. This will make it easier for banks and investors to better understand companies' climate impact, how sustainability issues affect companies' development, results

[28] See C. Cella (2023), "Taking their temperature: Swedish mutual funds and the Paris Agreement", *Staff Memo*, April, Sveriges Riksbank.

[29] See Climate-related risks and accounting.

[30] The CSRD is based on companies reporting on their actions and results in environmental, social and governance-related areas (ESG). The CSRD began to apply in 2024.

[31] The CSRD sets out the information that companies must disclose in their sustainability reporting and is based on a principle of proportionality, with smaller companies having simplified requirements compared to larger companies. The ESRS specifies how companies should report their sustainability information.

and position, and how they work with climate-related risks.[32] Better climate-related data can also lead to better pricing of externalities.

Financial institutions need to improve their reporting of climate risks

According to a 2023 ECB study, the majority of systemically-important financial institutions reported basic information, and their information on climate and environmental risks had improved compared to previous years. However, much relevant information was still missing and the quality of the existing information was inadequate. The conclusion was that the financial institutions' information on climate-related risks was insufficient for market participants to base their risk assessment on.[33]

At an international level, there are several initiatives on standardised climate reporting. The Riksbank has participated in the work of the EBA transparency group to develop standardised accounting templates on climate-related risks for banks.[34] Work is continuing on developing these standards. The major Swedish banks are among the largest in the EU. The largest banks in the EU must disclose both physical risks and transition risks, according to a standardised format where they present different key ratios such as the Green Asset Ratio (the share of green assets). The purpose of the banks reporting different key ratios is to make visible how much of the bank's balance sheet is defined as green according to the EU taxonomy.

The major Swedish banks' climate-related risk information was studied in an Economic Commentary published by the Riksbank.[35] The study describes different methods for evaluating how green banks are and describes the new Green Asset Ratio.[36] The analysis concludes that a combination of different metrics is needed to provide a comprehensive picture, and that banks differ in how they finance and enable the transition to a sustainable economy.

[32] For companies outside the EU, the International Sustainability Standards Board (ISSB), which comes under the IFRS Foundation, has developed sustainability standards that are very consistent with the ESRS. The International Financial Reporting Standards (IFRS) currently form the basis for financial reporting in around 140 countries. The goal is for sustainability standards to complement the existing financial accounting standards. The sustainability standards that have been produced are IFRS S1 (general sustainability risks) and S2 (climate-related disclosures).

[33] See ECB study, April 2023. The importance of being transparent - A review of climate-related and environmental risks disclosures practices and trends.

[34] See EBA publishes binding standards on Pillar 3 disclosures on ESG risks.

[35] See N. Frykström (2025), "The green asset ratio – a metric to measure banks contribution to a green transition", *Economic Commentaries* No. 2, Sveriges Riksbank.

[36] Green means that they fulfil the requirements of the EU taxonomy to be classified as environmentally friendly.

3 Sustainability in the management of financial assets

According to the Sveriges Riksbank Act, the Riksbank shall attach particular weight to how sustainable development can be promoted, as long as doing so does not negatively affect the objectives of its asset management or the principles regarding the Riksbank's tasks and management to a low risk. In order to achieve this, the Riksbank must identify, analyse and manage sustainability-related financial risks. A key part of this work is to monitor and report the carbon footprint of the assets. Starting in 2025, the Riksbank will expand its reporting on the footprint of its financial assets to enhance transparency and improve comparability with regard to the climate impact of the financial assets.

The gold and foreign exchange reserves form a large part of the Riksbank's financial assets. At the end of 2024, the value of the gold reserve amounted to SEK 117.5 billion and the foreign exchange reserves to SEK 460.2 billion. The Riksbank has gold and foreign exchange reserves primarily to be able to offer banks liquidity support in foreign currencies in times of financial stress and to enable the Riksbank to carry out currency interventions when necessary. In order to be well prepared, the foreign exchange reserves mainly consist of government bonds with high credit ratings in US dollars and euros. For the same reason, there are also some holdings in pounds sterling, as well as Norwegian and Danish kroner. To spread risks and increase returns, a small share of assets in Australian and Canadian dollars is also included.[37]

In addition, a large part of the Riksbank's financial assets consists of securities in Swedish kronor. These were purchased primarily during the covid-19 pandemic to support the economy and stabilise financial markets.[38] These purchases were discontinued in 2023. The holdings of assets in Swedish kronor have since declined as bonds have matured and as a result of the sales of government bonds that began in April 2023. At the end of 2024, the value of holdings in Swedish kronor amounted to SEK 437.3 billion. In November 2024, the Riksbank decided to keep a long-term holding of nominal government bonds corresponding to SEK 20 billion.[39] Sales of government bonds will continue until this level is reached or another decision is taken.

[37] At year-end 2024, the currency distribution in the reserves excluding gold was: 63.3 per cent US dollars, 20.7 per cent euros, 5.4 per cent pounds sterling, 2.5 per cent Norwegian kroner, 1.2 per cent Danish kroner, 4.4 per cent Australian dollars and 2.5 per cent Canadian dollars.

[38] Purchases during the pandemic included nominal and real government bonds, treasury bills, municipal bonds, covered bonds (mortgage bonds), corporate bonds and commercial paper. The Riksbank also purchased nominal government bonds for monetary policy purposes between 2015 and 2020.

[39] See "Decision on trade in Swedish nominal government bonds", in Minutes of the Monetary Policy Meeting, Annex B, November 2024, Sveriges Riksbank.

3.1 Sustainability of the foreign exchange reserves

In 2024, the Riksbank started work on developing the management of the gold and foreign currency reserves. The work focused on the management model and decision-making process for the composition of the reserves, with the aim of taking better account of the balance sheet as a whole and the need for income generation. The work also included how to integrate sustainability into the asset management in the future.

The Riksbank clarifies that the foreign currency reserves shall only consist of bonds issued by countries that have joined the Paris Agreement, in accordance with the Riksbank's previous practice. At the same time, the reserves need to contain assets in the currencies that may be needed for the Riksbank to fulfil its tasks, for example in a crisis. The sustainability of the foreign exchange reserves therefore depends on whether the countries whose currencies must be included in the reserves comply with international agreements and contribute to the transition. For example, the US left the Paris Agreement in January 2025. However, as the dollar is necessary for the Riksbank's preparedness and to maintain price and financial stability, the Riksbank will continue to hold US government bonds in its foreign exchange reserves.

The Riksbank has previously decided to invest only in bonds issued by Australian states and Canadian provinces whose footprint is equal to or lower than the respective country's level. The footprint is measured here as portfolio weighted average carbon intensity. This decision stands.

The Riksbank invests in bonds with different sustainability classifications, as they are part of the market in which the Riksbank operates.[40] The Riksbank has no specific objective for sustainability-classified bonds. They are included in the asset management because they are part of the market, just like other bonds. These investments are made on the condition that the bonds meet requirements regarding liquidity, return and risk. The Riksbank reports the proportion of these bonds in the foreign exchange reserves.

Expanded reporting of emissions for foreign exchange reserve assets

Since 2022, the Riksbank has reported an emissions metric for the foreign exchange reserves, calculated as portfolio weighted average carbon intensity.[41] As of 2025, reporting will be expanded with three new metrics: total carbon emissions, carbon footprint and carbon intensity. The calculation method of the emissions metrics is based on the recommendations for central banks developed by the NGFS, which in turn are based on recommendations from the Task Force on Climate-related Financial Disclosures (TCFD).

Previously, the Riksbank based its calculation of emission metrics solely on the production-related emissions of the issuers. This metric did not include the effects of land use,

[40] This includes bonds labelled according to the International Capital Market Association's (ICMA) guidelines for green, social, sustainable and sustainability-linked bonds.

[41] See E. Brattström and R. Gajic (2022), "The carbon footprint of the assets in the Riksbank's foreign exchange reserves", *Economic Commentaries* no. 4, Sveriges Riksbank.

land-use change and forestry (LULUCF). As of 2025, the Riksbank is expanding its reporting to include these aspects, as well as consumption-related emissions linked to domestic consumption and emissions from government institutions.

To enable comparisons between countries, regions and over time, emissions are related to various indicators of economic activity. Examples of such indicators are gross domestic product (GDP) for production emissions, population for consumption emissions and government expenditure for government emissions. When land use (LULUCF) is included in the calculations, net uptake of carbon dioxide can reduce total production emissions. This means that emissions are reported as lower compared to when land use is not taken into account. For detailed information on the emissions metrics, see the fact box Emissions metrics for the foreign exchange reserves.

The carbon footprint of the foreign exchange reserves

On 31 December 2024, portfolio weighted average carbon intensity was measured at 217.2 tonnes of carbon dioxide equivalents per million dollars. Table 1 shows the outcome of the four emissions metrics for bonds issued by countries and regions in the foreign currency reserves as at 31 December 2024, when they accounted for 92.7 per cent of the total market value of the Riksbank's foreign currency reserves.[42] The metrics have to be interpreted with some caution as the holdings that are included are given a higher weight in the calculation than if all holdings in the reserves had been included.

Table 1. Emissions metrics for the Riksbank's foreign exchange reserves on 31 December 2024

Tonnes of carbon dioxide equivalents per million US dollars

	Bonds issued by countries and regions			
	Production related emissions excluding land use	**Production related emissions including land use**	**Consumption related emissions**	**Government emissions**
Portfolio weighted average carbon intensity	217.2	195.2	18.1	227.4
Total carbon emissions	8,877,264.4	7,978,073.2	10,722,278.2	1,448,694.6
Carbon footprint	217.2	195.2	262.3	35.4
Carbon intensity	217.2	195.2	17.9	212.0

Note. In the calculations, emissions data from 2021 are used in the absence of more recent data. Production-related emissions are reported by the countries themselves, while data on consumption-related and government emissions are calculated by data providers Carbon4 Finance and ISS ESG respectively. All emission metrics are calculated on the basis of the nominal values of the bonds.

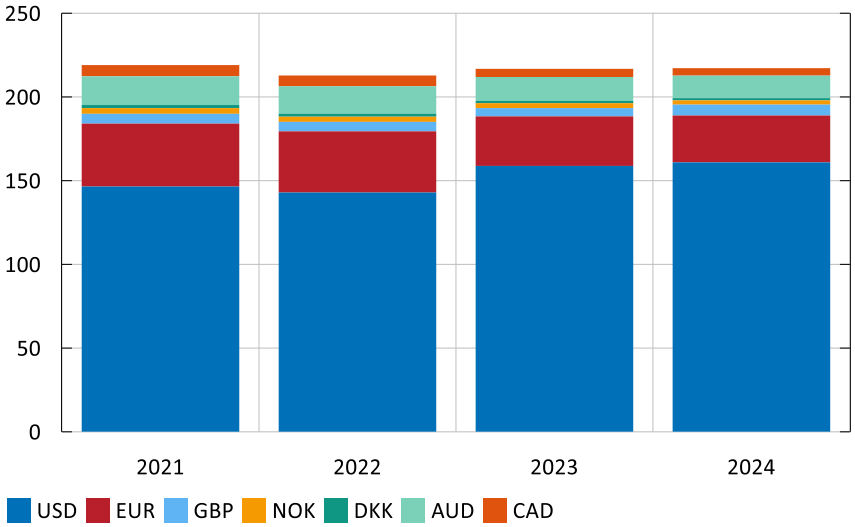
Sources: Carbon4 Finance, ISS ESG, UNFCCC, World Bank, Australian Bureau of Statistics, Statistics Canada and the Riksbank's own calculations.

[42] The following assets are not included in the calculations due to limited access to data or methodological guidance: physical gold (the gold reserve), cash and cash equivalents, bonds issued by intergovernmental organisations and financial derivatives (currency swaps and futures).

Chart 4shows the development of the portfolio weighted average carbon intensity as of 31 December 2024 and the three preceding years. The footprint of the foreign exchange reserves primarily depends on how much the Riksbank owns of a country's or region's securities and the country's or region's carbon intensity (the level of emissions in relation to GDP per issuer). Developments over the past four years are partly due to the share of holdings in US dollars having increased in 2023 while the share of assets in euros decreased, which together contributed to increasing the footprint. Over the years, the footprint for Australia has decreased, which has helped to reduce the footprint for that part of the reserves. The outcome is also affected by GDP figures and by the fact that only certain holdings are included in the calculations. The Riksbank continues to develop and refine its methods for monitoring and reporting the footprint over time. Over the period, the share of assets in US dollars has increased, which has contributed to a slight increase in the footprint since 2023.

Chart 4. Portfolio weighted average carbon intensity over time

Tonnes of carbon dioxide equivalents per million US dollars



Note. In the calculations, emissions data from 2021 are used in the absence of more recent data. The figure shows the portfolio weighted average carbon intensity based on production-related emissions excluding land use.

Sources: ISS ESG, UNFCCC, World Bank, Australian Bureau of Statistics, Statistics Canada and the Riksbank's own calculations.

The proportion of bonds with sustainability classifications in the foreign exchange reserves

Bonds with different sustainability classifications are defined here as bonds marked according to the guidelines applied by the International Capital Market Association (ICMA). This includes green, social, sustainable and sustainability-linked bonds. The Riksbank has no specific objective of owning a certain proportion of these bonds; instead the holdings mainly reflect the market’s supply. At the end of 2024, bonds with different sustainability classifications accounted for 1.9 per cent of the foreign exchange reserves.

FACT BOX – Emission metrics for the foreign exchange reserves

The Riksbank calculates four metrics for the carbon impact of the holdings of bonds issued by countries and regions that are part of the foreign exchange reserves. These metrics provide different perspectives on emissions, how they relate to the size of the reserves, and the economic activity of the issuing countries and regions.

Portfolio weighted average carbon intensity (WACI)
Shows how carbon-intensive the issuers in the foreign exchange reserves are. For each issuer, carbon intensity is calculated by dividing the emissions by an indicator of economic activity in the country or region (GDP, population or government expenditure). These individual intensities are then weighted according to the proportion of the portfolio that the issuer represents. Portfolio weighted average carbon intensity thereby focuses on how the portfolio's composition of individual issuers affects its total carbon intensity and is expressed in tonnes of carbon dioxide equivalents (tCO_2e) per million US dollars.

Total carbon emissions (TCE)
Total carbon emissions shows the portfolio's total emissions in absolute terms (tCO_2e), calculated by considering the portfolio's share of the respective issuer's economic activity (GDP). The metric does not take portfolio size into account but forms a basis for the two metrics below.

Carbon footprint (CF)
Carbon footprint relates total emissions to the amount invested (expressed in nominal value). By dividing total emissions by the nominal value of the portfolio, tCO_2e per million US dollars is obtained, allowing comparisons between portfolios of any size and over time.

Carbon intensity (CI)
Carbon intensity is based on the total emissions of the portfolio and divides them by an overall measure of the economic activity of all issuers together. Portfolio weighted average carbon intensity is based on individual issuer intensities weighted in the portfolio. Carbon intensity instead provides an overall picture of how emission-intensive the entire portfolio is in relation to its total economic activity. This results in an emissions metric (tCO_2e per million US dollars) that allows portfolios to be compared regardless of size and over time.

Similar results for metrics based on production-related emissions
When metrics are based on production-related emissions, weighted average carbon intensity, carbon footprint and carbon intensity yield similar results. This is because they are based on the same underlying data, weights and indicators of economic activity, which means that the outcomes are the same (see formulas in Annex 1).

3.2 Sustainability of the assets in Swedish kronor

When the Riksbank has purchased bonds issued by Swedish non-financial companies, sustainability aspects have been taken into account to manage sustainability-related financial risks.[43] As of September 2022, the Riksbank has only purchased bonds from companies that report their footprint according to Scope 1 and Scope 2. However, this did not affect the bonds that the Riksbank had already acquired by that date.[44] Since 2021, the Riksbank has reported the portfolio weighted average carbon intensity of the corporate bond holdings. As of 2025, the Riksbank also reports the portfolio weighted average carbon intensity of its holdings of Swedish government bonds.[45]

The carbon footprint for assets in Swedish kronor

At the end of 2024, the Riksbank's holdings of Swedish government bonds amounted to a nominal value of SEK 157.4 billion and its holdings of corporate bonds to SEK 4.0 billion. If no new decisions are taken, the holding of corporate bonds will mature by June 2027 at the latest. The portfolio weighted average carbon intensity was 73.6 tons for government bonds and 89.5 tons for corporate bonds per million US dollars. Since the calculation of corporate bonds is partly based on estimates, it should be seen as an indication and not as an exact figure.[46]

[43] See M. Andersson and M. Stenström (2021), "Sustainability considerations when purchasing corporate bonds", *Economic Commentaries* No. 3, Sveriges Riksbank.

[44] See "Decision, the Riksbank's bond purchases during the second half of 2022" in *Minutes of the Monetary Policy Meeting*, Annex B, June 2022, Sveriges Riksbank.

[45] Calculating the footprint of the holdings of covered bonds (mortgage bonds) and municipal bonds is more complex. Due to deficiencies in available data and methodologies, and the fact that these portfolios will eventually mature, the portfolio weighted average carbon intensity of these assets is not reported.

[46] The footprint of corporate bonds is measured as portfolio weighted average carbon intensity, where each company's emissions are set in relation to its revenues, which are then weighted according to its share of total corporate bond holdings. The calculation is based on both reported emissions and estimated emissions (Scope 1 and Scope 2).

4 Payments have a low carbon footprint

The Riksbank shall promote a well-functioning payment system. One of the Riksbank's tasks is to contribute to the stability and efficiency of the financial system, including the ability of the public to make payments. The Riksbank shall provide a system for the settlement of payments, contribute to the availability of cash to a satisfactory extent throughout Sweden, and ensure that the public can make payments in peacetime crisis situations and states of heightened alert. The Riksbank may, with the consent of the Riksdag, issue digital means of payment. The Riksbank has set the objective that payments in Sweden shall be safe, efficient and accessible. In order for payments to be efficient, the costs to society, including energy consumption, for various methods of payment should be low. Therefore, the Riksbank analyses sustainability-related risks and promotes sustainable development of the payment market, within its mandate.

Over six billion payments are made in Sweden each year. A majority of payments are made by card, while remaining payments are largely credit transfers such as direct debits and Swish. Examples of payment methods include cash, card payments, digital wallets and crypto-assets. They all have different environmental footprints. Cash payments require banknotes and coins, which require physical resources such as paper and metal. Digital payments often require energy-intensive servers and data centres to process transactions. How these data centres are operated affects the overall climate impact of the payment method. It is affected, for example, by whether renewable energy or fossil fuels are used. Examples of emerging technologies include block-chains and central bank digital currencies. Crypto-assets, such as Bitcoin, have been around for many years and have become increasingly popular for speculative investments. They can also be used as a means of payment, but this is rare.[47] Crypto-assets are very energy-intensive due to the method used to create the asset. With the emergence of new technologies, it is important to understand their long-term environmental impacts. Some new technologies have the potential to reduce overall resource use, while others may contribute to additional energy consumption and emissions.[48]

4.1 The Riksbank works to reduce the carbon footprint of cash management and payment infrastructure

The Riksbank has the sole right to issue banknotes and coins in Sweden. This means that the Riksbank supplies and destroys worn-out banknotes and coins and redeems invalid banknotes. The Riksbank works on sustainability from various aspects relating to

[47] See "Almost no one pays with cryptocurrencies" in *Payments Report*, December 2022, Sveriges Riksbank.

[48] See H. Eklööf (2022), "An overview of fintech and cryptoassets", *Staff memo*, May, Sveriges Riksbank and the Swedish Energy Agency (2023) "Energianvändning för utvinning av kryptovaluta" [Energy use for cryptocurrency mining], report in Swedish, January.

banknotes and coins. Key areas of work include design, procurement and agreements, and the handling of banknotes and coins.

In the lower denominations, the Riksbank issues coins instead of banknotes. Lower denominations are used more often and therefore suffer more wear than higher denominations, but coins last longer than banknotes. In 2015-2017, the Riksbank introduced a new banknote and coin series. The new coins and banknotes contain more climate-friendly components, which has a positive impact on production, transport and degradation. The new banknotes are smaller than the previous ones, making production more efficient. A 200-krona banknote was introduced to achieve a more efficient distribution between denominations, so that fewer banknotes need to be used. The two-krona coin was reintroduced for the same reason and, above all, to reduce the number of one-krona coins in circulation.

The Riksbank also requires that a certain part of the cotton used in the banknote paper ise organically grown, which means that it is grown without pesticides and with respect for the natural environment and human beings. The cotton is certified by the Global Organic Textile Standard (GOTS). The paper in Swedish banknotes is designed to be as physically sustainable as possible. This means that banknotes can circulate for longer than before and fewer banknotes need to be printed. The new coins are lighter than the previous versions, leading to lower transport costs. The Riksbank has also stopped using nickel and other alloys that were used in older coins. Steel, which has a lower environmental impact from mining, is mostly used today. Nickel and other alloys can also cause allergy problems for people using the coins. In 2022, the Riksbank also started using new banknote sorting machines that automatically and more accurately determine when used banknotes should be destroyed. This prevents banknotes from being unnecessarily destroyed.

4.2 The climate impact of payments in Sweden is low

The climate impact of payments in Sweden is very low, according to a study conducted by researchers at the Royal Institute of Technology and funded by the Riksbank.[49] Cards and cash are the means of payment that contribute the highest climate impact per payment in Sweden. Despite this, the total climate impact of all card and cash payments in Sweden is less than the total emissions of 2,000 Swedes in one year. The study also shows that the more a payment method is used, the higher its total climate impact. At the same time, the climate impact per transaction is lower, as the climate impact of, for example, IT systems, transport and materials can be spread over more payments.

Card payments that require more material and physical equipment, such as card terminals, have a higher climate impact than payments by Swish, for example. The European Central Bank (ECB) has also conducted a study on the climate impact of euro banknotes.[50] The study shows that the annual climate impact of using the banknotes in 2019

[49] See N. Arvidsson, F. Harahap, F. Urban and A. Nurdiawati (2024), "Climate impact assessment of retail payment services", Working paper series No 431, Sveriges Riksbank.

[50] See ECB study from 2023. Product Environmental Footprint study of euro banknotes as a payment instrument.

corresponded to 0.01 per cent of the total climate impact per citizen per year. This is roughly equivalent to driving a petrol car eight kilometres. The largest carbon footprint comes from the operation of ATMs, followed by cash transport.

The footprint of the Riksbank's instant payment settlement system is low

Through the RIX payment system, the Riksbank provides two services for payment settlement, RIX-RTGS for the settlement of high-value payments and RIX-INST for the settlement of smaller and instant payments in Swedish kronor. Settlement means that money, securities or both change hands in a transaction by making a transfer between two parties.

In 2022, the Riksbank launched the RIX-INST service to enable banks to offer more account-to-account payments that reach the recipient immediately. For example, from March 2024 onwards, all payments in the Swish mobile app are settled in the payment system. As from November 2024, the Riksbank has opened up RIX-INST to more types of instant payment. RIX-INST uses the Eurosystem's platform for instant payments, TIPS (TARGET Instant Payment Settlement). According to a report from Banca d'Italia, the TIPS platform has a low carbon footprint.[51] The report compares the energy consumption of TIPS with, among others, the VISA card network. The results indicate that TIPS is a more energy-efficient option, although the report points out that the comparison is between systems that handle different total volumes of transactions per year.

The carbon footprint of an e-krona would depend on its design

The Riksbank is investigating a digital complement to cash, known as the e-krona. Internationally, the concept is referred to as central bank digital currency (CBDC). E-krona would be digital kronor that are Swedish and issued by the Riksbank. As digital money, they could be used for more types of payments than cash.

In cooperation with the Royal Institute of Technology, the Riksbank has conducted a study on the potential environmental impact of a CBDC.[52] The rapid development of the payments market has led to new payment services and technologies. It is important to examine how a CBDC compares to other payment services in terms of efficiency. The development of a CBDC has potential environmental impacts mainly due to its electricity consumption. The design will determine the environmental impact of a CBDC, as the system can be scaled up to include multiple actors and is influenced by the location and energy sources of the server.

The study examines the environmental impact of a CBDC depending on its different technical designs. The technical design refers to how and where the information necessary for making payments is available. Whether several actors have the same information, a subset of the same information and whether the information is centralised have a bearing on the environmental impact. A centralised solution where the Riksbank

[51] See P. Tiberi (2021), "The Carbon Footprint of the Target Instant Payment Settlement (TIPS) System: A Comparative Analysis with Bitcoin and Other Infrastructures", *Research paper No. 5*, Banca d'Italia.

[52] See N. Arvidsson, F. Harahap, F. Urban and A. Nurdiawati (2024), "Potential Climate Impact of Retail CBDC Models", Working paper series No 437, Sveriges Riksbank.

has control may be less energy-intensive. The results show that the energy consumption per transaction for a centralised solution is comparable to that of card payments. In a decentralised design, more electricity supply is required, when each actor needs to operate and maintain larger systems themselves. This often requires more servers and computers, and increases the amount of data that needs to be processed per transaction. In a semi-centralised design, on the other hand, participating actors are primarily responsible for operating and maintaining systems, which facilitate their interfaces and services for consumers. With each additional actor, for the semi-centralised model as well as the decentralised model, one can potentially assume a linear or exponential increase in energy consumption. Whether it increases linearly or exponentially depends on the implemented validation process chosen for the transactions.

Validating payments is important to ensure the integrity of the transaction but also to maintain the security of the system. Validation is done through various consensus mechanisms. Consensus mechanisms such as Proof of Work[53] are used in cryptoassets and solve complex mathematical problems to confirm transactions. Proof of Work requires more energy than other types of consensus mechanisms, which instead tend to be more centralised. The study shows that a CBDC, which uses some form of block-chain, does not necessarily have a greater climate impact than existing traditional systems. The benefits of technological developments in the payments and securities markets are that settlement cycles can be shortened, and different types of conditional transactions can be carried out than those used today.

[53] Proof of Work is a consensus mechanism used in many cryptoassets to verify and authorise transactions on the block-chain network. It is designed to be resource-intensive and time-consuming, making it difficult for anyone to manipulate or attack the network.

5 Annex

Portfolio weighted average carbon intensity (WACI)

$$= \sum_{n}^{i} \left(\frac{current\ value\ of\ investment_i}{current\ portfolio\ value} \right) * \left(\frac{issuer's\ emissions_i}{issuer's\ economic\ activity_i} \right)$$

Total carbon emissions (TCE)

$$= \sum_{n}^{i} \left(\frac{current\ value\ of\ investment_i}{GDP_i} \right) * issuer's\ emissions_i$$

Carbon footprint (CF)

$$= \frac{\sum_{n}^{i} \left(\frac{current\ value\ of\ investment_i}{GDP_i} \right) * issuer's\ emissions_i}{current\ portfolio\ value}$$

Carbon intensity (CI)

$$= \frac{\sum_{n}^{i} \left(\frac{current\ value\ of\ investment_i}{GDP_i} \right) * issuer's\ emissions_i}{\sum_{n}^{i} \left(\frac{current\ value\ of\ investment_i}{GDP_i} \right) * issuer's\ economic\ activity_i}$$

The variables' current value of the investment and current portfolio value are based on nominal value, converted into US dollars. The issuer's emissions are expressed in the amount of tons of carbon dioxide equivalent[54] emissions per million US dollars. The indicator used for the economic activity of the issuer depends on the emissions on which the calculations are made: gross domestic product (GDP) for production emissions, population size for consumption emissions and government expenditure for public emissions. The lack of region-specific emission data is addressed by using the national data available. The lack of data for a year has been handled by taking the previous year's data. In the individual cases where data is missing for a specific year, the previous year's data has been used as a substitute.

[54] Carbon dioxide equivalents are a metric in which the warming potential of different greenhouse gases is translated into a standard unit. This is because emissions of a certain amount of greenhouse gas have different effects on the climate. This metric takes account of the varying extent to which different greenhouse gases affect the climate.

Table 2. Detailed explanation of the variables in the formulas above

Variable	Explanation	Unit	Source	Latest available data refers to
Production-related emissions	Emissions produced within a country's physical borders, including domestic consumption and exports. Production emissions are reported both excluding and including the effects of land use, land use change and forestry.	Tonnes of carbon dioxide equivalents, tCO_2e	ISS ESG (UNFCCC)	2021
Consumption-related emissions	Emissions linked to domestic demand, taking into account trade effects. This metric provides a broader picture of a country's emissions and addresses the problem of carbon leakage that occurs when production is moved from countries where the goods are later consumed.	Tonnes of carbon dioxide equivalents, tCO^2e	Carbon4 Finance	2021
Government emissions	Direct emissions (e.g. from buildings and vehicles) and indirect emissions (e.g. emissions linked to energy consumption and also expenditure, subsidies and investments) from the state.	Tonnes of carbon dioxide equivalents, tCO_2e	ISS ESG	2021
Gross domestic product, GDP	The Riksbank uses PPP-adjusted GDP at the 2021 price level. **GDP** is the sum of the total value added of all domestic producers plus any taxes on products and minus any subsidies not included in the value of the product. The **GDP deflator** is a metric used to adjust GDP for inflation. It shows how much the price level of all goods and services in a country has changed over time, compared to a base year. The conversion factor for **Purchasing Power Parity** (PPP) is a price deflator and currency converter that eliminates the effects of differences in price levels between countries.	USD million	The World Bank, the Australian Bureau of Statistics, Statistics Canada and the Riksbank's own calculations	2023
Population size	The total population of a country.	Number of people	The World Bank	2023
Final consumption expenditure	General government final consumption expenditure (formerly known as public consumption) includes all current expenditure on the purchase of goods and services (including employee benefits). It also includes most national defence and security expenditures but excludes military expenditures that form part of the state's capital formation.	USD million	The World Bank	2023

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