The NACE – CPRS – IAM mapping:
A tool to support climate risk analysis of financial portfolio using NGFS scenarios.

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Abstract
We propose a mapping from NACE codes of economic activities, into Climate Policy Relevant Sectors (CPRS) and into the variables of the process-based Integrated Assessment Models (IAM) used by the Network for Greening the Financial System (NGFS) to provide its climate scenarios. We discuss the classification of CPRS at the disaggregation level provided by CPRS Granular, which distinguishes across energy technologies (e.g. within transport, motor vehicles powered by combustion vs electric engines). Then, we describe the mapping of NACE 4-digit – CPRS Granular – IAM variables used in the scenarios of the NGFS. CPRS enable users to group the large number of NACE codes into few categories of climate transition risk. At this point, it is possible to identify for each NACE economic activity the most relevant IAM variable to use in the NGFS scenarios. This procedure enables the use of climate scenarios (e.g. NGFS) for climate-related financial disclosure and climate stress testing. The goal of this note, and of the proposed mapping is to support practitioners, financial supervisors, investors and academics in climate transition risk disclosure and climate transition risk assessment, providing a science-based, transparent and operational tool.

1. Introduction

The goal of this note, and of the proposed mapping, is to support practitioners, financial supervisors, investors and academics in climate transition risk disclosure and climate transition risk assessment, providing a science-based, transparent and operational tool.

Low-carbon transition policies are expected to affect economic sectors in very different ways (IPCC, 2022). For instance, there is a consensus that achieving the Paris Agreement climate target requires the electricity sector to expand and the fossil fuel sector to shrink. However, differences are expected also within these sectors depending on the specific climate mitigation scenarios and the technology used to produce energy and electricity.

In this report, the term economic activity[1] is used in line with the international standards ISIC, NACE or NAICS and refers to a production process, e.g. electric power generation. However, the same activity can be carried out with different technologies (e.g. coal-fired power plants or wind turbines). In the context of climate policies, the specific technologies used in the production process are very relevant because they are associated with very different levels of GHG emissions and transition risk. Financial institutions hold securities and loans associated to firms and these data typically come with the classification of firms in terms of

[1] "An economic activity takes place when resources such as capital goods, labor, manufacturing techniques or intermediary products are combined to produce specific goods or services. Thus, an economic activity is characterized by an input of resources, a production process and an output of products (goods or services)." https://ec.europa.eu/eurostat/statistics-explained/index.php?title=NACE_background#The_international_system_of_economic_classifications

their NACE codes or other similar economic classification systems. However, ISIC, NACE or NAICS economic classifications were not designed to disclose climate-relevant information, and do not provide an identification of the activities that are exposed to climate transition risk and could become "carbon stranded assets".

Climate transition risk refers to the risk associated with a disorderly low-carbon transition in which changes in the values of financial assets (respectively negative for fossil fuels and positive for renewable energy technologies) cannot be fully anticipated or hedged by market players. There are several reasons for the lack of anticipation, including climate policy uncertainty; a late-and-sudden alignment to climate targets (e.g. 2 degrees C) due to the complexity of the policy process; incomplete markets (e.g. insurance); deep uncertainty of future climate impacts on technological developments and social dynamics (Monasterolo, 2020).

Process-based Integrated Assessment Models (IAM, Weyant, 2017; Krey, 2014) are widely used to generate possible future trajectories of output of economic activities based on their energy technology (e.g. fossil fuels or renewables)[2]. Recently, IAM trajectories have been used to inform climate financial valuation adjustment and climate financial risk assessment in climate stress tests. The first approach to use the trajectories of IAM in climate stress-tests of financial institutions was developed by Battiston et al. (2017). Since 2020, process-based IAM have been used by the Network for Greening the Financial System (NGFS) to build climate mitigation scenarios (NGFS 2020, 2021) which are recommended for use by the financial industry and by financial supervisors in their climate stress test exercises (see e.g. Allen et al., 2020, Clerc et al., 2021, Alogoskoufis et al., 2021, Vermeulen et al., 2021).

The data output of IAM consists of a set of "variables" (e.g. the production of crude oil, measured in ExaJoules per year), defined and used as standard within the Integrated Assessment Modeling community[3]. However, the names and definitions of the IAM variables do not have a straightforward correspondence to the names of the economic activities in the international standard classifications. This is a problem for the climate risk analysis of financial portfolios because the issuers of securities or loans held by investors in their portfolios, can be easily classified in terms of their NACE or NAICS codes (because these codes are available from most data providers) but not in terms of IAM variables. Further, IAM variables are not provided with a classification in terms of their exposure to climate transition risk. Thus, the translation of IAM variables and trajectories into climate transition risk exposure of the activity is left up to the users. These features limit the use of the NGFS scenarios for climate risk assessment.

The Climate Policy Relevant Sectors (CPRS) introduced in Battiston et al. (2017) contributed to fill this gap by defining a unique correspondence between international standard classifications of economic activities and IAM variables, and by assigning IAM variables a specific climate transition risk profile based on a clear and transparent logic. Indeed, CPRS provide a classification of economic activities at a high granular level (e.g. NACE 4-digit, NAICS 6-digit) into unique climate transition risk classes based not only on their Greenhouse Gas

[2] This class of IAM is to be contrasted with the class of aggregate cost-benefit IAM such as DICE.

[3] For details see https://www.iamconsortium.org/scientific-working-groups/data-protocols-and-management/iamc-time-series-data-template/

(GHG) emissions profile, but also on their energy and technology profile, their business model (input substitutability) and policy relevance. Because of these features, CPRS enable us to map the NACE 4-digit (or NAICS) codes into the most relevant IAM variable counterparts. CPRS are available at increasing levels of granularity (from "CPRS Main" to "CPRS2" and then to "CPRS Granular". Thus, they are flexible to adapt to the available project-based information of the financial contract or security.

The mapping process and its logic are illustrated schematically in Figure 1. CPRS enable users to group the large number of NACE codes into few categories of climate transition risk. At this point, it is possible to identify for each NACE economic activity the most relevant IAM variable to use in the NGFS scenarios. This procedure enables the use of climate scenarios (e.g. NGFS) for climate-related financial disclosure and climate stress testing.

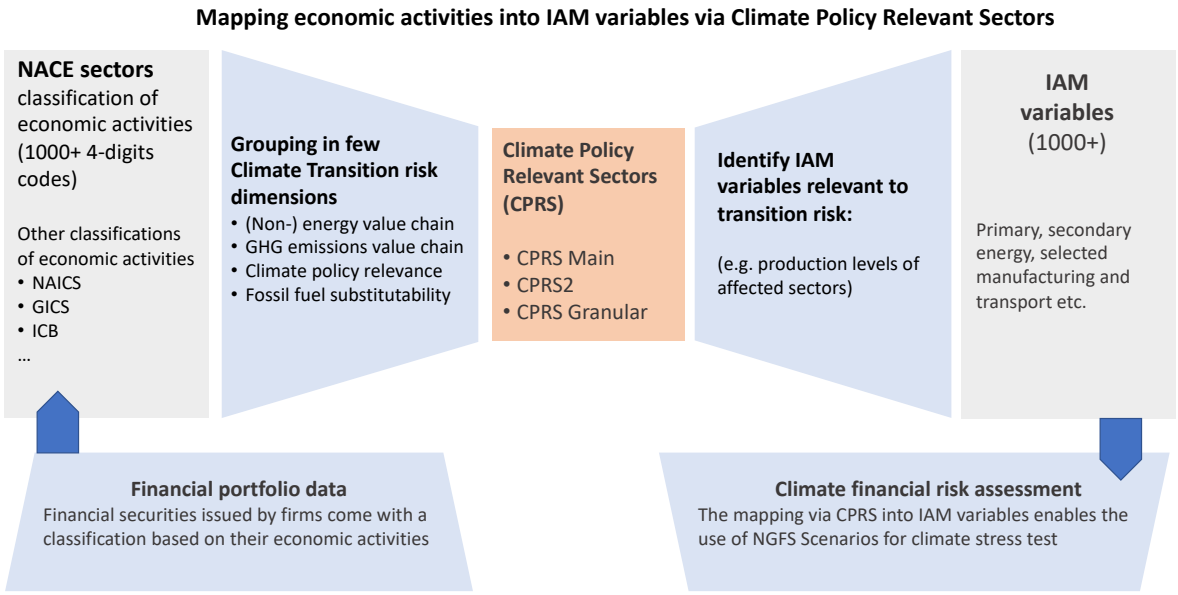


Figure 1. Rational for mapping the NACE codes into IAM variables by means of the Climate Policy Relevant Sectors (CPRS), from left to right. GICS and ICB are respectively the acronyms of the Global Industry Classification Standard (GICS) and the Industry Classification Benchmark (ICB), which are proprietary and not based on the international standards.

This technical note is structured as follows. First, we present the international standard classifications of economic activities. We focus on the NACE Rev2 classification used in the European Union (EU) and the NAICS, broadly used in the USA. Then, we introduce the process-based IAM and the organizational tree of their variables. Further, we present the classification of CPRS and their characteristics. In particular, the disaggregation level provided by CPRS Granular distinguishes across energy technologies (e.g. within transport, motor vehicles powered by combustion vs electric engines). Finally, we describe the mapping NACE 4-digit – CPRS Granular – IAM variables.

2. Standard classifications of economic activities

Firms are usually classified into standard sets of economic activities depending on their business characteristics (usually the type of economic activity). The classification defines a universe of economic activities that are partitioned into codes, identifying a specific type of business. The codes are associated to statistical units (e.g. the firm). Classifying activities into reference codes is important for comparison purposes, e.g. of economic performance across geographies and time, and for financial analysis. Indeed, financial data providers provide the classification code for firms' financial contracts, e.g. stocks and bonds.

In this regard, the ISIC - International System of Industrial Classification is the global reference classification of economic activities. ISIC has been tailored at the national and regional level. The two most used classifications are the NACE codes and the NAICS codes.

The NACE codes, in its latest revision called Rev. 2 (2012) represent the European System of Industrial Classification, used in all the countries of the EU. In contrast, the United States adopted first the SIC - Standard Industrial Classification in 1937, which has been replaced in 1997 by NAICS - North American Industrial Classification System.

The NACE and NAICS codes share common features. They are both hierarchical, going from the more aggregate level of information (usually level 1) to the most detailed one (usually level 4 or superior), returning over 1,000 codes. Similar to ISIC, NACE is organized into a tree structure composed of categories and subcategories of economic activities. The categories in the first level of the NACE classification are called (main) Sections and are indicated by letters of the Latin alphabet, from A to U. For instance, NACE Section B "Mining and quarrying" includes activities related to fossil fuel extraction and mining of metals and ores. Table 1 provides an example.

NACE Section	Division codes	# codes	Example NACE 4-digit code
A-AGRICULTURE, FORESTRY AND FISHING	01-03	55	A.02.02 Logging
B-MINING AND QUARRYING	05-09	30	B.05.1 Mining of hard coal
C-MANUFACTURING	10-33	360	C.19.20 Manufacture of refined petroleum …
D-ELECTRICITY, GAS, STEAM AND AIR CONDITIONING SUPPLY	35	40	D.35.21 Manufacture of gas
E-WATER SUPPLY; SEWERAGE, WASTE MANAGEMENT …	36-39	25	E.38.1 Waste collection
F-CONSTRUCTION	41-43	64	F.42.21 Construction of utility projects for fluids
G-WHOLESALE AND RETAIL TRADE; REPAIR OF MOTOR VEHICLES …	45-47	118	G.45.11 Sale of cars and light motor vehicles
H-TRANSPORTATION AND STORAGE	49-53	46	H.49.2 Freight rail transport
I-ACCOMMODATION AND FOOD SERVICE ACTIVITIES	55-56	17	I.56.21 Event catering activities
J-INFORMATION AND COMMUNICATION	58-63	46	J.63.11 Data processing, hosting and related …
K-FINANCIAL AND INSURANCE ACTIVITIES	64-66	31	K.65.12 Non-life insurance
L-REAL ESTATE ACTIVITIES	68	8	L.68.31 Real estate agencies
M-PROFESSIONAL, SCIENTIFIC AND TECHNICAL ACTIVITIES	69-75	41	M.70.10 Activities of head offices
N-ADMINISTRATIVE AND SUPPORT SERVICE ACTIVITIES	77-82	58	N.77.12 Rental and leasing of trucks
O-PUBLIC ADMINISTRATION AND DEFENCE; …	84	13	O.84.25 Fire service activities
P-EDUCATION	85	18	P.85.31 General secondary education
Q-HUMAN HEALTH AND SOCIAL WORK ACTIVITIES	86-88	24	Q.86.10 Hospital activities
R-ARTS, ENTERTAINMENT AND RECREATION	90-93	24	R.92.00 Gambling and betting activities
S-OTHER SERVICE ACTIVITIES	94-96	28	S.95.22 Repair of household appliances …
T-ACTIVITIES OF HOUSEHOLDS AS EMPLOYERS; …	97-98	9	T.97.00 Activities of households …
U-ACTIVITIES OF EXTRATERRITORIAL ORGANISATIONS …	99	4	U.99.00 … extraterritorial organisations …
Grand Total		**1059**	

Table 1. NACE Rev2 classification of economic activities at the section level. Columns report information as follows: the name of each NACE section; the range of codes at 2-digit level (divisions); the count of codes included in each section; example activity at 4-digits level.

Source: Eurostat (2012).

In terms of granularity of information, NACE codes get up to 4-digits, while NAICS codes provide more granular information about a firm's business, getting up to the 6-digit codes. It is also possible to draw a correspondence between NACE and NAICS codes. The mapping NACE – NAICS is replicable and objective across jurisdictions, and readily available for most assets associated with mid large counterparties.

NACE and NAICS classifications are however subject to limitations that can affect our ability to identify the core business of the firm. First, the codes are self-declared by the firm, leaving space to high degrees of discretion that may impair our understanding of firms' business (e.g. several automobile or gas firms adopting a K-finance code).

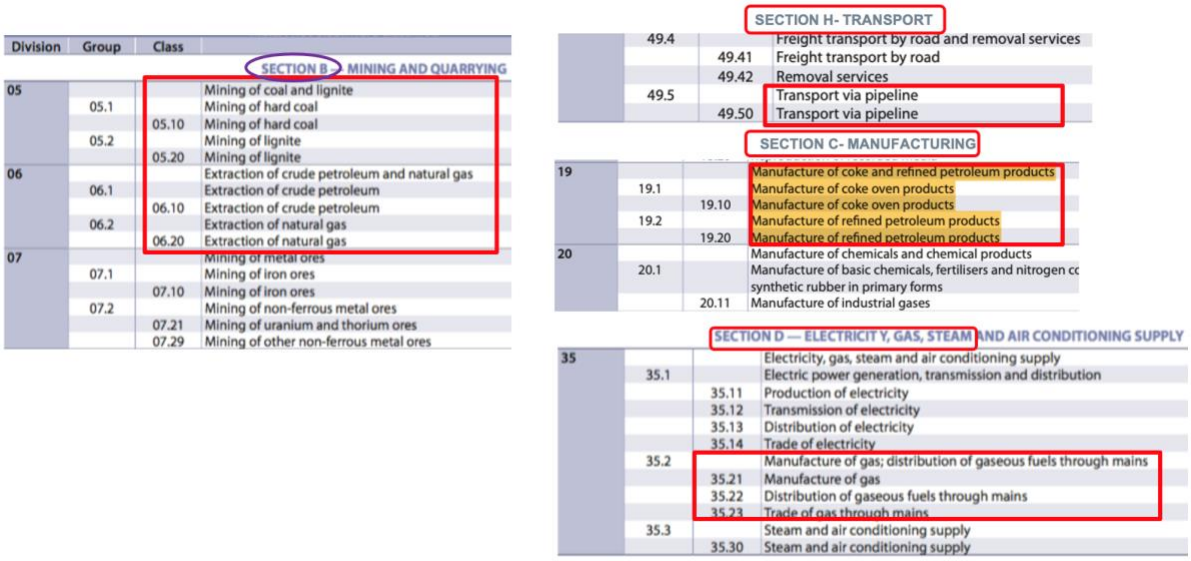
Second, such classifications were developed before climate change was recognised as a source of economic and financial risk. Therefore, their codes are not designed to provide climate-relevant information (e.g. GHG emissions, climate risk exposure) that are needed by analysts and investors. For instance, the current granularity of NACE Rev2 codes at 4-digit level for utilities does not allow us to distinguish the climate risk exposure and impact of the activity (e.g. solar versus coal-based power plants).[4]

Let's take the example of fossil fuels firms, i.e. firms extracting, processing and trading coal, oil and gas. Fossil fuels firms are relevant to identify carbon stranded assets in the economy and finance because in all decarbonization scenarios (e.g. IPCC, 2021)[5] their output is estimated to decline considerably in order to achieve a carbon budget coherent with a 1.5 degrees C or a 2 degrees C target (IPCC, 2022).

Intuitively, NACE section "B – Mining and Quarrying" should contain fossil fuels-related activities (see left panel in Figure 2). In fact, fossil fuels-related activities are spread across NACE codes and sectors. For instance, "transport via pipeline", which refers to transport of oil and gas, and corresponds to the NACE 4-digit code 49.50, is included in section H-transport (see top right panel in Figure 2). Similarly, for section "C – Manufacturing", the NACE 4-digit code 19.20 represents "manufacture of refined petroleum products".
In addition, and importantly, section "D – Electricity, gas, steam and air conditioning supply", doesn't allow for distinguishing the type of energy technology (e.g. fossil fuel or renewables) with which electricity is produced. For instance, while utilities producing electricity from renewables (e.g. wind, solar) are expected to expand their business within all decarbonization scenarios, and thus have a positive economic and financial performance, utilities producing electricity from fossil fuels (e.g. coal, oil, gas) will experience a shrink in their output and, thus, their economic and financial performance.

Therefore, using solely the NACE or NAICS codes, no matter their granularity level, in order to identify the climate relevance of a firm, could lead to large errors in the identification of potential carbon stranded assets.

[4] In contrast, the NAICS classification is already more granular in this sector.
[5] In this document, we refer to the climate mitigation scenarios elaborated by process-based IAMs and reviewed by the IPCC in its Assessment Report. However, similar considerations hold for the scenarios developed by the International Energy Agency (IEA).



Division	Group	Class	
			SECTION B MINING AND QUARRYING
05			Mining of coal and lignite
	05.1		Mining of hard coal
		05.10	Mining of hard coal
	05.2		Mining of lignite
		05.20	Mining of lignite
06			Extraction of crude petroleum and natural gas
	06.1		Extraction of crude petroleum
		06.10	Extraction of crude petroleum
	06.2		Extraction of natural gas
		06.20	Extraction of natural gas
07			Mining of metal ores
	07.1		Mining of iron ores
		07.10	Mining of iron ores
	07.2		Mining of non-ferrous metal ores
		07.21	Mining of uranium and thorium ores
		07.29	Mining of other non-ferrous metal ores

			SECTION H- TRANSPORT
	49.4		Freight transport by road and removal services
		49.41	Freight transport by road
		49.42	Removal services
	49.5		Transport via pipeline
		49.50	Transport via pipeline
			SECTION C- MANUFACTURING
19			Manufacture of coke and refined petroleum products
	19.1		Manufacture of coke oven products
		19.10	Manufacture of coke oven products
	19.2		Manufacture of refined petroleum products
		19.20	Manufacture of refined petroleum products
20			Manufacture of chemicals and chemical products
	20.1		Manufacture of basic chemicals, fertilisers and nitrogen co
			synthetic rubber in primary forms
		20.11	Manufacture of industrial gases
			SECTION D — ELECTRICITY, GAS, STEAM AND AIR CONDITIONING SUPPLY
35			Electricity, gas, steam and air conditioning supply
	35.1		Electric power generation, transmission and distribution
		35.11	Production of electricity
		35.12	Transmission of electricity
		35.13	Distribution of electricity
		35.14	Trade of electricity
	35.2		Manufacture of gas; distribution of gaseous fuels through mains
		35.21	Manufacture of gas
		35.22	Distribution of gaseous fuels through mains
		35.23	Trade of gas through mains
	35.3		Steam and air conditioning supply
		35.30	Steam and air conditioning supply

Figure 2: Activities related to the fossil-fuel value chain are found in several sections of the NACE classification: e.g. section B, C, D and H. How to read the figure: from left to right of each block, the first column "division" indicates the NACE 2-digit code, the "group" indicates the 3-digit code and the "class" indicates the 4-digit code, followed by a description of the economic activity. Source: own elaborations on Eurostat data (Eurostat, 2012).

3. Process-based IAM and their variables

The integrated assessment modeling consortium (IAMC) has developed a standard data format[6] that had been used by the IAM research community for more than a decade. This standard data is now widely applied in model inter-comparison studies, in the NGFS database, in the IAMC databases for IPCC Assessment Reports (such as the SR1.5 and AR6 reports) and is also used by individual modeling teams to report their outputs.

The IAMC variable names follow a few basic rules:

- Variables are organized in a hierarchical structure which is specified by separators "|"
- Variable names can include none, one or more separators (e.g. "Population", "GDP|PPP", "Emissions|CO2|Energy")
- For variables with one or more separators, the left-most word indicates a broad variable category or an indicator (e.g. "GDP", "Emissions", "Primary Energy")
- The separators define two types of relationships among variables:
    - Relationships for indicators calculated with different metrics or methods: e.g. "GDP|PPP" and "GDP|MER"
    - Aggregate relationships providing disaggregation across sectors, fuels, technologies or gases: e.g. "Emissions|CO2" = "Emissions|CO2|AFOLU" + "Emissions|CO2|Energy" + "Emissions|CO2|Industrial Processes"
- Several alternatives may exist for aggregate relationships (e.g. Final Energy is decomposed by sector and by fuel)

[6] For details see: https://www.iamconsortium.org/scientific-working-groups/data-protocols-and-management/iamc-time-series-data-template/

- Elements pertaining to the same hierarchical level can sometimes be aggregates themselves (e.g. “Primary Energy|Fossil” is the aggregate of “Primary Energy|Coal”, “Primary Energy|Oil” and “Primary Energy|Gas”)

Different databases using the same data format can provide different levels of detail on these variables. For example, the public database for the AMPERE[7], LIMITS[8], or CD-LINKS[9] projects contain around 100-150 variables per scenario, whereas the more recent databases like the NGFS[10] or AR6[11] database contain more than 700 variables per scenario. Table 2 shows a list of selected categories at the first level (thus most aggregate) of the hierarchy with the number of sub-variables associated. As IAM are designed to focus on changes in the energy system and in GHG emissions, they provide more numerous and granular IAM variables for these categories. In contrast, as described earlier, NACE[12] is designed for national accounts across economic sectors. Therefore, a mapping between IAM variables and NACE codes is neither intuitive nor straightforward.

Categories (1st level) of IAM variables	Count	Unit of measure	Example variable
Agricultural Demand	11	tDM	Agricultural Demand|Crops|Energy
Agricultural Production	7	tDM/yr	Agricultural Production|Energy|Crops
Capacity Additions	24	GW/yr	Capacity Additions|Electricity|Coal
Capacity	64	GW	Capacity|Electricity|Coal
Capital Cost	34	$/kW	Capital Cost|Electricity|Coal|w/ CCS
Carbon Intensity	16	MtCO2/Mt	
Carbon Sequestration	16	Mt CO2/yr	Carbon Sequestration|Land Use|Afforestation
Emissions	123	Mt/yr	Emissions|CO2|Energy|Demand|Transportation|Aviation
Energy Expenditures	5	$/yr	
Energy Service	19	m2 or pkm	Energy Service|Transportation|Freight|International Shipping
Final Energy	336	EJ/yr	Final Energy|Industry|Steel|Solids|Fossil
Food Demand	2	kcal/cap/day	Food Demand|Crops
Forestry	6	m3/year	Forestry Demand|Roundwood|Wood Fuel
Investment	74	$/yr	Investment|Energy Supply|Electricity|Non-Biomass Renewables
Land Cover	13	ha	Land Cover|Forest|Managed
Material consumption	6	Mt	
Price	55	$/EJ	Price|Carbon
Primary Energy	40	EJ/yr	Primary Energy|Gas
Production	7	Mt	Production|Cement
Secondary Energy	71	EJ/yr	Secondary Energy|Electricity|Solar
Transport stock	9	Vehicles	
Trade	4	EJ/yr	Trade|Primary Energy|Gas|Volume
Water	3	km3/yr	
Grand total	945		

[7] https://tntcat.iiasa.ac.at/AMPEREDB/dsd?Action=htmlpage&page=welcome
[8] https://tntcat.iiasa.ac.at/LIMITSDB/dsd?Action=htmlpage&page=welcome
[9] https://data.ene.iiasa.ac.at/cd-links/
[10] https://data.ene.iiasa.ac.at/ngfs/
[11] https://data.ece.iiasa.ac.at/ar6
[12] The same holds for NAICS variables.

Table 2: Categories of IAM variables. Columns report information as follows: name of the most aggregate categories of IAM variables; count of the variables in each category; unit of measure of the variables; example variables where relevant.

4. The Climate Policy Relevant Sectors (CPRS)

Climate-related financial disclosure and climate financial risk assessment gained growing attention in the agenda of central banks, financial supervisors and investors (TCFD, 2017, NGFS, 2019, BIS, 2021, U.S. SEC, 2022). Climate-related financial disclosure refers to the process of identifying the exposure of non-financial and financial firms to climate risks. In contrast, climate financial risk assessment refers to the process of translating exposures into adjustments in the financial valuation of firms' securities (e.g. stocks, bonds) and loans, and into financial risk metrics for an investor. The latter is usually calculated with measures, such as the Value at Risk, aimed to capture the largest losses in a portfolio conditioned to shocks (Battiston et al. 2017).

So far, climate-related financial disclosure has been based on firms' reporting of their GHG emissions[13]. Nevertheless, there are well known limitations to the contribution of carbon footprint and GHG emissions accounting to disclosure. Both suffer from lack of transparency and standards in reporting and could deliver misleading messages with regards to firms and investors' climate risk exposure and climate alignment. For instance, an electricity company with coal-based plants could reduce its Scope 1 emissions intensity by expanding its business line in electricity trading, without investing in decarbonization of its plants. Thus, the firm would show lower GHG emissions and thus better carbon reporting but would not have decreased its exposure to climate transition risk, nor its contribution to climate change. Further, GHG emissions are disclosed mostly by large and listed firms, leaving Small and Medium Enterprises (SME), which represent the core of the economy in the EU, out of radar.

In order to fully account for the relevance of an activity for climate transition risk, and its alignment to climate mitigation scenarios, we need to complement carbon footprint and GHG emissions accounting. To fill this gap, in 2017 a group of scholars introduced the Climate Policy Relevant Sectors (CPRS, Battiston et al., 2017) and used them to assess the individual and systemic risk of a disorderly transition for investors, in the climate stress test of the financial system. The CPRS provide a standardized and actionable classification of activities (at the NACE Rev2, 4-digit level) whose revenues could be affected positively or negatively in a disorderly low-carbon transition. In particular, CPRS allow us to group NACE sectors in few categories with distinct features in terms of climate transition risk. The classification of an individual firm or economic activity into CPRS is based on four criteria which are reported in Table 3.

[13] Nowadays, most financial data provides include information about scope 1, 2 and 3 emissions for listed companies. CDP provides information of over 5000 surveyed large firms (https://cdn.cdp.net/cdp-production/comfy/cms/files/files/000/003/025/original/2020_01_06_Full_GHG_Emissions_Dataset_Summary.pdf).

Role in value chain	Role in GHG emissions chain	Specific policy processes	Business model (input substitutability)
Primary energy (e.g. fossil fuel)	Direct/ indirect	Authorities	Fossil fuel substitutability: low/ medium/high
Secondary energy (fuel mix)	CO2 vs other GHG	Fiscal policy (taxes, subsidies)	Other types of emission reductions
Production of goods/ services (non-energy)	Negative emissions	Corporte lobbying	

Table 3: A description of the four guiding criteria for classifying economic activities into CPRS.

The first dimension "Role in the value chain" considers if an economic activity produces energy (primary or secondary) or goods. The second dimension "Role in GHG emissions chain" considers the type of GHG emissions caused by the activity (mostly direct, i.e. Scope 1) or mostly indirect (i.e. Scope 2 and 3), whether emissions are mostly in terms of CO2 or other greenhouse gases and whether the activity can deliver negative emissions (such as afforestation).
The third dimension "Specific policy processes" considers if the group of economic activities is commonly recognised as a policy actor with some lobbying capacity representing its interests and/or specific national/local authorities exist in most OECD countries. For instance, in many countries, oil and gas companies have traditionally an influence on national politics and enjoy specific excise duties and are regulated by specific authorities. These characteristics make these activities distinct from, e.g., activities related to buildings for which different specific national authorities exist in most countries, dealing, for instance, with housing policies.
The fourth dimension "Business model" considers if fossil fuel provision (or its support) is an output (i.e. extraction, refinement, sales) or an input to the activity. In the latter case, a low (high) substitutability of fossil fuel as an input implies higher (lower) levels of transition risk, since the sector can adapt slower or faster to the low carbon transition.
Note that if a firm operates in multiple business lines corresponding to different NACE codes, its risk depends on the relative importance of these business lines. One approach is to look at the revenue shares. Further, there are NACE codes corresponding to economic activities for which there are multiple CPRS Granular and multiple IAM variables. This is the case, for instance, of electricity generation or manufacturing of cars.

Thus, the CPRS allow us to consider the economic and financial risk stemming from the (mis)alignment to the climate targets of firms and sectors, and to quantify the potential carbon stranded asset (Leaton, 2011; McGlade and Ekins, 2015).

4.1 Increasing the Disaggregation levels: from CPRS Main to CPRS2 and CPRS Granular

CPRS are available at different levels of granularity, depending on the level of disaggregation of information about the firm's energy technology (i.e. the type of energy or electricity that the activity uses, for instance electricity production out of coal).

At their most aggregate level, we obtain CPRS Main, which include CPRS1-fossil-fuel, CPRS2-utility, CPRS3-energy-intensive, CPRS4-buildings, CPRS5-transportation, CPRS6-agriculture. The classification of economic activities into CPRS Main is based on the NACE codes. Table 4

explains the rationale for allocating NACE 4-digit codes into CPRS Main according to the four criteria discussed above. Examples for each CPRS Main are also provided.

CPRS main	Category of economic activities	Role in GHG emissions value chain	Specific policy processes	Nature of transition risk in relation to business model	NACE 4 digits Main groups of codes (selected, see full table)
Fossil fuel	Carry out / support production / delivery of primary energy based on fossil fuel.	Mostly indirect CO2 emissions	Oil politics, taxes/subsidies	No fuel substitutability	B-Mining and quarrying: coal, oil and gas; C-Manufacturing: coal, oil and gas; D-Electricity and gas (e.g. 35.21); G-Wholesale: fuel sales (e.g. 47.30); H-Transportation: pipelines (e.g. 49.50).
Utility electricity	Carry out or support production of secondary energy.	Mostly direct CO2 emissions (fuel mix).	Electricity authorities (e.g. feed-in tariffs)	Medium fuel substitutability (e.g. wind farms).	D-Electricity production, transmission and distribution (e.g. 35.11, 35.12, 35.13)
Energy intensive	Manufacturing activities with intensive use of energy according to EU classification Carbon Leakage	Mostly direct CO2 emissions (fuel mix).	No specific policy processes as a group.	Low substitutability (e.g. steel or rockets)	See Carbon Leakage list. B-Mining and quarrying (e.g. 07.10, 07.29, 08.91 etc.); C-Manufacturing (about 200+ sectors, e.g. 11.01, 13.10, 15.11 etc.). NOTE: Nace codes falling in other CPRS are not included.
Transport	Provision of or support to transport services (e.g. vehicles manufacturing, roads and railways)	Mostly direct CO2 emissions (fuel mix).	Transport authorities and policies.	Low substitutability (e.g. motor vehicles fleet)	C-Manufacturing: motor vehicles, ships and trains (e.g. 29.10, 29.20, 30.11, 30.20 etc.); F-construction: roadways and railways (e.g. 42.11, 42.12); G-Wholesale: vehicles (e.g. 45.32); H-Transportation: land, air, and sea transport (49.10, 49.20, 49.41, 50.10, 51.10, etc.)
Buildings	Provision of or support to buildings services (e.g. residential and commercial)	Mostly direct CO2 emissions (fuel mix).	Housing policies.	Low substitutability (e.g. heating/cooking)	F-Construction: residential and commercial building (e.g. 41.10, 41.20, 43.22, 43.91 etc.); I-Accommodation (e.g. 55.10, 55.20); L-Real-estate (e.g. 68.10,68.20, 68.30); M-Professional: architectureal activities (e.g. 71.11)
Agriculture	Provision of and support of agriculture and forestry	Direct CO2 emissions from fossil fuel; other direct GHG emissions. Negative emissions (afforestation).	Agricultural policies.	Low Substitutability (as for transport). But emission reductions via low carbon farming.	A - Agriculture forestry and fishery (from 01.10 to 02.40)

Table 4: Example of mapping of individual NACE 4-digit codes into CPRS Main.

Figure 3 shows an example of application of the classification of the portfolio of investors into CPRS Main by type of financial contracts. The first step consists in remapping assets associated to a NACE Rev2 sector into corresponding CPRS Main. The second step consists in carrying out the mapping for each financial instrument. The third step carries out the appropriate aggregation, at the portfolio level, of financial instruments classified into CPRS Main.

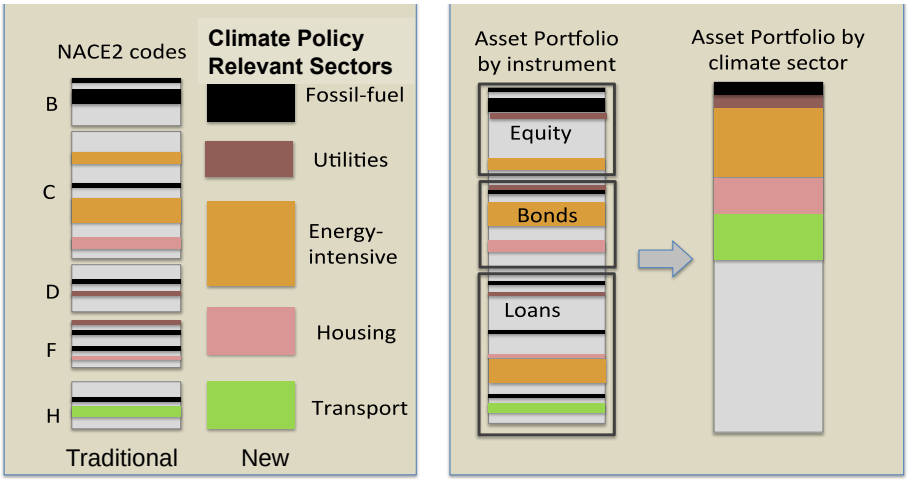


Figure 3: Classification of the financial contracts and securities of an investor's portfolio into CPRS Main. Source: Battiston et al. (2017).

When more granular information about firms' revenues by energy technology is available, it is possible to increase the granularity of CPRS representation from CPRS Main to CPRS2. While still being based on information that can be retrieved from the NACE 4-digit classification of the activity, CPRS2 add details to CPRS Main with regard to the business specialization by energy technologies, and their contribution to the firm's revenues. Figure 4 shows an

application of CPRS2 classification to the financial market. We report an example of the total market capitalization of equity shares and outstanding amount of bonds issued by EU non-financial corporations (NFCs) in 2013, 2015, and 2018 by CPRS1 (then renamed CPRS Main) and CPRS2 (Alessi et al., 2019).

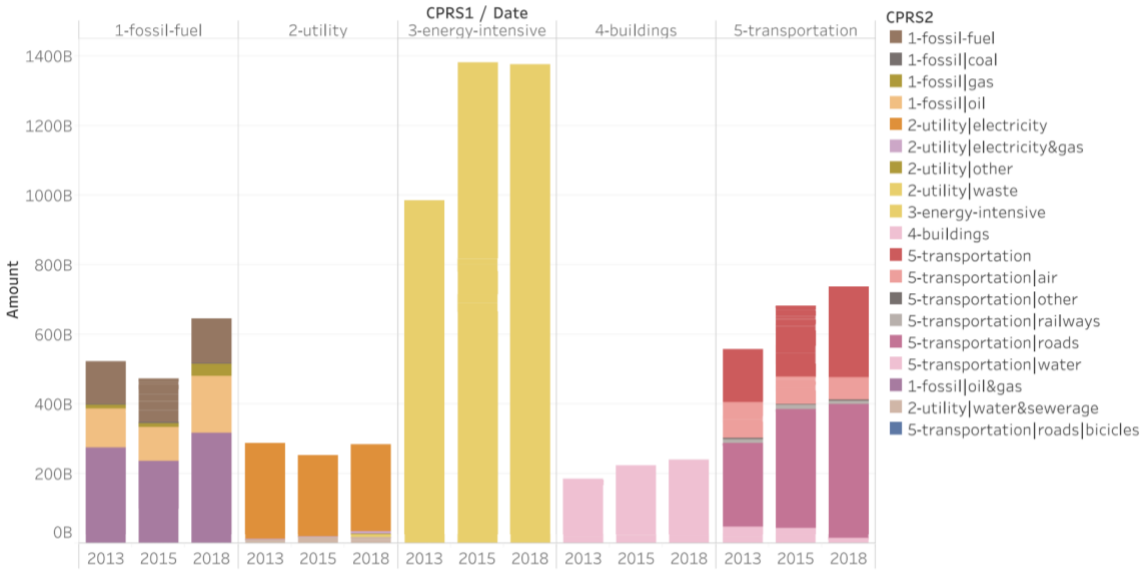


Figure 4: Application of CPRS2. The bars represent a breakdown of the total market capitalization of equity shares and outstanding amount of bonds issued by EU NFCs classified in CPRS Main (1-5 only) in 2013, 2015, and 2018. The bars' shadings represent further disaggregation of the total market capitalization into CPRS2.

4.2 CPRS Granular

CPRS Main and CPRS2 allow users to associate a climate transition risk profile to economic activities when detailed information about their energy technology is not available. In contrast, CPRS Granular allows us to integrate information about the energy technology of the plants owned by the firm, considering its business lines, and their contribution to the firms' revenues. This information is then associated to the financial contracts of the firm, and from here into climate adjusted financial valuation and financial risk assessment.

This feature is important because firms, including those in sectors that are relevant for the transition (e.g. transport, utilities) may have plants that differ in terms of energy technology (e.g. combustion engine cars vs EV). Thus, depending on their technologies, plants and business lines belonging to the same firm could be either positively or negatively affected in the transition. Therefore, considering information at firm level only would lead to averaging positive and negative values, leading to large errors in estimates of the firm's climate transition risk exposure. We discussed above that this information is not provided by NACE 4-digit codes and it is elaborated based on information about revenues shares of firms extracted from companies' reports.

Therefore, the CPRS Granular classification is a key tool for assessing the economic and financial performance of a firm conditioned to climate mitigation scenarios, including the NGFS scenarios, and to quantify its potential risk of carbon stranded assets.

More precisely, CPRS Granular provides a uniform classification of companies' plants and business lines, according to the energy technology utilized. When firms are active in several lines of business and information on the relative shares of revenues is available, CPRS-Granular enables to perform a classification of company's activities according to the weight of the technologies in the firm business. For instance, a car manufacturer may derive 80% of revenues from vehicles with internal combustion engine and 20% from electric vehicles. These two activities correspond to different trajectories in the NGFS scenarios and are associated with different levels of climate transition risk.

To illustrate the different levels of granularity, Table 5 show some examples of categories in the CPRS Main – CPRS2 – CPRS Granular mapping (the full mapping is available online[14]).

CPRS Main	**CPRS2**	**CPRS Granular**
1-fossil-fuel	1-fossil	fuel|fossil|gas
1-fossil-fuel	1-fossil|coal	fuel|fossil|coal
1-fossil-fuel	1-fossil|gas	fuel|fossil|gas|extraction
1-fossil-fuel	1-fossil|gas	fuel|fossil|gas|manufacturing
1-fossil-fuel	1-fossil|gas	fuel|renewable|biogas|manufacturing
1-fossil-fuel	1-fossil|oil	fuel|fossil|oil|manufacturing
1-fossil-fuel	1-fossil	fuel|fossil|transportation|water
2-utility	2-utility|electricity	electricity|fossil|coal|generation
2-utility	2-utility|electricity	electricity|fossil|gas|generation
2-utility	2-utility|electricity	electricity|nuclear|generation
2-utility	2-utility|electricity	electricity|renewable|biomass|generation
2-utility	2-utility|electricity	electricity|renewable|hydro|generation
2-utility	2-utility|electricity	electricity|renewable|ocean|generation
2-utility	2-utility|electricity	electricity|renewable|solar PV|generation
2-utility	2-utility|electricity	electricity|renewable|wind|generation
5-transportation	5-transportation|air	transportation|air|infrastructure
5-transportation	5-transportation|air	transportation|air|vehicles|combustion
5-transportation	5-transportation|railways	transportation|rail|infrastructure
5-transportation	5-transportation|railways	transportation|rail|infrastructure|combustion
5-transportation	5-transportation|railways	transportation|rail|infrastructure|combustion
5-transportation	5-transportation|railways	transportation|rail|infrastructure|electric
5-transportation	5-transportation|railways	transportation|rail|infrastructure|electric
5-transportation	5-transportation|railways	transportation|rail|vehicles|combustion
5-transportation	5-transportation|railways	transportation|rail|vehicles|electricity
5-transportation	5-transportation|roads	transportation|road|vehicles|combustion
5-transportation	5-transportation|roads	transportation|road|vehicles|electric
5-transportation	5-transportation|roads	transportation|road|vehicles|hybrid
5-transportation	5-transportation|roads	transportation|road|vehicles|hydrogen

Table 5: Examples of economic activities at different levels of granularity from CPRS Main into CPRS2 up to CPRS Granular.

[14] The full table is available at https://www.finexus.uzh.ch/en/projects/CPRS.html

Finally, and importantly, the CPRS classification is replicable and comparable across portfolios and jurisdictions. It is also fully compatible with the EU Taxonomy for sustainable activities (Alessi et al., 2021). This means that the CPRS distinguishes between the climate transition risk exposure as well as the sustainability aligned activities that a firm may own. In this regard, in Table 6 CPRS are mapped into the EU Taxonomy activities, providing an application to sustainable activities within the NACE Rev2 D.35.11 "Production of electricity".

NACE	CPRS main	CPRS-2	CPRS granular	EU Taxonomy activity number	EU Taxonomy activity name
D.35.11	2-utility	2-utility|electricity|generation	electricity|renewable|solar PV|generation	4.1	Electricity generation using solar photovoltaic technology
D.35.11	2-utility	2-utility|electricity|generation	electricity|renewable|solar concentrated|generation	4.2	Electricity generation using concentrated solar power (CSP) technology
D.35.11	2-utility	2-utility|electricity|generation	electricity|renewable|wind|generation	4.3	Electricity generation from wind power
D.35.11	2-utility	2-utility|electricity|generation	electricity|renewable|ocean|generation	4.4	Electricity generation from ocean energy technologies
D.35.11	2-utility	2-utility|electricity|generation	electricity|renewable|hydro|generation	4.5	Electricity generation from hydropower
D.35.11	2-utility	2-utility|electricity|generation	electricity|renewable|geothermal|generation	4.6	Electricity generation from geothermal energy
D.35.11	2-utility	2-utility|electricity|generation	electricity|renewable|biomass|generation	4.8	Electricity generation from bioenergy

Table 6: Mapping of CPRS sectors (all levels of granularity) to the EU Taxonomy activities.[15]

For these reasons, the CPRS classification is regarded as a reference for climate financial risk assessment and has been used by several international financial institutions to assess investors' exposure to climate transition risk.

5. Mapping NACE codes into IAM variables by means of CPRS

The CPRS provide a simple way to associate to each NACE 4-digit sector the most relevant IAM variable and its related forward-looking trajectory across the NGFS scenarios. This mapping is illustrated by selected examples in Table 7, as explained in the following.

In order to use the NGFS scenarios for climate financial risk assessment, we should ask, for instance, which assets we should associate to a IAM variable called "Secondary Energy|Gases|Natural Gas". Would it be correct to consider only the securities of firms engaged in the extraction of natural gas, or should we consider some other activities as well? Economic activities related to natural gas in terms of financial risk can be found in NACE codes located in different NACE sections. The CPRS provide the conceptual framework to put together with a clear logic (see Section 3) the NACE codes relevant for this IAM variable. For

[15] Note that we used the EU Taxonomy sector classification currently available at https://ec.europa.eu/sustainable-finance-taxonomy/. EU Taxonomy sector "4.7- Electricity generation from renewable non-fossil gaseous and liquid fuels" has not been mapped. CPRS granular sector "electricity|renewable|biomass|generation" is mapped to the EU Taxonomy sector "4.8-Electricity generation from bioenergy".

example, the codes B.06.20 “Extraction of natural gas”, D.35.21 “Manufacture of gas”, H.49.50 “Transport via pipeline” are grouped together in CPRS Granular under “fuel|fossil|gas” (extraction, manufacturing or transport) because: activities’ revenues depend on the value chain of natural gas, they are subject to the same authorities and policies (within a country) and they have the same level of input substitutability. Moreover, CPRS Granular identifies a subsector of the code H.50.20 “Sea and coastal freight water transport” for the transportation, specifically, of fossil fuels (such as refined oil or liquified natural gas) via tank ships. Note that the latter is a sector of specific interest to the insurance and banking industry for size and risk. Without CPRS Granular, the mapping could be lost and so the risk associated.

As another example, from the point of view of financial risk, which assets should we associate to the IAM variable “Final Energy|Transportation|Passenger|electricity”? Should we consider Section D, which includes activities of electricity generation and transmission, or section H which includes activities of transportation via rails and roads? By means of CPRS2 the activities in F.42.12 “Construction of railways and underground railways”, C.30.20 “Manufacture of railway locomotives and rolling stock”, and H.49.20 “Freight rail transport” are grouped together and mapped into “5-transportation|rail” because revenues in these activities depend on the development of transport services via railways. Furthermore, with CPRS Granular we can distinguish between railways transport powered by electricity vs combustion (largely fossil fuel at the moment). This distinction is important because the trajectories of these two variables are very different in most NGFS scenarios. Similar reasoning applies to the activities related to transportation via roads.

Table 7 illustrates this mapping for selected activities. More examples are provided in the Appendix, while the complete mapping is available online[16]. The CPRS dimensions related to the firms’ technology and business models and to climate policy relevance strengthen the analysis of climate financial risk. In particular, CPRS enables the use of the IAM variables in the NGFS scenarios in order to identify and quantify carbon stranded assets, and thus to assess climate financial risk of financial contracts and portfolios.

[16] https://www.finexus.uzh.ch/en/projects/CPRS.html

NACE code	NACE Description	CPRS Main code	CPRS Granular	NGFS Phase 3
B.05.10	Mining of hard coal	1	fuel|fossil|coal	Primary Energy|Coal
B.06.20	Extraction of natural gas	1	fuel|fossil|gas|extraction	Primary Energy|Gas
D.35.21	Manufacture of gas	1	fuel|fossil|gas|manufacturing	Secondary Energy|Gases|Natural Gas
H.49.50	Transport via pipeline	1	fuel|fossil|gas|transport	Primary Energy|Gas
C.19.20	Manufacture of refined petroleum products	1	fuel|fossil|oil|manufacturing	Secondary Energy|Liquids|Oil
H.50.20	Sea and coastal freight water trans	1	fuel|fossil|transport|water	Primary Energy|Oil
D.35.21	Manufacture of gas	1	fuel|renewable|biogas|manufacturing	Secondary Energy|Gases|Biomass
D.35.11	Production of electricity	2	electricity|fossil|coal|generation	Secondary Energy|Electricity|Coal
D.35.11	Production of electricity	2	electricity|fossil|gas|generation	Secondary Energy|Electricity|Gas
D.35.11	Production of electricity	2	electricity|nuclear|generation	Secondary Energy|Electricity|Nuclear
D.35.11	Production of electricity	2	electricity|renewable|biomass|generation	Secondary Energy|Electricity|Biomass
D.35.11	Production of electricity	2	electricity|renewable|hydro|generation	Secondary Energy|Electricity|Hydro
D.35.11	Production of electricity	2	electricity|renewable|ocean|generation	Secondary Energy|Electricity|Ocean
D.35.11	Production of electricity	2	electricity|renewable|solar PV|generation	Secondary Energy|Electricity|Solar|PV
D.35.11	Production of electricity	2	electricity|renewable|wind|generation	Secondary Energy|Electricity|Wind
H.51.10	Passenger air transport	5	transportation|air|infrastructure	Energy Service|Transportation|Passenger|Aviatio
C.30.30	Manufacture of air and spacecraft and related machinery	5	transportation|air|vehicles|combustion	Energy Service|Transportation|Aviation
F.42.12	Construction of railways and underground railways	5	transportation|rail|infrastructure	Energy Service|Transportation|Rail
H.49.10	Passenger rail transport, interurban	5	transportation|rail|infrastructure|combustion	Final Energy|Transportation|Liquids
H.49.20	Freight rail transport	5	transportation|rail|infrastructure|combustion	Final Energy|Transportation|Liquids
H.49.10	Passenger rail transport, interurban	5	transportation|rail|infrastructure|electric	Final energy|Transportation|Electricity
H.49.20	Freight rail transport	5	transportation|rail|infrastructure|electric	Final energy|Transportation|Electricity
C.30.20	Manufacture of railway locomotives and rolling stock	5	transportation|rail|vehicles|combustion	Energy Service|Transportation|Rail
C.30.20	Manufacture of railway locomotives and rolling stock	5	transportation|rail|vehicles|electricity	Energy Service|Transportation|Rail
C.29.10	Manufacture of motor vehicles	5	transportation|road|vehicles|combustion	Final Energy|Transportation|Passenger|Liquids
C.29.10	Manufacture of motor vehicles	5	transportation|road|vehicles|hydrogen	Final Energy|Transportation|Passenger|Hydrogen
C.29.10	Manufacture of motor vehicles	5	transportation|road|vehicles|electric	Final Energy|Transportation|Passenger|Electricity
C.29.10	Manufacture of motor vehicles	5	transportation|road|vehicles|hybrid	Final Energy|Transportation|Passenger|Electricity

Table 7: Mapping of NACE 4-digit sectors into IAM variables by means of the CPRS for example sectors. Information is reported as follows: NACE code of the economic activity at 4-digit level; description of the activity; code of the CPRS Main category; name of the CPRS granular sector; name of the IAM variable. More examples in the Appendix. Full mapping available online.

6. Conclusion

In this note, we have introduced the first mapping of NACE codes into IAM variables by means of CPRS, covering all levels of disaggregation (CPRS Main, CPRS2, CPRS Granular). NACE codes are a standard classification of economic activities (together with NAICS they are compatible with the international standard classification ISIC). The IAM variables considered here are those provided in the NGFS scenarios (phase 3, September 2022). The CPRS is a classification of economic activities that builds on NACE and provides science-based categories of climate transition risk. It can be applied to all types of financial assets (e.g. stocks, loans, bonds) and geographic jurisdictions thus making possible comparisons across investors.

According to chapter 15 of the IPCC WGIII's AR6 report (Kreibiehl et al., 2022), poor climate-financial risk assessment is a main barrier to scale up financial capital into low-carbon and climate aligned activities. In this regard, a main challenge stands in identifying the assets of a firm that can become carbon stranded assets, and the assets that could instead have a positive impact on the low-carbon transition.

The NACE-CPRS-IAM mapping introduced here contributes to address this gap, by linking the energy technologies and revenues models of the firms issuing the securities to the NGFS scenarios. First, the mapping enables a better understanding of the climate transition risk relevance of firms based on their business model, the composition of their business lines and relevance on firms' revenues. This information, in turn, is fundamental for investors, central banks, financial supervisors and analysts to correctly quantify the risk of carbon stranded assets - and related losses – in a portfolio, as well as the opportunities of greening investment strategies, and portfolio rebalancing. Second, it allows for translating IAM forward-looking trajectories of output into adjustment in financial valuation of contracts, accounting for the climate transition risk of the firms' business lines and revenues.

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Appendix 1 Mapping of economic activities from NACE codes to NGFS phase 3 variables by means of the CPRS-Granular classification

NACE code	NACE Description	CPRS Main	CPRS Granular	NGFS3
B.05.10	Mining of hard coal	1-fossil-fuel	fuel|fossil|coal	Primary Energy|Coal
B.05.20	Mining of lignite	1-fossil-fuel	fuel|fossil|coal	Primary Energy|Coal
C.19.10	Manufacture of coke oven products	1-fossil-fuel	fuel|fossil|coal	Secondary Energy|Gases|Coal
D.35.22	Distribution of gaseous fuels through mains	1-fossil-fuel	fuel|fossil|gas|distribution	Secondary Energy|Gases|Natural Gas
B.06.20	Extraction of natural gas	1-fossil-fuel	fuel|fossil|gas|extraction	Primary Energy|Gas
D.35.21	Manufacture of gas	1-fossil-fuel	fuel|fossil|gas|manufacturing	Secondary Energy|Gases|Natural Gas
H.49.50	Transport via pipeline	1-fossil-fuel	fuel|fossil|gas|transport	Primary Energy|Gas
B.09.10	Support activities for petroleum and natural gas extraction	1-fossil-fuel	fuel|fossil|oil&gas|extraction	Primary Energy|Fossil
B.06.10	Extraction of crude petroleum	1-fossil-fuel	fuel|fossil|oil|extraction	Primary Energy|Oil
C.19.20	Manufacture of refined petroleum products	1-fossil-fuel	fuel|fossil|oil|manufacturing	Secondary Energy|Liquids|Oil
G.46.71	Wholesale of solid, liquid and gaseous fuels and related products	1-fossil-fuel	fuel|fossil|sale	Primary Energy|Fossil
H.50.20	Sea and coastal freight water transport	1-fossil-fuel	fuel|fossil|transport|water	Primary Energy|Gas
D.35.22	Distribution of gaseous fuels through mains	1-fossil-fuel	fuel|renewable|biogas|distribution	Secondary Energy|Gases|Biomass
D.35.21	Manufacture of gas	1-fossil-fuel	fuel|renewable|biogas|manufacturing	Secondary Energy|Gases|Biomass

F.42.22	Construction of utility projects for electricity and telecommunications	2-utility	electricity|fossil	Investment|Energy Supply|Electricity
D.35.11	Production of electricity	2-utility	electricity|fossil|coal|generation	Secondary Energy|Electricity|Coal
D.35.11	Production of electricity	2-utility	electricity|fossil|gas|generation	Secondary Energy|Electricity|Gas
D.35.11	Production of electricity	2-utility	electricity|nuclear|generation	Secondary Energy|Electricity|Nuclear
F.42.22	Construction of utility projects for electricity and telecommunications	2-utility	electricity|renewable	Investment|Energy Supply|Electricity
D.35.11	Production of electricity	2-utility	electricity|renewable|biomass|generation	Secondary Energy|Electricity|Biomass
D.35.11	Production of electricity	2-utility	electricity|renewable|hydro|generation	Secondary Energy|Electricity|Hydro
D.35.11	Production of electricity	2-utility	electricity|renewable|ocean|generation	Secondary Energy|Electricity|Ocean
D.35.11	Production of electricity	2-utility	electricity|renewable|solar PV|generation	Secondary Energy|Electricity|Solar|PV
D.35.11	Production of electricity	2-utility	electricity|renewable|wind|generation	Secondary Energy|Electricity|Wind
C.23.51	Manufacture of cement	3-energy-intensive	energy-intensive|cement	Production|Cement
C.23.52	Manufacture of lime and plaster	3-energy-intensive	energy-intensive|cement	Production|Cement
C.23.62	Manufacture of plaster products for construction purposes	3-energy-intensive	energy-intensive|cement	Production|Cement
C.23.65	Manufacture of fibre cement	3-energy-intensive	energy-intensive|cement	Production|Cement

C.26.11	Manufacture of electronic components	3-energy-intensive	energy-intensive|electrical	Final Energy|Industry
C.20.15	Manufacture of fertilisers and nitrogen compounds	3-energy-intensive	energy-intensive|fertilisers and agrochemicals	Fertilizer Use|Nitrogen
C.20.20	Manufacture of pesticides and other agrochemical products	3-energy-intensive	energy-intensive|fertilisers and agrochemicals	Final Energy|Industry|Chemicals
C.24.10	Manufacture of basic iron and steel and of ferro-alloys	3-energy-intensive	energy-intensive|iron and steel	Production|Steel
C.24.20	Manufacture of tubes, pipes, hollow profiles and related fittings, of steel	3-energy-intensive	energy-intensive|iron and steel	Production|Steel
C.24.3	Manufacture of other products of first processing of steel	3-energy-intensive	energy-intensive|iron and steel	Production|Steel
C.24.51	Casting of iron	3-energy-intensive	energy-intensive|iron and steel	Production|Steel
C.24.52	Casting of steel	3-energy-intensive	energy-intensive|iron and steel	Production|Steel
B.07.10	Mining of iron ores	3-energy-intensive	energy-intensive|non-fossil mining	Production|Steel
C.24.43	Lead, zinc and tin production	3-energy-intensive	energy-intensive|other	Production|Non-ferrous metals
C.24.44	Copper production	3-energy-intensive	energy-intensive|other	Production|Non-ferrous metals
C.21.10	Manufacture of basic pharmaceutical products	3-energy-intensive	energy-intensive|pharmaceutical	Final Energy|Industry|Chemicals
C.21.20	Manufacture of pharmaceutical preparations	3-energy-intensive	energy-intensive|pharmaceutical	Final Energy|Industry|Chemicals
C.20.16	Manufacture of plastics in primary forms	3-energy-intensive	energy-intensive|rubber and plastics	Primary Energy|Oil

C.20.17	Manufacture of synthetic rubber in primary forms	3-energy-intensive	energy-intensive|rubber and plastics	Primary Energy|Oil
C.22.11	Manufacture of rubber tyres and tubes; retreading and rebuilding of rubber tyres	3-energy-intensive	energy-intensive|rubber and plastics	Final Energy|Industry|Chemicals
C.22.19	Manufacture of other rubber products	3-energy-intensive	energy-intensive|rubber and plastics	Final Energy|Industry|Chemicals
C.20.11	Manufacture of industrial gases	3-energy-intensive	fuel|hydrogen|green	Secondary Energy|Hydrogen|Electricity
C.20.11	Manufacture of industrial gases	3-energy-intensive	fuel|hydrogen|non-green	Secondary Energy|Hydrogen|Fossil
C.24.46	Processing of nuclear fuel	3-energy-intensive	fuel|nuclear	Primary Energy|Nuclear
B.07.21	Mining of uranium and thorium ores	3-energy-intensive	fuel|nuclear|extraction	Primary Energy|Nuclear
F.41.20	Construction of residential and non-residential buildings	4-buildings	buildings	Energy Service|Residential and Commercial|Floor Space
I.55.10	Hotels and similar accommodation	4-buildings	buildings	Energy Service|Residential and Commercial|Floor Space
H.51.10	Passenger air transport	5-transportation	transportation|air|infrastructure	Energy Service|Transportation|Passenger|Aviation
H.51.2	Freight air transport and space transport	5-transportation	transportation|air|infrastructure	Energy Service|Transportation|Aviation
H.51.21	Freight air transport	5-transportation	transportation|air|infrastructure	Energy Service|Transportation|Aviation
C.30.30	Manufacture of air and spacecraft and related machinery	5-transportation	transportation|air|vehicles|combustion	Energy Service|Transportation|Aviation

F.42.12	Construction of railways and underground railways	5-transportation	transportation|rail|infrastructure	Energy Service|Transportation|Rail
H.49.10	Passenger rail transport, interurban	5-transportation	transportation|rail|infrastructure|combustion	Final Energy|Transportation|Liquids
H.49.20	Freight rail transport	5-transportation	transportation|rail|infrastructure|combustion	Final Energy|Transportation|Liquids
H.49.10	Passenger rail transport, interurban	5-transportation	transportation|rail|infrastructure|electric	Final energy|Transportation|Electricity
H.49.20	Freight rail transport	5-transportation	transportation|rail|infrastructure|electric	Final energy|Transportation|Electricity
C.30.20	Manufacture of railway locomotives and rolling stock	5-transportation	transportation|rail|vehicles|combustion	Energy Service|Transportation|Rail
C.30.20	Manufacture of railway locomotives and rolling stock	5-transportation	transportation|rail|vehicles|electricity	Energy Service|Transportation|Rail
F.42.11	Construction of roads and motorways	5-transportation	transportation|road|infrastructure	Energy Service|Transportation|Road
C.29.10	Manufacture of motor vehicles	5-transportation	transportation|road|vehicles|combustion	Final Energy|Transportation|Passenger|Liquids
C.29.10	Manufacture of motor vehicles	5-transportation	transportation|road|vehicles|electric	Final Energy|Transportation|Passenger|Electricity
C.29.10	Manufacture of motor vehicles	5-transportation	transportation|road|vehicles|hybrid	Final Energy|Transportation|Passenger|Electricity
C.29.10	Manufacture of motor vehicles	5-transportation	transportation|road|vehicles|hydrogen	Final Energy|Transportation|Passenger|Hydrogen

C.30.11	Building of ships and floating structures	5-transportation	transportation|water|vehicles|combustion	Energy Service|Transportation|Freight|International Shipping
C.30.11	Building of ships and floating structures	5-transportation	transportation|water|vehicles|electric	Energy Service|Transportation|Freight|International Shipping
A.01.4	Animal production	6-agric. etc.	agric. etc|agriculture|livestock	Agricultural Production|Non-Energy|Livestock
A.01.1	Growing of non-perennial crops	6-agric. etc.	agric. etc|agriculture|non-perennial crops	Agricultural Production|Non-Energy|Crops
A.02.10	Silviculture and other forestry activities	6-agric. etc.	agric. etc|forestry|afforestation & reforestation	Land Cover|Forest|Managed

Table A1: Mapping of economic activities from NACE codes to NGFS phase 3 variables by means of the CPRS-Granular classification. A selection of 72 codes (mostly at 4 digits codes) is shown. The full table is available at https://www.finexus.uzh.ch/en/projects/CPRS.htm