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Measuring Climate Risks with Indirect Emissions*

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Climate change poses completely new challenges for the financial markets, and thus the consideration of green aspects is becoming explicitly required by regulators and investors. Most of the reports which influence the market in this way evaluate the climate or environmental impact of a product or process based on their alignment with a regulatory standard. However, the methods applied for measurement do not always provide a proper description of the relationship between the investments and the natural resources. Most analyses evaluate investments related to economic sectors based exclusively on direct emissions, while indirect impacts, which represent a substantial part of total emissions, are not taken into account. In the study, the methods and results which are currently applied are compared to calculations including indirect impacts as well.

Journal of Economic Literature (JEL) codes: E58, G21, Q53, Q54

Keywords: climate change, sectoral exposure, greenhouse gas emissions, indirect flows

1. Introduction

In addition to the decrease in biodiversity, one of the modern world's most serious problems is air pollution and climate change caused by the increasing amount of harmful emissions, which fundamentally threaten the preservation of viable environmental conditions for the future generations. As a result of human activity, the average temperature of the Earth has increased by 1 degree Celsius compared to the average temperature before the industrial revolution. In order to avoid a global environmental disaster and decrease adaptation costs, the average temperature increase should be limited to 1.5 degrees Celsius (*IPCC 2022*), which would require the reduction of greenhouse gases by 7 per cent annually (*Friedlingstein et al. 2020; Tokarska – Matthews 2021*) and the fundamental restructuring of economies.

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It can be rightly claimed that climate change is reshaping every segment of the economy and society, thus posing completely new challenges for the financial markets. The emergence or reinforcement of green aspects and the tendency to move towards operations respecting ESG (Environment, Social, Governance) principles present the greatest business challenge for banking, investment and insurance services in the coming years. At the same time, international and national legislation will also impose more and more specific regulatory requirements in this regard. From the taxation of CO2 emissions through to the support of research and investment in developing sustainable technologies, fiscal and monetary political interventions can also greatly contribute to the success of initiatives aiming to protect our environment (*Hansen 2022; Boneva et al. 2021; Boneva et al. 2022*). According to a study by *Dikau and Volz* (*2021*), 52 per cent of the 135 central banks they examined are working to promote sustainable growth, either directly or by supporting governmental policies that target sustainability objectives. The importance of the latter lies in the fact that monetary policy measures that take green aspects into account can help the financial system and the economy as a whole to become sustainable (*Kolozsi et al. 2022a*).

The Magyar Nemzeti Bank (Central Bank of Hungary, MNB) launched its Green Programme in 2019 (*MNB 2019*), with the aim of supporting the sustainability of the Hungarian financial intermediary system and strengthening Hungary's competitiveness by means of financial products and services. With its Green Capital Requirement Allowance Programme[1] (*MNB 2021*), which was announced in 2020, the central bank aimed to improve the energy efficiency of the domestic housing stock. As part of the Green Monetary Policy Toolkit Strategy, the launch of the Green Home Programme of the FGS (Funding for Growth Scheme) also resulted in stimulation of the green housing loan market (*Matolcsy 2022; MNB 2022b*). Moreover, other MNB initiatives also contributed to the spread of corporate green bonds and green government securities to a great extent.

In the capital market segment, top priority areas now include complying with ESG directives, financing innovative, green technologies, and thus realising investments while considering the aspects of environmental protection, as well as establishing investment and capital funds related to the environment. In the case of the insurance sector, it can be stated that the number of unit-linked products tied to sustainability objectives has increased significantly in recent years, posing extraordinary challenges for market players and the regulatory authority

[1] *Zöld vállalati és önkormányzati finanszírozásra vonatkozó tőkekövetelmény kedvezményt vezet be az MNB* (*MNB introduces preferential capital requirements for green corporate and municipal financing*). Press release, Magyar Nemzeti Bank, 2020. https://www.mnb.hu/sajtoszoba/sajtokozlemenyek/2020-evi-sajtokozlemenyek/zold-vallalati-es-onkormanyzati-finanszirozasra-vonatkozo-tokekovetelmeny-kedvezmenyt-vezet-be-az-mnb. Downloaded: 21 October 2022.
https://www.mnb.hu/letoltes/tajekoztato-lakascelu-zold-toke-kedvezmeny.pdf. Downloaded: 21 October 2022.

(*Deák et al. 2022*). Regarding the bond markets, green bonds are becoming more and more popular among both investors and issuers, with the purpose of directly or indirectly financing the investments of environmental protection projects.

More and more financial market players are recognising the importance of managing environmental and climate risks and are working to improve their processes and methodologies related to ESG risks. Due to the lack of a standard methodology and regulatory requirements, many market players are unable to properly integrate environmental aspects into a risk management framework according to the actual risks, and therefore, the process gets bogged down with the initial application of oversimplified approaches (*Gyura 2020*).

With the dynamic transformation of financial markets, the burden on supervisory bodies to formulate an appropriate regulatory framework is also increasing; cf. the study by *Campiglio et al.* (2018) for further details in this regard. We must also highlight that one of the challenges central banks face is the development of national and international green financial standards to better identify and measure sustainability and climate risks, and to set real environmental objectives and achieve real impacts with their application. The latter needs to be emphasised as commercial banks, for example, are less interested in financing alternative industries with low carbon intensity, due to specific aspects of the credit market and the regulatory requirements currently in place (*Málits et al. 2022*). Hence, it is no wonder that in the past few years, the number of laws, recommendations, strategies and standards related to green finance has risen significantly as part of the adaptation to market changes (*Bhandary et al. 2021*).

In its action plan on financing sustainable growth (*European Commission 2020*), the European Commission presents a comprehensive strategy with three objectives and ten action plans to ensure that capital flows towards sustainable investments, to integrate sustainability considerations into risk management frameworks and to promote long-term transparency. In order to establish a single conceptual framework, the so-called EU Taxonomy Regulation on the establishment of a framework for promoting sustainable investments[2] has also established a definition of sustainable economic activity and its compliance criteria. Regarding investment products, the concept of sustainability risk and the obligation to report it were introduced in the EU regulation on sustainability disclosures[3] (Sustainable Finance Disclosures Regulation – SFDR). The European Commission's proposal package on banking regulation includes the requirements for market players in the

[2] https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52019XC0620(01)&from=EN
[3] https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32019R2088&from=EN

banking sector, supplemented with detailed sustainability[4] aspects. According to the MNB's updated green recommendation[5] published in August 2022, the central bank expects Hungarian credit institutions to switch to green operations, and to manage, report and disclose climate change-related and environmental risks by 2025.

With respect to the corporate sector, many recommendations and draft guidelines related to green aspects have been published. For instance, the disclosures of large companies covering environmental issues are laid down in the Non-Financial Reporting Directive (NFRD),[6] while the principles of corporate sustainability reporting are laid down in the CSRD proposal[7] (Corporate Sustainability Reporting Directive). In order to monitor the adaptation to specific recommendations and legislation and to provide transparency on the green transformation of the financial markets, national and international supervisory authorities regularly publish related studies, as well as green finance and sustainability reports.

Most of the reports affecting the market in this way evaluate the effects and significance of a certain product or economic activity on the climate and the environment based on their compliance with criteria set out by the regulator. However, the methods applied for measurement do not always provide a proper description of the relationship between a certain investment/economic activity to be evaluated and the natural resources. This may be due to the fact that indirect impacts are not or are only inadequately represented in the measurements of environmental exposure quantified by certain indicators and models.

In this study, based on current regulatory standards, we examine how the measurements of risk exposure determined by the methods of industry classification and applied to quantify climate risks can be affected if the calculations are carried out taking into account different levels of emissions in the supply chains of products and services. This assessment is of particular importance, as regulatory standards typically require supervised institutions to quantify only the direct and, in some cases, the indirect impacts of the operations of their proprietary entities, whereas a true assessment of the assets, investments and financial institutions financed would require a comprehensive quantification of the direct and indirect environmental impacts. The importance of properly measuring climate risks is further underlined by the new regulation of the European Banking Authority (EBA) (*EBA 2022*), which sets out a number of new reporting and methodological

[4] https://eur-lex.europa.eu/resource.html?uri=cellar:14dcf18a-37cd-11ec-8daf-01aa75ed71a1.0023.02/DOC_1&format=PDF
https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52021PC0663&from=EN

[5] *Megújított MNB-ajánlás: 2025-ig minden bank működése váljék zölddé* (Updated MNB Recommendation: all bank operations should be green by 2025). Press release, Magyar Nemzeti Bank, 5 August 2022 https://www.mnb.hu/sajtoszoba/sajtokozlemenyek/2022-evi-sajtokozlemenyek/megujitott-mnb-ajanlas-2025-ig-minden-bank-mukodese-valjek-zoldde. Downloaded: 18 October 2022.

[6] https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32014L0095&from=EN

[7] https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52021PC0189&from=EN

requirements for institutions issuing securities which are traded on regulated markets. The institutions in question will have to report their ESG risks through qualitative disclosures from 2024 and quantify their transition and physical risks using quantitative methods and indicators. Furthermore, quantitative methods are also required to be able to quantify the total amount of (direct and indirect) CO2 emissions of the funded instruments.

In our analysis, we quantify the values of greenhouse gas emissions (GHG emissions) of each economic sector taking into account different emission categories and then rank the environmental impact of the sectors. We compare the results of the quantification of direct impacts with the calculations defined by environmentally extended input-output tables,[8] which involve indirect impacts as well. Applying this form of input-output tables of sectoral relations, we are able to examine the environmental effects of the final demand using several different environmental indicators (*Gáspár 2020*).

2. Current methodology for measuring climate risks

The quantification of sustainability risks and the potential for climate risk reduction in financial markets has recently also received increasing attention from both researchers and practitioners. Nonetheless, despite the emergence of a number of new recommendations and regulations, there is still no standard methodology for measuring sustainability and climate risks and the related regulatory environment also keeps changing. The lack of a methodology to quantify and compare climate risks for different asset classes further complicates the task of supervisory bodies, both within institutions and at the sectoral level. In terms of practices in Hungary, the MNB has been supporting market players with a number of reports, methodological guidelines, studies and recommendations, as the resulting "greening" of the financial market offers significant environmental benefits.

In order to understand the new risk management framework that integrates environmental aspects as well, it is important to clarify what the terminology defined by the legislator really means in terms of risk management, as it is vital for the proper assessment and management of climate risks that the risks actually be identified and measured. Pursuant to Article 1 of the SFDR, a sustainability risk is considered to be any environmental, social or management event or circumstance, the occurrence or existence of which may have an actual or potentially significant negative impact on the value of the investment. Among all sustainability risks, climate risk can be considered one of the most significant risks, and we can distinguish between physical and transition risks within this group. Transition risks

[8] Environmentally extended multiregional input-output tables, EE-MRIOT

include all risks arising from the transition to a carbon-neutral and climate change resilient economy. The main focus of our study is on transition risks, while physical risks are detailed in the study of *Baranyai and Banai* (*2022*).

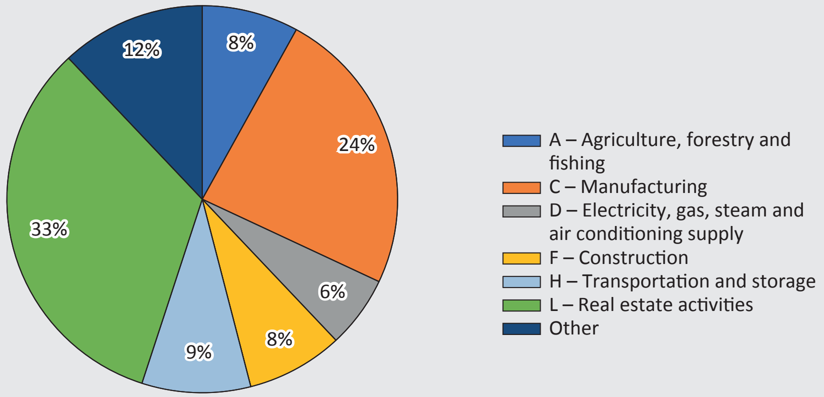
A simple method to quantify climate risks can be the quantification of the GHG emissions contribution of economic sectors and/or companies. Before choosing the right methodology, it is also important to clarify which level of the corporate value chain (Scope 1,2,3) generates the emissions we would like to measure with the methodology. In practice, three emission categories can be distinguished (*GHG Protocol 2004*). Direct emissions are listed in the category of Scope 1, which compiles the emissions of units under the direct influence of companies. The category of Scope 2 includes indirect emissions that are created during the generation of electricity used for a company's own purposes but not owned by the company. All other direct emissions generated during the full lifecycle of the corporate value chain that cannot be listed among Scope 1 or Scope 2 emissions belong to the Scope 3 category.

Determining individual sector exposure using the methodology of Climate Policy Relevant Sectors (CPRS) created by *Battiston et al.* (*2017*) has become widespread in the financial sector and is applied by many supervisory authorities. The advantage of the methodology lies in its easy implementation as it completely relies on the classification of economic activities applied by the EU (*Eurostat 2008*) for the classification and identification of risks.

When applying the CPRS methodology, economic activities are classified and listed with NACE Rev2 codes. Assuming that the economic activity of certain sectors may contribute more to greenhouse gas emissions, corporate exposures are classified as follows: (1) fossil fuel, (2) utilities, (3) energy intensive, (4) housing, (5) transport, (6) agriculture, (7) finance, (8) scientific research and development, and (9) other. Based on the CPRS methodology, sectors that are potentially affected by transition risks due to their nature are listed in sectors 1–6, and the ones with negligible climate risk exposure are listed in sectors 7–9.

Based on the CPRS methodology, the MNB (*MNB 2022d*) classified 57 per cent of the total credit exposure of the Hungarian banking system (manufacturing industry and real estate activities) into the categories potentially affected by transition risks. *Figure 1* shows the sectoral distribution of Hungarian credit exposures.

Figure 1
Breakdown of the Hungarian banking system's CPRS 1–6 exposures by sectors



Source: Edited on the basis of MNB (2022c) data

Based on the methodology applied by the European Banking Authority (*EBA 2021*) and the available data on GHG intensity, the MNB classified the credit exposures of the Hungarian banking system in GHG group 6 (*Table 1*). The corresponding GHG intensity values are assigned to certain company exposures based on the Eurostat NACE Rev2 sector codes and are then classified into the corresponding GHG groups according to the criteria based on the GHG intensity data.

Table 1
GHG intensity groups and the classification of corporate loans in the Hungarian banking system

GHG group	Entry criterion	Exposure amount (HUF billions)	Distribution (%)
Very low	GHG ≤ P10	2,056.63	20.11
Low	P10 < GHG ≤ Q1	1,391.49	13.61
Medium	Q1 < GHG ≤ Median	1,404.49	13.74
Medium/High	Median < GHG ≤ Q3	3,657.28	35.77
High	Q3 < GHG ≤ P90	1,265.27	12.37
Very high	GHG > P90	450.15	4.40

Source: MNB (2022c)

Ritter (*2022*) created five risk categories by jointly applying the methodologies of CPRS and the European Banking Authority and evaluated the transition risks of the Hungarian banking system. Based on this analysis, 1.2 per cent of the Hungarian institutions were classified in the high transition risk category, while 55 per cent of the Hungarian institutions were classified in the upper-middle quartile, which is also significantly exposed to climate risks.

The Task Force on Climate-related Financial Disclosures (TCFD) of the Financial Stability Board[9] proposes five different indicators to quantify climate risks (carbon footprint and carbon exposure), which only take into account Scope 1 and Scope 2 GHG emissions.

In line with the TCFD recommendation,[10] the MNB quantifies the Weighted Average Carbon Intensity (WACI) metric and the ratio of carbon-intensive assets, in order to measure the climate transition risks of the asset portfolios of the central bank. For each portfolio, the WACI metric used by the MNB quantifies the GHG emissions along with the added value per unit, according to the following relationships (*Kolozsi et al. 2022b; MNB 2022a*):

For corporate asset portfolios:

$$\mathrm{WACI} = \sum_{i} \frac{MV_{Si}}{MV_{Pi}} * I_{GHGi} \qquad (1)$$

where:

- MV_{Si} is the market value of the sector,
- MV_{Pi} is the market value of the portfolio,
- I_{GHGi} is the GHG intensity of the sector.

For sovereign asset portfolios:

$$\mathrm{WACI} = \sum_{\mathrm{i}} \frac{\mathrm{E_i}}{\mathrm{MV_{Pi}}} * \frac{\mathrm{GHG_i}}{\mathrm{nGDP_i}} \qquad (2)$$

where:

- E_i is the exposure value,
- MV_{Pi} is the market value of the portfolio,
- GHG_i is the country's GHG emissions,
- $nGDP_i$ is the country's nominal GDP value.

[9] Financial Stability Board: https://www.fsb.org/
[10] https://assets.bbhub.io/company/sites/60/2020/10/FINAL-2017-TCFD-Report-11052018.pdf; https://assets.bbhub.io/company/sites/60/2020/10/FINAL-TCFD-Annex-Amended-121517.pdf; https://assets.bbhub.io/company/sites/60/2020/09/2020-TCFD_Guidance-Risk-Management-Integration-and-Disclosure.pdf.

The ratio used to identify the carbon-intensive industries in Hungary is determined based on the Hungarian TEÁOR (NACE) codes according to the following relationship:

$$\mathrm{CI} = \frac{\mathrm{MV_{CIS}}}{\mathrm{MV_P}} \tag{3}$$

where:

- MV_{CIS} the market value of the carbon intensive sector
- MV_P is the market value of the portfolio

Methodologies based on sectoral classification can generally be claimed to lead to distortions in certain cases, as corporations may have several profiles that involve completely different sectors of industry.

In the case of products with a basic design linked to sustainability objectives, the application of the aforementioned methodologies requires due care. Regarding green bonds, *Mihálovits and Tapaszti* (*2018*) provided a comprehensive description on the difficulties and possibilities of quantifying the environmental benefits of this design. The authors also suggested that the environmental impact related to a specific project could be measured by quantifying the reduction of pollutant emissions, but a generally accepted indicator has not been published yet, despite several initiatives.

In addition to individual financial instruments, climate change also has a significant impact on the financial system as a whole. Climate risk stress tests simulated for complex scenarios are able to clearly demonstrate the effects of climate risks on the stability of the financial system. Climate risk stress tests can be carried out by means of macroeconomic models based on statistical-econometric methods, as it is essential to consider the complex interactions between environmental considerations, energy use and economic processes in the analyses (*Boros 2020*). Furthermore, according to *Battison et al.* (*2017*) and *Roncoroni et al.* (*2021*), the CPRS classifications mentioned above may be easily applied as input data in climate risk stress tests.

The analyses and methodologies mentioned above share the common feature of quantifying the climate risk exposure of sectors/portfolios based on the GHG intensity data published by Eurostat. Due to the fact that during the production of the data, emissions are accounted for in the sector where they actually enter the atmosphere, the results only include emissions that belong to the category of Scope 1. Therefore, it may occur that the approaches do not provide a comprehensive quantification of transition risks and thus distort reality, as they ignore indirect emissions created during the whole course of the supply chain. The real estate development sector may serve as a good example for this: it has insignificant current emissions as the resources and emissions are used at an earlier stage of the supply chain, starting from the extraction of raw materials to produce cement (*Resch et al. 2020*).

3. Indirect and direct emissions in the measurement of climate risks

3.1. Data used

In our analysis, the ranking of sectors was primarily carried out based on their direct (Scope 1) GHG emissions. To set up the ranking, we relied on Eurostat's database widely applied in regulatory practice, which commonly classifies economic activities into sectors based on the NACE Rev2 code (*Eurostat 2008*). Based on the NACE Rev2 classification, 21 sectoral categories with different letter codes were created. The GHG emissions of each sector were quantified using Eurostat's GHG emission data[11] available since 2008 in an annual breakdown for each sector. Since during the compilation of Eurostat data, GHG emissions are accounted for in the sectors they are actually released into the atmosphere, direct emissions were quantified based on these data. GHG emissions were quantified for Hungary (in tons) based on the data published in the first quarter of 2022.

In order to quantify indirect impacts, we used the EORA26 database, which publishes input-output tables and environmental indicators for the period 1990–2015, with regard to 189 countries and 26 sectors. EORA26 derives data on final demand from the national accounts of each country, the gross value of output, intermediate consumption data and value added from the national accounts of the UN database, and commercial data from the UN ComTrade database (*Lenzen et al. 2012, 2013*).

Table 2 presents an overview of the sectoral activities that were taken into account during the sectoral ranking in the analysis. 19 sectors were compared based on the sectoral classification of Eurostat, and 26 sectors based on EORA26.

[11] GHG= CO2 + N2O(CO2eq) + CH4(CO2eq) + HFC(CO2eq) + PFC(CO2eq) + NF3(CO2eq) + SF6(CO2eq)

Table 2
Summary table of sectors used in the analysis

Sector (Eurostat)	Sectors (EORA26)
A – Agriculture, forestry, fishing (agriculture) B – Mining and quarrying C – Manufacturing D – Electricity, gas, steam and air conditioning supply E – water supply; sewerage, waste management and remediation activities F – Construction G – Wholesale and retail trade; repair of motor vehicles and motorcycles H – Transportation and storage I – Accommodation and food service activities J – Information and communication K – Financial and insurance activities L – Real estate activities M – Professional, scientific and technical activities N – Administrative and support service activities O – Public administration and defence, compulsory social security P – Education Q – Human health and social work activities R – Arts, entertainment and recreation S – Other service activities	Agriculture Fishing Mining and quarrying Food industry Electricity Wood and paper industry Manufacturing of textiles and wearing apparel Metal industry Manufacture of machinery Vehicle manufacturing Repair and Maintenance Construction Retail Wholesale Petroleum refining industry Public administration Transportation Education Financial intermediation and Business activities Post and telecommunications Recycling Catering industry Other manufacturing Households Reexport & Reimport Other

Source: Eurostat, EORA26

It is necessary to highlight that the sectoral classification of the EORA26 database and the NACE Rev2-code-based Eurostat database cannot be considered identical, but each sector's contribution to GHG emissions can be quantified with both databases, and so the comparison of results can be carried out based on the ranking of their share of emissions.

3.2. Methodology

The direct and indirect resource requirements of each product and service were calculated with the help of EE-MRIOT (*Tukker et al. 2013; Wood et al. 2015; Stadler et al. 2018; Dombi et al. 2018*). By converting the intermediate production matrix of the EE-MRIOT to a Leontief inverse, the aggregate resource requirement and emissions of all final demands (consumption, investment, public purchasing, exports) can be calculated, leading to a so-called footprint indicator, which can be matched to Scope 3 emissions regarding GHG emissions.

This step identifies the values of total emissions associated with the products and services of each sector, regardless of the stage in the supply chain that they are generated at. Comparing these values with direct emissions also reveals indirect GHG emissions that are essential to the creation of a sector's outputs but cannot be measured directly in that sector. Several databases of these types are freely available. For our calculations, we used the EORA26 tables available disaggregated for 26 sectors, with global coverage for the period 1990–2015.

$$x = (I - A)^{-1} \cdot y \quad (4)$$

$$M = L_{GHG} \cdot y_i \quad (5)$$

where:

- x is the gross value of output,
- I is the identity matrix,
- A is a matrix describing the direct relationship among the sectors,
- y_i is the type of final demand (consumption, gross fixed capital formation, changes in inventories, government purchases and exports),
- L_{GHG} is the Leontief inverse matrix.

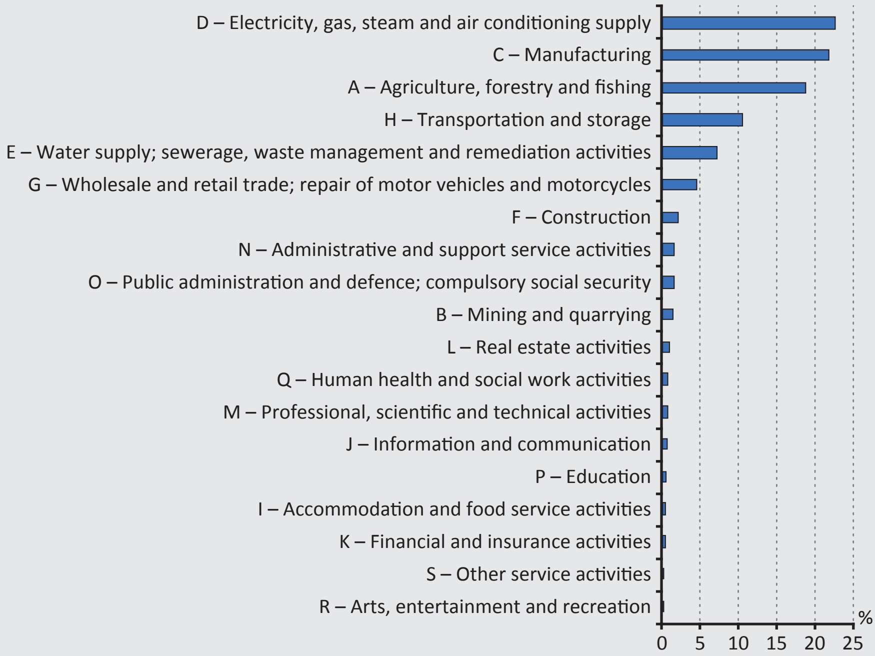
The Leontief inverse matrix comprises both direct and indirect monetary relations among the sectors. The next step is the calculation of the total emissions (M) of the sectors by including any environmental indicator. We chose GHG emissions for our analysis, which was multiplied by the final demand (*Steen-Olsen et al. 2016; Schaffartzik et al. 2014*). Among others, environmental indicators include the use of water, land and natural resources, measured in mass. In our calculations, the total final demand was taken into consideration.

3.3. Results

In order to identify potential differences arising from the application of various methodologies, we first quantified the GHG emissions of each sector based on Eurostat's GHG emissions data. The climate risk of each sector was measured by the ratio of the respective sector's contribution to total GHG emissions.

The ranking of the sectors based on their direct emissions is presented in Figure 2. If we take only the direct (Scope 1) emissions into account, the results show that sector D – Electricity, gas, steam and air conditioning supply sector contributes the most to the total GHG emissions with 12.09 Mt emissions (24 per cent), followed by sector C – Manufacturing industry with emissions of 11.64 Mt (23 per cent). The three largest emitters (D-C-A sectors) account for 66 per cent of total direct emissions.

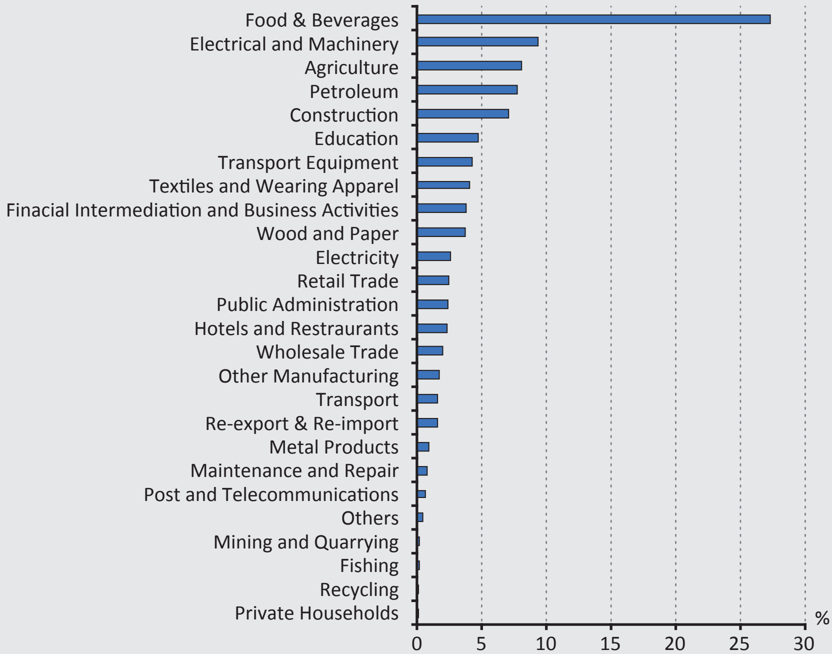
Figure 2
Share of each sector in direct (Scope 1) GHG emissions based on annual data for 2021



Source: Edited on the basis of Eurostat data

After the quantification of direct impacts, we applied EE-MRIOT based on the EORA26 database to quantify the total (direct and indirect) GHG emission of the sectors and we determined their contribution to total emissions. The ranking of the sectors based on our calculations is presented in *Figure 3*. Examining the overall ranking of emissions by sector, the food & beverages is responsible for the largest emission, followed by the electrical and machinery, agriculture, petroleum and the construction industry. The five largest emitters account for 60 per cent of the total emissions. Although the years of the results, which include indirect emissions as well, do not match with the ones observed in the MNB report, the economic structure has not changed in essence. Among the sectors significant in terms of total emissions, the share of agriculture and the manufacturing industry was each 10 per cent lower in GDP in 2021, while the share of trade and automotive manufacturing increased by 15 per cent. The sectors involving high climate risks are not affected at all by the seasonal effect.

Figure 3
Total share of each sector (Scope 1, 2, 3) in GHG emissions based on annual data for 2015



Source: Edited on the basis of EORA26

The agriculture is considered major emitter based on both the direct and total emission rankings. Regarding the construction industry, the contribution to direct GHG emissions of 2.15 per cent (1.1 Mt) is combined with a total emission share of 7 per cent.

In addition to ranking sectors, it is worth examining the sectoral distribution of Hungarian financial asset portfolios, which provides a comprehensive picture of the transition risks of existing portfolios. Based on the MNB's TCFD report (*MNB 2022a*), regarding the Funding for Growth Scheme, about HUF 540 billion was related to trade and vehicle repair, around HUF 420 billion to real estate activities and roughly HUF 370 billion to the manufacturing industry, out of the loan portfolio of HUF 2,535 billion outstanding at the end of 2021. With respect to the Bond Funding for Growth Scheme, out of the total portfolio of HUF 1,550 billion, some HUF 370 billion of exposure can be identified in the manufacturing industry, approximately HUF 200 billion of exposure in the construction industry, and about HUF 150 billion of exposure in the category of real estate activities. The MNB also carried out the carbon footprint analysis of the fiscal expenditure (Scope) of the general government (*MNB 2022a*). Sectors characterised by high direct expenditure typically do not receive significant central funding, but based on our results, the climate exposure of education, trade and housing activities is presumably higher than their exposure reported by the MNB.

Based on the currently applied methodologies, the transition risks of asset portfolios and the carbon intensity classification of the sectors are quantified using direct emissions data, so that exposures related to real estate, construction and machinery manufacturing and repair are assigned to lower risk categories, even though they may incur significant risks based on their total emissions. Therefore, it is reasonable to assume that if we take indirect GHG emissions into account in the calculation of the currently applied WACI metric weighted with exposure, the carbon intensity value and risk classification of the respective asset portfolios will change significantly.

It should be noted that emissions created from sectoral operations can be identified by ranking total emissions, and with their application, respective risk assessment methodologies may provide a more comprehensive picture of each sector's contribution to the actual environmental impact. For the methodologies used to assess the climate risk of each sector, and thus to support or penalise economic activities through supervisory or governmental support, it is recommended to extend the calculations beyond direct impacts to indirect emissions created during the whole operation.

4. Summary

Adequate management of climate risks in the financial markets is receiving more attention from both market players and supervisory authorities. Our study provides an overview of methodologies currently applied to identify and measure climate risk exposures. With respect to Hungarian and international practices, it can be said that the MNB supports the market adoption of international regulatory requirements and recommendations in several ways, and it analyses the potential effects of the measures in its reports, which are published regularly. In this dynamically changing regulatory environment, it is essential to publish analyses related to the methodologies applied, as due to the lack of a commonly accepted practice, the current aim is to create the best market practices.

Regarding the methodologies measuring transition risks, we can claim that they typically take direct emissions into account, or indirect emissions created by the operation or proprietary units at most. The importance of taking the total of indirect impacts into account is further underlined by the regulation of the European Banking Authority issued in 2022, which requires the market players involved to measure and disclose Scope 3 emissions from 2024. However, when quantifying GHG emissions, it is often difficult to access the data, especially in the case of Scope 3 emissions. At the moment, 36 per cent of Hungarian banks quantify emissions belonging to the category of Scope 1, 32 per cent of them quantify emissions in Scope 2 category, and less than 10 per cent of them quantify emissions in Scope 3 category. However, in order to provide sustainable operations, establish strategies and reduce climate risks, it is imperative for institutions to be able to appropriately measure emissions created during their own operations, and the climate risks of instruments and investments funded by them. In addition to the proper measurement of emissions, moving in the direction of carbon neutrality also requires the disclosure and publication of information. Hungarian institutions, however, only publish emission data related to their own operations, and the introduction of emission-related disclosures of funded instruments and investments has not been carried out. Nonetheless, the EORA26 database, which was used in our analysis and is available to the public free of charge, and the methodology presented may provide help and serve as a starting point for market players to develop disclosures and thus comply with regulatory requirements.

In the next step of the research, we need to recalculate certain indicators together with indirect impacts, in order to properly identify carbon intensive sectors and exposures, and thus point out the differences created by the application of various emissions categories with respect to several asset classes. In the future, the results of further analyses may serve as a basis for the development of methodologies that supervisory authorities apply, and the expansion of the Green Monetary Policy Toolkit Strategy and the Green Capital Requirement Allowance Programme. Prospectively, we also suggest analysing indirect emissions at a corporate level, establishing and promoting the so-called hybrid LCA-IO models, which combine the advantages of the two approaches (corporate, product, service and macro-level sectoral analysis).

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