Environmental and Resource Economics (2024) 87:191–217
https://doi.org/10.1007/s10640-023-00821-2

The Climate Actions and Policies Measurement Framework: A Database to Monitor and Assess Countries' Mitigation Action

Daniel Nachtigall[1] · Luisa Lutz[1] · Miguel Cárdenas Rodríguez[1] · Filippo Maria D'Arcangelo[2] · Ivan Haščič[1] · Tobias Kruse[2] · Rodrigo Pizarro[1]

Accepted: 16 October 2023 / Published online: 9 January 2024

Abstract

There are major gaps in the measurement of the adoption and stringency of countries' climate actions and policies, notably in a manner coherent across countries, time, sectors, and instrument types. The Climate Actions and Policies Measurement Framework (CAPMF) aims to fill this gap. It is the most extensive structured and internationally harmonised climate mitigation policy database available to date. Currently, it comprises 130 policy variables, grouped into 56 policy instruments and other climate actions, covering 50 countries and the EU-27 as a block for the period 1990–2022. Results indicate that countries strengthened their climate action between 1990 and 2022 in terms of policy adoption and policy stringency, although at different paces. Policy adoption, policy stringency and policy mixes changed over time and differ substantially across countries and country groups. Importantly, regression analysis suggests a significant relationship between stronger climate action and greater emission reductions. Mitigation policies helped reduce emissions by about 12% in the last 5 years; most of this effect is attributable to a reduction in the energy intensity of the economy, and only residually to other factors such as a reduction of GHG intensity.

Keywords Climate change · Climate policy · Climate action · Market-based instruments · Non market-based instruments · Policy instruments · Carbon pricing · Policy effectiveness

JEL Classification H23 · Q48 · Q54 · Q58

This paper is based on the OECD Environment Working Paper No. 203 (https://doi.org/10.1787/2caa60ce-en). The views expressed here are those of the authors and do not represent the official views of the OECD or of its member countries.

✉ Daniel Nachtigall
Daniel.Nachtigall@OECD.org

[1] Organisation for Economic Co-operation and Development (OECD), Environment Directorate, 2 Rue André Pascal, 75016 Paris, France

[2] Organisation for Economic Co-operation and Development (OECD), Economics Department, 2 Rue André Pascal, 75016 Paris, France

1 Introduction

To achieve countries' Nationally Determined Contributions (NDCs) and net-zero targets, as well as the collective goal of the Paris Agreement, countries need information about which policy approaches work most effectively and efficiently. Providing evidence-based guidance to countries requires the existence of harmonised climate policy data. However, to date, there is a lack of a structured and harmonised climate policy database that would cover a large number of countries over a long time period. The Climate Actions and Policies Measurement Framework (CAPMF), presented in this paper, attempts to fill the gap by compiling a climate policy database that provides selected information on countries' mitigation policy landscapes at a granular level.

The CAPMF is a structured and harmonised climate mitigation policy database with 130 policy variables, grouped into 56 policy instruments and other climate actions (hereafter "policies"), covering 50 countries and the EU-27 as a block from 1990 to 2022. The CAPMF was developed under the OECD International Programme for Action on Climate (IPAC), which supports countries' progress towards net-zero greenhouse gas (GHG) emissions through regular monitoring and policy evaluation (IPAC 2022). The CAPMF database is publicly available on the OECD data explorer (https://oe.cd/dx/capmf).

The CAPMF includes climate mitigation actions and policies presented in a way that is consistent with the organisation of information on policies and measures under the UNFCCC (UNFCCC 2022) and the IPCC frameworks (IPCC 2022). The CAPMF covers both climate policies with an explicit intent of advancing mitigation domestically and abroad as well as non-climate policies that have an expected positive effect on mitigation. These include sectoral, cross-sectoral, and international policies as well as market-based instruments (e.g. carbon taxes, subsidies for zero-carbon technologies), non-market-based instruments (e.g. standards, bans), and other climate actions (e.g. short-term and long-term emissions targets, climate governance, climate data).

The CAPMF is complementary to UNFCCC stocktaking efforts (UNFCCC 2022). Compared to the UNFCCC efforts, this paper goes a step further by tracking, at a more granular level, the policies that have been adopted and their level of stringency. For example, the latest UNFCCC synthesis report on NDCs revealed that 91% of countries were committed to mitigation actions in energy supply, 82% in the transport sector, and 77% in the building sector, among others (UNFCCC 2022). The work developed in this paper provides essential information at a granular scale on policy adoption and the stringency (i.e. the degree to which climate actions and policies incentivise or enable GHG emissions mitigation at home or abroad) of countries' climate action. While policy adoption and policy stringency do not measure policy effectiveness, they are the first key steps for assessing effectiveness.

The major contributions of the CAPMF and this paper to the literature are the following:

- The CAPMF constitutes a unique structured and harmonised climate mitigation policy data based on common definitions, across a long time period, and for a large number of countries. The CAPMF panel data comprises many more policy variables than any comparable policy database.

- The CAPMF panel data enables researchers to carry out econometric and statistical analyses, which may support the design of comparable policy recommendations across countries.
- This paper illustrates novel descriptive results on the evolution of climate action as well as differences in policy adoption, policy stringency, and policy mixes across countries, country groups, and over time.
- This paper also carries out an econometric cross-country evaluation of climate policies, providing insights into the usefulness of the CAMPF for analysing the effectiveness of climate policies in terms of reducing emissions. It finds that mitigation policies, as covered by the CAPMF, are associated with an emission reduction of about 12% in the last five years. While the effects should not be interpreted causally, the econometric analysis helps establishing the relevance of the CAPMF data for tracking the relationship between climate policies and climate-related outcomes (e.g. emissions, energy intensity) and exemplifies how the CAPMF can be employed for future empirical analysis, estimating effects of climate policies on environmental and economic outcomes.

The remainder of this paper is structured as follows: Sect. 2 presents the CAPMF including its objectives, scope, and structure, and discusses the methodology for measuring the various policy variables. Section 3 presents some results of the CAPMF. Section 4 contains an empirical analysis, relating emissions with the CAPMF and its subcomponent within a regression framework. Section 5 discusses some limitations of the CAPMF and provides guidance for interpretation. Finally, Sect. 6 summarises the main findings and outlines possible future work areas. More details on, i.a., the description of policy variables and descriptive results can be found in the accompanying OECD working paper (Nachtigall et al. 2022), which this paper is based on.

2 Scope, Structure, and Methodology

2.1 Scope and Value Added

The CAPMF is a structured and harmonised database on climate *mitigation* actions and policies. The CAPMF considers *governments'* policies at face value. It does not take into account direct or indirect outcomes or information on how climate policies are perceived.[1] The 2022 edition of the CAPMF provides 130 policy variables grouped into 56 policies for 50 countries (all but one OECD members and accession candidates, G20 countries) and the European Union as a block from 1990 to 2022.[2] Collectively, these countries contribute to more than 63% of global GHG emissions.

[1] For example, the CAPMF includes countries' public R&D expenditure on low-carbon technology, but not the number of patents filed by countries' inventors, which are an outcome of public policies. The CAPMF also does not capture environmental outcomes such as GHG emissions or emissions intensities. Moreover, climate actions and policies of non-government actors (e.g. the private sector) are not within the scope of the CAPMF as long as there is no direct government involvement. Finally, the CAPMF does not account for the enforcement of climate policies.

[2] The 50 countries include Argentina, Australia, Austria, Belgium, Brazil, Bulgaria, Canada, Chile, China, Colombia, Costa Rica, Croatia, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, India, Indonesia, Ireland, Israel, Italy, Japan, Korea, Latvia, Lithuania, Luxembourg, Malta, Mexico, Netherlands, New Zealand, Norway, Peru, Poland, Portugal, Romania, Russian Federation, Saudi Arabia, Slovak Republic, Slovenia, South Africa, Spain, Sweden, Switzerland, Türkiye, the United Kingdom. Moreover, the CAPMF includes the European Union.

The CAPMF stocktaking exercise includes 75% of policy instrument types listed in the policy framework of the IPCC (2022) Working Group III report. Policies not covered by the CAPMF include bans on SF_6 emissions (which represent less than 2% of global GHG emissions in 2020 (EPA 2022), or biofuel mandates, which are deliberately excluded from the CAPMF because of issues related to potential increased emissions from direct and indirect land use change. The CAPMF does, however, include some policies on GHG other than carbon dioxide (CO_2), such as methane and nitrous oxide.

The CAPMF covers both climate policies with an explicit intent of advancing mitigation (e.g. carbon taxes, GHG emissions standards, subsidies for zero-carbon technologies) as well as non-climate policies that have an expected positive effect on mitigation (e.g. fuel excise taxes, energy efficiency standards, congestion charges). While it provides a toolbox of possible actions that countries may wish to consider, the CAPMF is not intended to be prescriptive to countries' policy approaches. At this stage, the CAPMF focusses primarily on national policies, covering only a few sub-national approaches.[3]

The CAPMF sources data from data collection efforts within and outside the OECD. Data sources include information from policy databases such as the OECD Policy Instruments for the Environment (PINE) database (OECD 2021), the IEA Policies and Measures database (IEA 2021), and the ITF Transport Climate Action Directory (ITF 2021). The CAPMF draws on other official data, including from the United Nations Statistical Division (UNSD), the United Nations Framework Convention on Climate Change (UNFCCC) and the World Bank.

Table 1 shows selected climate and environmental policy data bases along their respective characteristics. NewClimate Institute's Climate Policy Database (Nascimento et al. 2021), the EEA data base on GHG policies and measures in Europe (EEA 2023), the Policy Instruments for the Environment (PINE) Database (OECD 2021) and the IEA Policies and Measures Database (IEA 2023) are inventories of national climate mitigation policies combined with a taxonomy that allows to assign different policies to sectors and policy instrument types. The EEA data base also includes planned policies as well as other details such as total GHG emissions reductions from specific policies or other objectives. The PINE data base has the largest time and country coverage of the four, as it has been in place since 1996. Moreover, it is verified by government officials.

Compared to other existing climate or environmental databases, the value added of the CAPMF is twofold: first, compared to policy databases such as the OECD Policy Instruments for the Environment (PINE) database (OECD 2021), IEA's Policies and Measures, NewClimate Institute's Climate Policy Database or LSE's Climate Change Laws of the World, the CAPMF provides a harmonised panel dataset of climate policy variables consistently measured for a large set of countries and the 1990–2020 period. This harmonised dataset is designed for statistical analysis—it enables researchers to carry out descriptive or econometric analyses on the effects of climate policies on economic and environmental outcomes. In addition, the CAPMF calculates the stringency of each policy based on a harmonised methodology, allowing to track policy development.

Second, compared to harmonised panel datasets or composite indices such as the OECD Environmental Policy Stringency (EPS) Index (Botta and Koźluk 2014; Kruse et al. 2022) or German Watch's Climate Change Performance Index (CCPI), the CAPMF covers a much larger number of climate policies. For example, the EPS comprises 13 policy

[3] Sub-national policies included in the CAPMF are emissions trading schemes, carbon taxes, renewable energy auctions, renewable energy portfolio standards, and motorway speed limits.

Table 1 Key characteristics of climate policy data bases

Name	Institution	Approach	Types of instruments covered	Time coverage	Country coverage
Climate Policy Data Base	NewClimate Institute, Wageningen University, PBL Netherlands Environmental Assessment Agency	Inventory of selected national climate mitigation policies adopted in a given year with taxonomy and implementation date	Regulatory instruments, market-based instruments, targets, information instruments, RD&D, institutions	• First release date: 2019 • Oldest policy entry: 1927 • Release frequency: annual	42 countries including EU
Climate Change Laws of the World	Grantham Research Institute at LSE, Sabin Center at Colombia Law School	Inventory of selected national climate mitigation legislation and policies adopted in a given year with implementation date	Climate and climate-related laws, laws promoting low carbon transitions	• First release date: 2010 • Oldest policy entry: 1947 • Release frequency: on a rolling basis	196 countries plus EU
Policy Instruments for the Environment (PINE) Database	OECD	Inventory of selected national climate mitigation policies adopted in a given year with taxonomy and implementation date	Taxes and fees, tradable permits, subsidies, deposit-refund schemes, and voluntary approaches	• First release date: 1991 • Oldest policy entry: 1917 • Release frequency: annual	130 countries
EEA database on greenhouse gas policies and measures in Europe	European Environment Agency	Inventory of selected planned and adopted climate measures and policies with taxonomy and implementation date	Regulations, market-based instruments, voluntary approaches, fiscal policies, education	• First release date: 2021 • Oldest policy entry: 1930 • Release frequency: annual	European Union
The IEA's Policies and Measures (PAMS) Database	IEA	Inventory of selected past, existing or planned government policies and measures with taxonomy and implementation date	Taxes, regulations, grants, performance-based policies, targets	• First release date: 1999 • Oldest policy entry: 1948 • Release frequency: updated periodically	154 countries + EU
Climate Actions and Policies Measurement Framework (CAPMF)	OECD	Structured and harmonized national climate policy data base which consistently tracks a defined set of instruments	Market-based instruments, regulations, international commitments, subsidies, institutions	• First release date: 2023 • Oldest policy entry: 1990 • Release frequency: annual	50 countries + EU27

Note: The Climate Change Laws of the World (GRI 2023) constitutes an inventory of national climate mitigation legislation and policies. While it does not have a taxonomy that allows the user to tag policies, it will be enhanced with an AI-powered tool to allow for more detailed searches of the data base

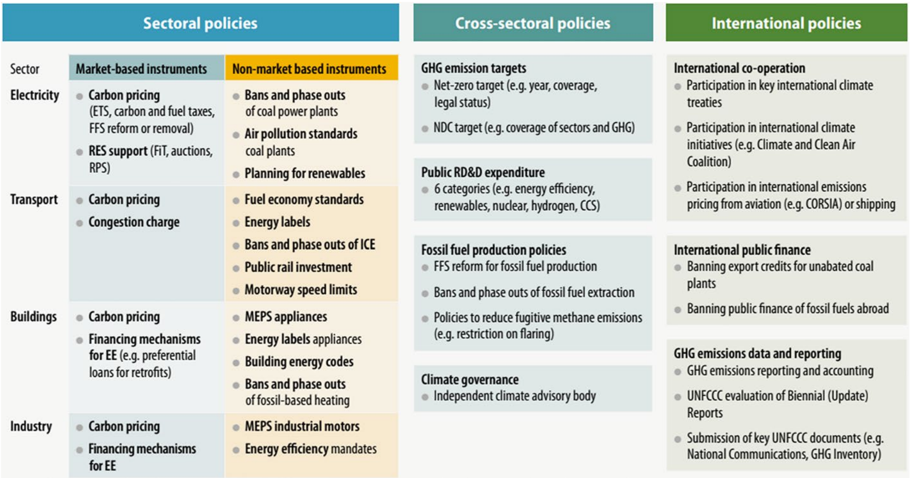

Fig. 1 The structure of the CAPMF *Note*: ETS: Emissions trading system; FFS: Fossil fuel support; RES: Renewable energy sources; FiT: Feed-in-tariff; RPS: Renewable Portfolio Standard; EE: Energy efficiency; ICE: Internal combustion engine; MEPS: Minimum energy performance standard; CCS: carbon capture and storage

variables, whereas the CAPMF includes 130. The CCPI mixes output-based variables (e.g. GHG emissions) with a few policy variables based on subjective expert assessment, whereas the CAPMF is based on objective information about governments' climate actions as written in law or other policy documents.

The CAPMF categorises policy data in two ways. First, the policy variables are categorised into sectoral, cross-sectoral, and international climate actions and policies (Section 'Structure'). Second, they are categorised by policy type, including *market-based instruments* (e.g. feed-in-tariffs, emissions trading schemes), *non market-based instruments* (e.g. emissions limit values, bans or phase-outs of fossil fuel equipment and infrastructure), and *targets, governance, and climate data* (e.g. NDCs, net-zero targets, climate governance) (Table 5).

2.2 Structure

The structure of the CAPMF is aligned with relevant OECD work classifying policy instruments such as the PINE database and the EPS Index. The CAPMF is organised across three building blocks, which reflect the spectrum of countries' climate actions and policies: sectoral policies, cross-sectoral policies, and international policies (Fig. 1).

Sectoral policies are defined as policies that can be constrained to or are designed to apply to a specific source or economic sector (e.g. emission limit values for passenger cars, phase-out of power plants). This version of the CAPMF covers the IPCC source sectors, including power generation, industry, transport, and buildings. It is planned to extend the work towards agriculture, land use, land-use change, and forestry (AFOLU), and waste. In most countries, sectoral policies are proposed by the respective ministry. For each sector, the CAPMF explicitly distinguishes between market-based instruments and non market-based instruments.

Cross-sectoral actions and policies refer to policies that cut across more than one emission source or sector. These are overarching policy areas to mitigate or remove domestic GHG emissions that cannot be easily attributed to a specific sector (e.g. GHG emissions targets, climate governance).

International policies refer to policy commitments associated with international conventions or agreements where more than one country participates (e.g. participation in international climate agreements, international public climate-related finance). While international policies do not necessarily reflect domestic mitigation commitments or efforts, these policies and international coordination are vital to reaching the goals of the Paris Agreement given the global nature of the climate change challenge. Some countries explicitly highlight the importance of international policies to reduce emissions abroad (Finnish Government 2019). Supra-national policies such as those adopted by the European Union (EU) are recorded for both the EU aggregate and each Member State.

The modular structure of the CAPMF facilitates the analysis of the building blocks separately. This may be relevant for countries that have different policy approaches emphasising specific types of policy instruments. For example, practitioners may not want to take international policies into account when the major focus of their work is on domestic mitigation efforts.

Each building block consists of a number of modules (e.g. targets in national cross-sectional policies and actions). Each module encompasses a number of climate actions and policies (e.g. net-zero targets and NDC in targets) and each policy can consist of a number of policy variables (e.g. target year of net-zero targets).

More details on the policies covered by the 2022 edition of the CAPMF, including the measurement of policy variables the rationale for inclusion, the data source, a detailed description of the underlying raw data, as well as information on country and time coverage can be found in the accompanying OECD working paper (Nachtigall et al. 2022).

2.3 Methodology: Normalisation and Missing Data

The CAPMF *groups* its 130 policy variables into 56 policies. This is to aggregate policy variables that describe the same policy instrument or are otherwise similar in nature. For example, the CAPMF comprises four variables on feed-in-tariffs (FiT) for renewable electricity (support level and contract duration for both solar PV and wind), but only one variable for renewable energy portfolio standards. Hence, the CAPMF groups the four variables into one to assess the extent to which a country has adopted a FiT.

The CAPMF normalises each policy variable based on the *in-sample distribution across all countries and years*. Normalisation is necessary to map different dimensions of policy variables into one common dimension. For example, the contract duration of FiT is measured in years whereas the FiTs' support level is measured in USD per MWh.

Normalisation also allows for determining policy stringency. Policy stringency is defined as the degree to which climate actions and policies incentivise or enable GHG emissions mitigation at home or abroad. This allows to track within-country evolution of countries' policy stringency and ensures that countries' policy stringency can change only if there is a change in a policy. More precisely, if a country has, for example, increased its carbon tax, this will be reflected in a higher policy stringency value. Importantly, the policy stringency is determined based on all observed data until 2022, meaning that a country's policy stringency does not decrease if other countries strengthen their efforts.[4]

For each policy variable, a stringency level between 0 and 10 is assigned as follows:

- A level of 0 is assigned if a policy or action is not in place.
- All other levels are assigned according to the in-sample distribution across all years and countries so that the percentiles constitute the thresholds between the levels. More precisely, a level of 10 is assigned if the value of the policy variable is at or above the 90th percentile after excluding all observations where the policy variable is not in place.[5] A level of 9 is assigned if the value falls between the 80th and 90th percentile and so on. Finally, a level of 1 is assigned if the value of the policy variable is below the 10th percentile but is in place.[6] This methodology is straightforward for most variables but needs to be interpreted carefully for some.[7]
- For binary or categorical variables, a level of 10 is assigned to the highest value of the policy variable. All other values of categorical variables are linearly mapped into the space from 1 to 10.[8]

Subsequently, the policy variables describing the same 'policy' are grouped into one by assigning equal weights to all underlying policy variables. For example, each of the four FiT policy variables receive a weight of 0.25. The equal weighting assumption is conservative as it does not make any judgement call on the relative importance of various policy variables.[9]

All policy variables with *missing data* receive a policy stringency of zero to enable the grouping and are labelled as 'missing' in the published database.[10] The CAPMF does not impute values for missing data even where this would be possible. This is a conventional way to deal with missing data because it does not require any assumption about the imputation procedure (Gachau et al. 2021).

The only exception from the treatment of missing data refers to *missing data in* $t-1$. In each annual update, the CAPMF aims to provide data for the previous year to capture an up-to-date picture of countries' climate action. For some policy variables, however, data

[4] Adding new countries and years to the sample may require a re-attribution of bin thresholds and therefore lead to a reattribution of stringency levels (Botta and Koźluk 2014[9]). To reflect changing samples bin thresholds will be updated at regular intervals, e.g. every five years. Once updated, the entire time series of all policy variables will also be recalculated.

[5] First excluding the observations, where an instrument is not in place, and then performing the normalisation is advisable, as this avoids having extreme values that dominate the grouping (Talukder et al. 2017[22]).

[6] All bin thresholds will be available upon request.

[7] For example, a low share of rail investment could be due to a preference for individual transport options or due to context-specific factors such as population density or geography.

[8] For example, the values from 1 to 5 of a categorical variable would get the stringency levels 2, 4, 6, 8, and 10 respectively.

[9] While grouping is necessary to aggregate policy variables that describe the same policy instrument, it naturally simplifies the multi-dimensional nature of climate policies into a single dimension. Assuming equal weights between the different dimensions neglect the fact that some policy dimensions (e.g. price of FiT) might be more important than others (e.g. duration of FiT). Note, however, that the OECD will publish the CAPMF data for both the policy variable and the policy level so that practitioners could apply different weights if they wished.

[10] These data points are shown as 'missing' when the data of CAPMF is published and an explanation for the missing data is provided (e.g. data not collected or not reported).

will not be available in such a timely manner. For those, the CAPMF imputes the missing data in $t - 1$ based on the observation of the previous year.

3 Descriptive Results

One of the primary purposes of the CAPMF is to provide consistent data to track countries' policy adoption and development. This section presents some selected results of the CAPMF. More results can be found in the accompanying OECD working paper (Nachtigall et al. 2022).

In 2022, high levels of average policy stringency across all policies can mainly be observed in developed countries (Fig. 2). OECD countries, notably in Europe exhibit high levels of average policy stringency, whereas particularly low levels can be found in Latin America, the Middle East and Asia. However, all countries remain far from reaching high levels of average policy stringency. On the scale from 0 to 10, the United Kingdom reached the highest level (6.3) of all countries, while Peru reached the lowest level (1.3).

Countries have, on average, accelerated their climate action between 2010 and 2022 (Fig. 3). These countries both adopted new policies and increased the stringency of existing policies. Across all countries, the increase in policy adoption has been particularly focussed on auctioning renewable electricity, carbon pricing and, more recently, bans and phase out of fossil fuel equipment and infrastructure such as coal power plants. Yet, more needs to be done in most countries to reach NDCs and net-zero targets.

At the country level, most countries increased the number of adopted policies between 2015 – the year of the Paris Agreement—and 2022. However, some countries did not increase the number of adopted policies and others even removed policies.

Policy adoption and stringency differ significantly across country groups (Fig. 4). This partially reflects different economic realities, starting conditions, policy path dependency, or public acceptance of climate action. Not surprisingly, non-OECD countries adopted fewer and less stringent policies than OECD countries. OECD countries, on average, adopted 39 policies with 19 stringent ones, whereas non-OECD countries adopted 25 with

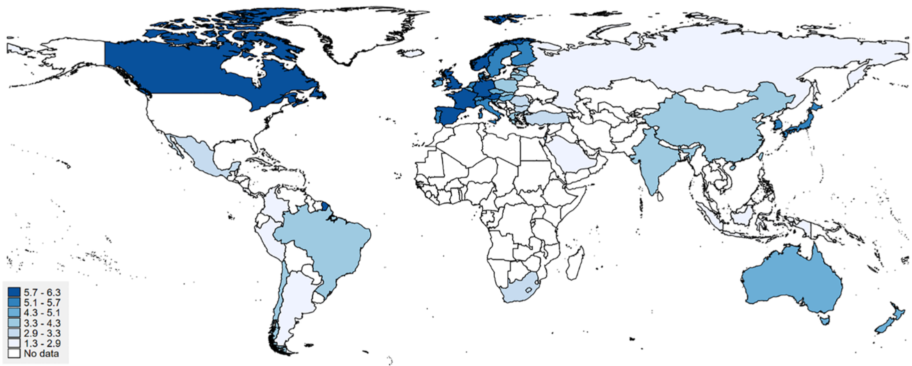

Fig. 2 Climate policy stringency differs across countries *Note*: Shades of colour show different levels of policy stringency. Darker shades indicate higher levels of stringency, whereas lighter shades indicate lower levels of stringency. Country-level policy stringency is calculated by averaging policy stringency across all 56 policies for the year 2022

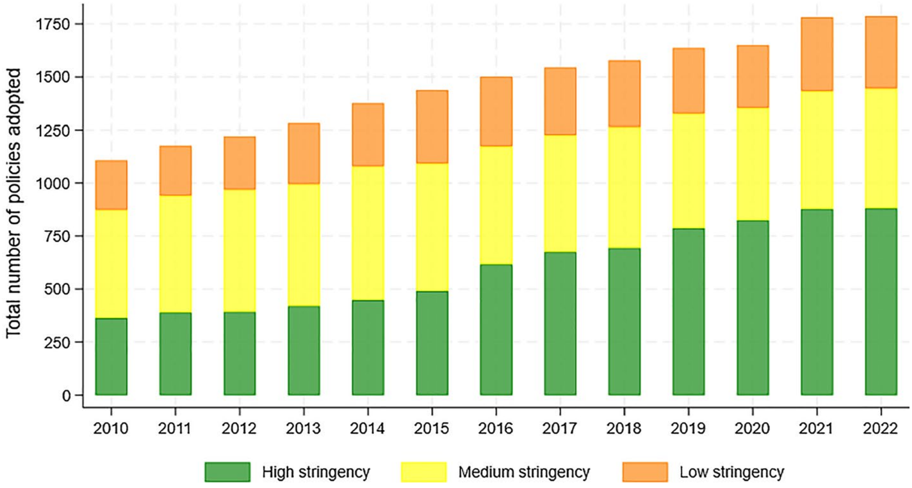

Fig. 3 Countries strengthened their climate action between 2010 and 2022. *Note*: Low stringency is defined as a stringency score of 0–3, medium stringency as 4–7 and high 8–10

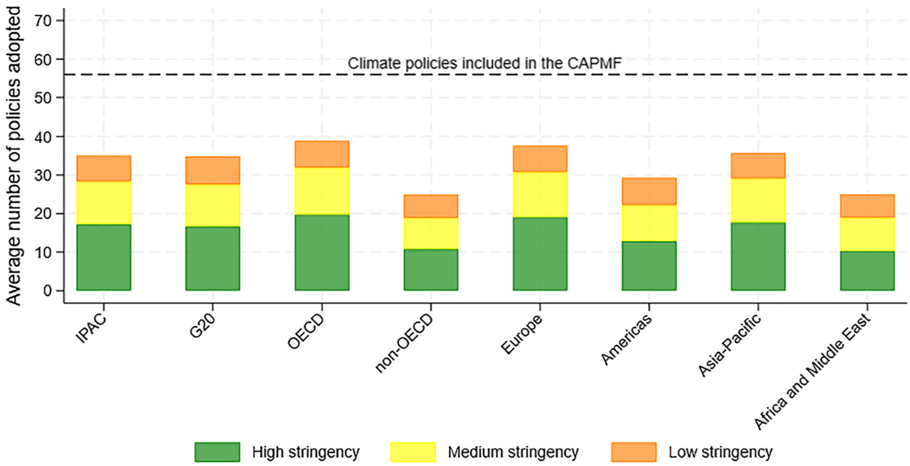

Fig. 4 Policy adoption and policy stringency differ across country groups *Note*: Number and stringency of climate policies by selected country group in 2022. Low stringency is defined as a stringency score of 0–3, medium stringency as 4–7 and high 8–10

10 considered highly stringent. Regionally, European countries adopted the most policies on average (37 policies), followed by Asia–Pacific (35) and the Americas (29).

Policy adoption and policy stringency differ substantially across countries (Fig. 5). No country has adopted all policies included in the CAPMF. Policy adoption varies between 47 adopted policies in Canada, France and the United Kingdom to 13 in Peru. Heterogeneity in policy adoption partially reflects countries' different policy approaches and climate ambition. Aggregation of climate action by county group hides important cross-country differences. For example, while most European countries have many policies with above average policy stringency in place, this does not hold true for all European countries. Similarly, some large economies in the Americas have many policies

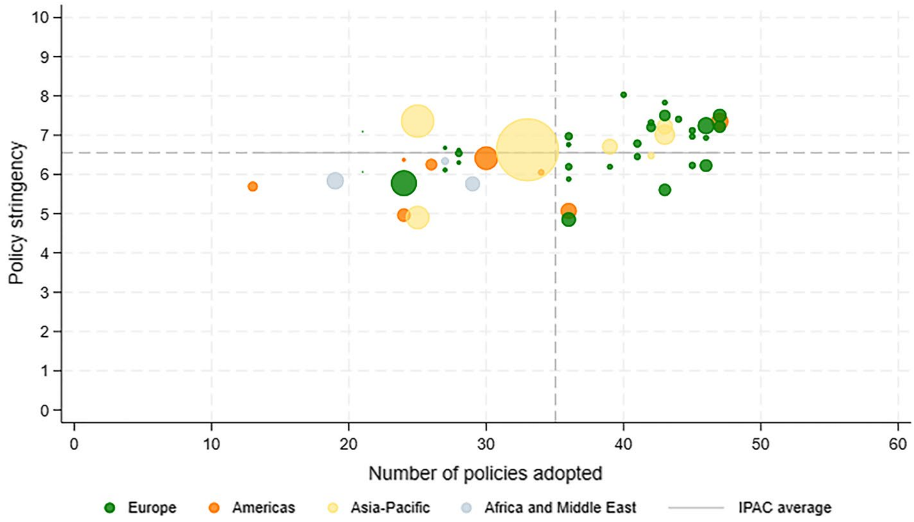

Fig. 5 Policy adoption and policy stringency differ substantially across countries *Note*: Policy stringency and policy adoption by country in 2020. Bubble size is proportional to countries' GHG emissions

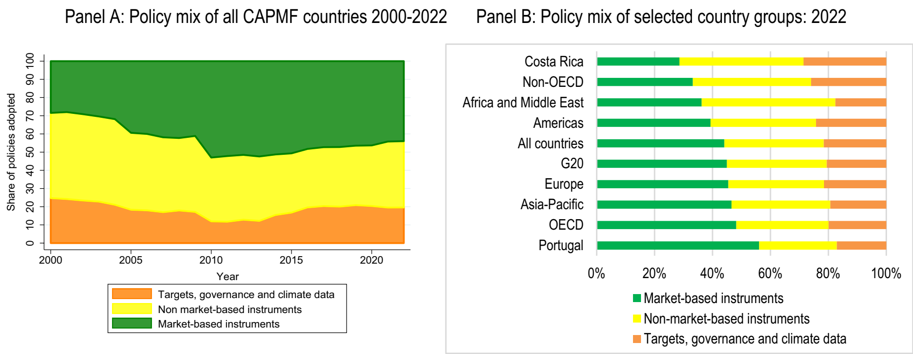

Fig. 6 Climate policy mixes differ substantially across countries and change over time *Note*: Portugal and Costa Rica are included for illustrative purposes. They are the countries with the highest and lowest share of market-based instruments on the policy mix

with above average stringency in place whereas other countries in the Americas have fewer and less stringent policies in place. Most Asian economies, notably big Asian emitters, also have fewer policies with below average stringency in place.

Over the last 20 years, countries' policy mix changed (Fig. 6, Panel A). For example, in the early 2000s, market-based instruments represented less than 30% of adopted policy instruments, but they represent almost 50% in 2010. The increasing uptake of market-based instruments has occurred since 2005, primarily driven by the implementation of the EU Emissions Trading System (EU ETS) and other subsequent carbon pricing schemes. However, in the last decade the relative importance of market-based instruments decreased.

The policy mix also differs substantially across countries (Fig. 6, Panel B). While some countries (e.g. Portugal) primarily rely on market-based policies, such as carbon pricing

Table 2 Policy adoption of policy instruments varies greatly across country groups

Summary statistics for year 2022, transport sector only

Transport sector policy instruments	Number of countries with with policy adopted	Share of countries in CAPMF inventory	Share of G20 countries	Share of OECD countries	Share of non-OECD countries
Congestion charges	4	8%	10%	11%	0%
Emissions trading scheme	6	12%	12%	14%	7%
Carbon tax	17	33%	36%	41%	14%
Ban and phase out of passenger cars with ICE	31	61%	62%	73%	29%
Public investment in rail infrastructure	35	69%	79%	81%	36%
Fuel economy standards	40	78%	86%	84%	64%
Energy labels for passenger cars	40	78%	86%	78%	79%
Fossil fuels subsidies reform	42	82%	86%	95%	50%
Fossil fuels excise taxes	44	86%	86%	97%	57%
Speed limits on motorways	44	86%	88%	89%	79%

Legend: Share of adopted policies 0% 20% 40% 60% 80% 100%

ICE: internal combustion engine

under the EU ETS or Feed-in Tariffs for renewable energy, others (e.g. Costa Rica) place more emphasis on non-market-based instruments, such as minimum energy performance standards and bans or phase-outs of fossil-fuel equipment or infrastructure. While countries employ different policy mixes, on average, countries tend to strengthen climate action through several instruments at a time. This can be partially observed from the high pairwise correlation across policy types within countries (see Appendix Tables 6 and 7). At the country group level, OECD countries use a relatively higher share of market-based instruments compared with non-OECD countries. Interestingly, policy mixes are fairly homogeneous across country groups with little variations for OECD, European, G20, and Asia–Pacific countries from the CAPMF average.

Policy adoption of specific policy instruments varies greatly across country groups as illustrated for instruments in the transport sector (Table 2). Only 4 and 6 countries adopted (city-level) congestion charges and included the transport sector in their ETS, respectively. Some countries adopted carbon taxes (17) and already announced or legislated bans or phase-outs of passenger cars with internal combustion engines (31), though the share of countries adopting these instruments is significantly lower or even zero in non-OECD countries. Most countries adopted fuel economy standards, energy labels for passenger cars, fuel excise taxes, and speed limits on motorways. However, policy adoption of fuel excise taxes and fuel economy standards is significantly lower in non-OECD countries. Compared to labels and speed limits, fuel excise taxes and fuel economy standards put more direct costs on users, potentially facing public acceptability problems. This may explain the relatively lower policy penetration in non-OECD countries. Regional differences in fossil fuel subsidy reform and investment in public rail infrastructure are likely driven by data availability constraints.

It is important to remember that policy adoption and policy stringency measure governments' climate action, but not necessarily policy effectiveness. Yet, policy adoption and stringency can be seen as a proxy for policy effectiveness as, e.g., more stringent policies can be expected to reduce emissions to a greater extent. For example, a very stringent emission limit value for coal power plants can be expected to lead to higher emissions

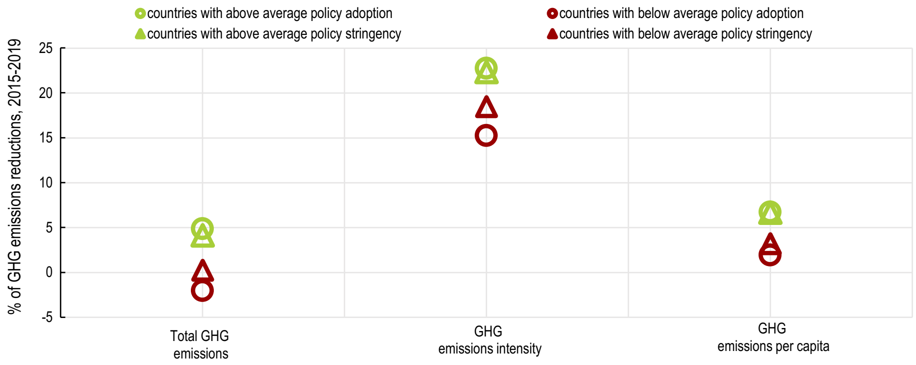

Fig. 7 Countries with stronger climate action are associated with steeper emissions reductions

reduction compared to a laxer one. However, the overall effects of increased policy adoption and policy stringency depend on factors such as emissions coverage and economic costs and likely have different impacts across countries.

This paper sheds more light on this. The descriptive evidence suggests that countries with relatively larger policy adoption or larger average policy stringency are associated with deeper GHG emissions reductions between 2015 and 2019 (Fig. 7). In fact, countries with an above-average number of adopted policies and above-average policy stringency were most successful in reducing their total GHG emissions as well as their GHG emissions intensity and GHG emissions per capita between 2015 and 2019 compared to countries below the respective average.[11] This analysis is purely descriptive and does not imply any causal relationship between policy adoption or policy stringency and GHG emissions reduction. The next section illustrates the relationship between policy stringency and GHG emissions reduction more in depth.

4 Empirical Analysis: The Effects of Climate Policies on GHG Emissions

This section sheds light on the environmental effectiveness of climate policies. Using regression analysis, the effect of higher climate policy stringency, as measured by the CAPMF, on country-level emissions is estimated. This serves two purposes. First, it provides an overarching assessment of mitigation policy instruments spanning 48 countries and 21 years (from 2000 to 2021).[12] Second, it establishes the relevance of the CAPMF for tracking the relationship between climate policies and climate-related outcomes such as emissions, emissions intensity, and energy intensity.

[11] This analysis uses data on GHG emissions up to 2019 to not confound the results with those of the effects of the COVID-19 pandemic on emissions.

[12] The empirical analysis includes all countries covered by CAPMF except for Peru and Romania, for which information on some of our control variables is missing. Columns 1 to 4 in Table 10 in "Appendix B" show that the effects are the same with a reduced set of controls and Peru and Romania included.

A stringency measure is built as a composite index at the country-year level by averaging across all 56 policies.[13] Using a composite index on policy stringency in a cross-country analysis builds on prior work, including the use of the OECD EPS index to assess the effects of climate policies on emissions (Frohm et al. 2023), employment (Dechezleprêtre et al. 2020) and innovation in clean technologies (Dechezleprêtre and Kruse 2022) and the OECD Effective Carbon Rates to estimate the effect of carbon pricing on CO_2 emissions and government tax revenues (D'Arcangelo et al. 2022).

This section investigates the effect of climate policy stringency on several outcomes that are crucial for the low-carbon transition such as GHG emissions, CO_2 emissions and energy intensity of the economy. The main emission data are taken from PRIMAP's national historical emissions time series (Gütschow et al. 2016), which offers comprehensive country coverage and a transparent methodology.[14] Energy data are taken from the IEA's World Energy Statistics and Balances to calculate energy intensity indicators.

The baseline empirical specification is the following:

$$Y_{ct} = \beta CAPMF_{ct-1} + X'_{ct}\gamma + \delta_c + \delta_t + \varepsilon_{ct} \tag{1}$$

where Y_{ct} is the outcome variable (such as log CO_2 emissions) in country c and year t. CAPMF_{ct-1} is obtained averaging the stringency values across all 56 policies and is standardised to have a mean of zero and standard deviation of one. The use of a lagged CAPMF index reduces concerns of simultaneity. This approach closely follows the existing literature (Best et al. 2020; Eskander and Fankhauser 2020) in the choice of a standard set of controls X_{ct} to isolate the effect of policy stringency on outcomes. Table 8 in "Appendix B" contains the descriptive statistics of the variables employed for the empirical analysis in this section and Table 9 in "Appendix B" shows the correlation matrix.

The controls include several economic variables (all in 2017 constant USD and in PPP) to account for time-varying confounders. The estimation equation includes (log) GDP, obtained from the OECD National Accounts and complemented with the World Bank's *World Development Indicators* (WDI) as well as (log) GDP squared to accommodate any nonlinear relationship emerging from an environmental Kuznet's curve. The Hodrick-Prescott decomposition further controls for cyclical components in GDP, the import share of GDP (calculated from WDI based on OECD National Accounts) and the service share of GDP (OECD*, Trade in goods and services*) control for varying economic structure. Moreover, the estimation includes (log) population from WDI and a measure of the rule of law sourced from the *Worldwide Governance Indicators* to control for enforcement and saliency of policies following Best et al. (2020).[15] The model also includes country fixed effects, δ_c, which control for all time-invariant difference across countries, and year fixed effects, δ_t, which control for time-specific shocks that are common across countries. In

[13] This provides a transparent and easily reproducible approach to computing the average. Alternatively, an average can also be built from the modular structure presented in Sect. 2 by first calculating the unweighted average of the stringency across all policies within a module (e.g. Feed in Tariffs, auctions, carbon taxes in electricity) and second creating the unweighted average across all 15 modules (e.g. electricity, industry, transport, targets). We show in the robustness checks that this does not affect the key results (Table 11 columns 3–5 in "Appendix B").

[14] Results of the analysis do not vary when other GHG emission data sources are considered (see Table 11 in "Appendix B").

[15] Values for 2001 (missing in the original data) are imputed as a simple mean of those for 2000 and 2002.

Table 3 Effects of climate policies on environmental outcomes

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	GHG	CO_2	CO_2	CO_2	CO_2	Energy/GDP	CO_2/Energy
L.CAPMF	−0.120***	−0.123***		−0.188***	−0.044	−0.096***	−0.019
	(0.034)	(0.040)		(0.062)	(0.028)	(0.033)	(0.026)
L. Number of policies			−0.007*	0.007			
			(0.004)	(0.006)			
GDP	−1.529**	−1.971**	−1.803**	−1.963***	−1.219*	−0.857**	−1.995***
	(0.577)	(0.713)	(0.743)	(0.683)	(0.687)	(0.371)	(0.673)
GDP squared	0.083***	0.102***	0.098***	0.101***	0.084***	0.019	0.080***
	(0.021)	(0.025)	(0.026)	(0.024)	(0.024)	(0.015)	(0.024)
HP Filter	−0.023***	−0.025***	−0.027***	−0.023**	−0.022**	−0.003	−0.021**
	(0.008)	(0.009)	(0.008)	(0.008)	(0.008)	(0.009)	(0.009)
Population	0.314**	0.328*	0.325*	0.374**	0.125	0.302	0.046
	(0.144)	(0.172)	(0.187)	(0.172)	(0.121)	(0.213)	(0.148)
Service % of GDP	−0.001	−0.002	−0.001	−0.002	−0.004	0.004	−0.005
	(0.003)	(0.004)	(0.004)	(0.004)	(0.004)	(0.003)	(0.004)
Import % of GDP	0.002	0.009	0.011	0.010	0.006	0.006	0.004
	(0.006)	(0.008)	(0.008)	(0.008)	(0.008)	(0.005)	(0.008)
Rule of law	0.090	0.130*	0.125	0.134*	0.152**	−0.045	0.163**
	(0.057)	(0.069)	(0.073)	(0.067)	(0.062)	(0.045)	(0.066)
Energy/GDP					0.738***		
					(0.076)		
Observations	993	993	993	993	952	952	952
Year f.e	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country f.e	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Within R2	0.62	0.58	0.56	0.59	0.67	0.34	0.26

***Signify statistical significance of the coefficient at 1%, ** at 5%, and * at 10% significance level. All dependent variables, GDP and population are in logs. Total final energy consumption data is missing for 2021, which reduces the sample size in columns 5 to 7. Standard errors clustered at the country and year level

Table 10 in "Appendix B" control variables are added gradually to show that no individual control variable drives the results.

Controlling for output and population is especially important as they are crucial determinants of emissions that are likely to confound the policy effect. Secular growth in economic activity and population correlates with the progressive increase in climate policy stringency and their omission would lead to an upward bias of the estimation. Because output and population are kept constant by including them as independent variables, this approach is tantamount to estimating the effect of CAPMF on emission intensities (per GDP unit and capita). In turn, this shuts down those explanatory channels of emissions, including the potential slowdown of economic activity due to climate policy.

Results suggest that implementing climate policies are effective in reducing emissions, as suggested by the negative and statistically significant coefficients on CAPMF (Table 3).

This effect is also substantial: a unit increase of the standardised CAPMF index is associated with a reduction of about 12% in both GHG emissions (column 1) and CO_2 emissions (column 2). The results are also robust to using CO_2 emissions intensity as the dependent variable (− 12%, Column 2 in Table 11) or GHG intensity (−14%).

Since the index is standardised, a unit increase is equal to one standard deviation. For comparison, this is approximately the average increase in the index over 5 years from 2015 to 2020. Since the index has increased by 2.3 points in the 2000–2021 period, this estimate implies that mitigation policies have contributed to an average reduction of about 28% in emissions in the period, compared to the absence of policies, while holding constant our set of control variables.[16] This estimate should be taken with care, as it is obtained by extrapolating reduced form average effects to the full sample but provides a rough estimate of the magnitude of effects. For example, it does not account for general equilibrium effects that occurred over the twenty-year period.

Next, we explore the relationship of emissions with the number of policies. Eskander and Fankhauser (2020) use the stock of mitigation policies as a proxy of policy stringency. When CO_2 emissions are regressed on the stock of policies computed from the CAPMF database, results are qualitatively and quantitatively similar to theirs (column 3). Adopting a new policy is associated with a decrease in CO_2 emissions by about 7%. This effect is not statistically significant anymore when the CAPMF index is used in conjunction with the number of policies (column 4). Given the CAPMF captures the stringency of climate policies it lends itself better for explaining the emission reductions associated with climate policies compared to the number of policies.

Columns 5 to 7 of Table 3 investigate the channels through which emissions have been reduced. First energy intensity (measured as total energy consumption over GDP) is introduced on the right-hand side (column 5), shutting down this channel for emission reduction. The coefficient on CAPMF reduces and is not statistically significant anymore, suggesting that most of the emission reduction attributable to mitigation policies is due to improvements in energy intensity. This hypothesis is tested by regressing energy intensity on the CAPMF (column 6), finding that a unit increase in the mitigation policy index is associated with a decrease in energy intensity of about 10%. In contrast, the effect of mitigation policies on the emission intensity of energy (CO_2 emissions over total energy consumption) is close to zero and not statistically significant, although the coefficient is negative (column 7). These results together suggest that mitigation policies have reduced emissions predominantly by reducing the energy intensity of the economy, rather than by reducing the emissions produced per unit of energy consumed.

Instead of assessing the effect across all types of policies and targets on emissions, regressions in Table 4 assess the effect at a more granular level (see the structure in Fig. 1). First, market-based, non market-based, and other policies (column 1) are included separately by creating sub-indices for these policy types and standardising them with a mean of zero and standard deviation of one.[17] The stringency of market-based and 'other' (i.e.

[16] Since all economies in the sample grew over this period, the effect reflects the decrease in emissions intensity due to climate policies.

[17] The CAPMF normalises each policy variable based on the in-sample distribution across all countries and years. For this reason, it cannot be used to compare the stringency score across policy groups (e.g. market-based policies are more stringent than non-market-based policies). It can however be used to compare the effects on emissions of a 'typical change' in stringency as observed in the past, i.e. one standard deviation change in the underlining index.

Table 4 The effects of different policy instruments on emissions

Dep. Var	(1) CO_2 All countries	(2) CO_2 Annex I	(3) CO_2 Non-Annex I	(4) CO_2 All countries	(5) CO_2 Annex I	(6) CO_2 Non-Annex I
L.Market-Based	−0.065***	−0.047***	−0.079*			
	(0.019)	(0.016)	(0.044)			
L.Non-Market-Based	−0.041	−0.055*	0.018			
	(0.030)	(0.031)	(0.045)			
L. Other	−0.046*	−0.036	0.032			
	(0.024)	(0.023)	(0.028)			
L.Cross-sectoral				−0.034**	−0.026*	−0.072
				(0.015)	(0.014)	(0.067)
L.Sectoral				−0.081**	−0.080***	−0.018
				(0.031)	(0.028)	(0.050)
L.International				−0.079**	−0.038	0.046
				(0.033)	(0.023)	(0.032)
GDP	−1.904**	−1.507**		−1.900**	−1.527**	
	(0.710)	(0.643)		(0.695)	(0.651)	
GDP squared	0.098***	0.080***		0.097***	0.080***	
	(0.025)	(0.024)		(0.025)	(0.024)	
HP Filter	−0.021**	−0.017**		−0.021**	−0.018**	
	(0.009)	(0.008)		(0.009)	(0.008)	
Population	0.302	0.111		0.217	0.109	
	(0.177)	(0.185)		(0.183)	(0.196)	
Service % of GDP	−0.002	−0.005		−0.002	−0.004	
	(0.004)	(0.003)		(0.004)	(0.003)	
Import % of GDP	0.010	0.014**		0.011	0.015**	
	(0.008)	(0.006)		(0.008)	(0.006)	
Rule of law	0.127*	0.104		0.111	0.099	
	(0.068)	(0.063)		(0.067)	(0.064)	
Observations	993	993		993	993	
Within Adj. R^2	0.59	0.64		0.60	0.64	
Year f.e	Yes	Yes		Yes	Yes	
Country f.e	Yes	Yes		Yes	Yes	

***Signify statistical significance of the coefficient at 1%, **, at 5%, and * at 10% significance level. All dependent variables, GDP and population are in logs. Standard errors clustered at the country and year level

targets, governance and climate data) policies is significantly negatively associated with emissions, while non market-based are negatively but not significantly associated with emissions. This could be explained by systematic differences across countries, including in their ability to enforce policies. A model is estimated allowing the coefficient to vary by Annex I countries (column 2) and non-Annex I (column 3), according to the UNFCCC definition. Annex I countries exhibit a larger effect for non market-based and other policies, but the effects are not statistically different from those for non-Annex I countries.

Second, differences between cross-sectoral, sectoral, and international policies are explored (column 4). A unit increase in the stringency has larger effects on emissions for sectoral and international policies (-8%) than for cross-sectoral policies (-3%). The effect sizes are larger for sectoral policies in Annex I countries while the opposite is true for cross-sectoral policies (column 5). However, the low precision in the estimates for non-Annex I countries (column 6) cautions against a definitive conclusion as the coefficients for Annex I and non-Annex I are not significantly different from one another.

5 Discussion

The CAPMF provides a wealth of structured and harmonised data. However, they come with some limitations. This section discusses three caveats to keep in mind for the interpretation of results from the CAPMF. These include:

- The CAPMF provides no information on implementation or enforcement
- The CAPMF does not reflect policy effectiveness
- The CAPMF may not accurately reflect countries' policy approaches because it does not cover all climate actions and policies and because country circumstances may differ.

First, the CAPMF measures climate actions and policies as they are in law, but it does not account for the *implementation or enforcement of climate policies*. While it is difficult to observe whether policies are enforced or not, future work could attempt to include variables that monitor policy enforcement. Note also that the preliminary evidence presented in Sect. 3 suggests that countries with a higher number of adopted policies and above-average policy stringency are associated with larger emissions reductions, suggesting that countries implemented and enforced their policies.

Second, the applications of the CAPMF should be interpreted in an informative not in a normative way. In particular, it is important to keep in mind that policy stringency and policy coverage do not per se reflect policy effectiveness, and stringency needs to be interpreted carefully for some policies. By no means, the CAPMF suggests that all countries should adopt all policies to the highest possible level. Instead, different policy mixes may be required to achieve countries' emission reduction targets and the goals of the Paris Agreement more generally, depending on national circumstances. For example, a country with only a few adopted policies may be highly effective in terms of reducing GHG emissions if it has the right policy mix in place. Conversely, a country with many policies in place might not be able to reduce GHG emissions if its policy mix is not well-tailored to its circumstances.

Countries have different starting positions and very specific circumstances regarding their abatement potential. For example, even a relatively moderate carbon price could trigger large amounts of GHG emission reductions in a country with vast low-cost abatement potential. Conversely, a high carbon price may hardly trigger any emissions reductions if applied to sectors that lack commercially viable zero-carbon alternatives.

Third, countries have different policy approaches which need to be taken into account in the interpretation of the results from the CAPMF. Policy approaches are defined as policies that are generally accepted and considered legitimate in a specific country at a specific point in time (Cerna 2013). Countries' policy approaches to climate mitigation are the result of a complex interaction of multiple factors, including the resource base (e.g. Nordic countries may not have subsidies for solar PV for good reasons), legal traditions (e.g. carbon taxes in the European Union are levied nationally and require unanimity, which is why the EU chose to adopt an ETS), and path dependence (e.g. countries opting for ETS, but not carbon tax). Consequently, some policies included in the CAPMF may not be part of some countries' policy approaches. For example, certain policies included in the CAPMF may not be relevant in some countries because of a lack of relevant resources (e.g. subsidies for solar PV in countries with low insolation) or lack of relevance (e.g. subsidies for renewable electricity in countries with already decarbonised electricity systems).

Another reason why countries' policy approaches may not be fully reflected in the CAPMF are *data availability* constraints. In fact, the CAPMF does not cover all climate actions and policies. Strictly speaking, any conclusion or interpretation from the CAPMF is only valid for the *measured* climate actions and policies. Not accounting for the unmeasured climate actions can lead to misleading interpretation, notably in cross-country comparison. However, the relevance of this problem will decrease as new policies and actions are integrated into the CAPMF. The accompanying working paper presents a list of the most relevant policies currently not included (Nachtigall et al. 2022).

6 Conclusion

This paper presents the CAPMF, the most extensive, structured, and internationally harmonised climate mitigation panel data set to date. The CAPMF covers 130 policy variables that are grouped into 56 policies for 50 countries and the EU-27 from 1990 to 2022. The CAPMF database is *publicly available* on the OECD data explorer https://oe.cd/dx/5if. Selected indicators are also publicly available on the IPAC Climate Action Dashboard and on a dedicated data visualisation platform https://oecd-main.shinyapps.io/climate-actions-and-policies/. Using this granular data, the CAPMF allows for a stocktaking of countries' climate policies. Insights from this stocktaking include:

- Countries expanded their climate action between 2010 and 2022, increasing both the number of adopted policies covered by the CAPMF and their policy stringency. Most, but not all countries adopted new policies between 2015 and 2022.
- Policy adoption and policy stringency varies considerably across countries, country groups and instruments. In 2022, the number of adopted policies varied between 13 and 47. In 2022, policy adoption also varies across policies, ranging from 0 (e.g. phase outs of cars with internal combustion engines) to 51 (ratification of at least one of the major international climate agreements).
- Countries' policy mixes changed over time and differ substantially across countries and country groups.
- Countries with relatively larger policy adoption or larger average policy stringency are associated with deeper GHG emissions reductions between 2015 and 2019.

The paper also provides an empirical application of the CAPMF by investigating the relationship between climate policies and emissions. Emissions (GHG and CO_2) are related in a panel regression to a composite index constructed by averaging policy stringency at the country-year level. A unit change in the standardised index (about the average change that occurred in the last five years) is associated with a reduction in emissions by 13%. Reduction in energy intensity of the economy is a key determinant of emission abatement, accounting for about half of the policy-induced reduction. These results are robust to different specifications as well as different ways of averaging the data. While the effects should not be interpreted causally, the econometric analysis establishes the relevance of the CAPMF data for tracking the relationship between climate policies and climate-related outcomes. It showcases how the CAPMF can be used in future empirical analyses to estimate effects of climate policies across countries and sectors. Using micro-data, future work may be able to identify potentially causal effects of environmental policies on firm outcomes across sectors and countries.

Future work can be divided into two work streams: First, the continuation and expansion of policy stocktaking and data collection. The CAPMF could be extended towards sectors and modules currently not included (i.e. agriculture, LULUCF, waste, and climate finance) as well as other policy variables in already existing modules when data become available or is collected through questionnaires (e.g. policies to promote sustainable transport modes, climate governance).

Second and more importantly, the policy data of the CAPMF could be used to carry out a number of *qualitative and quantitative analyses*. While Sect. 4 offered preliminary empirical evidence on the relationship between an aggregated CAPMF index and emissions, the novel data opens up several possibilities for further empirical research. Some questions that can be addressed with this new data include, but are not limited to:

- Investigating the environmental effectiveness of climate policy instruments and different policy mixes. This analysis would shed light on the relative importance of different types of policies or instruments and could carve out the effectiveness under different country contexts.
- Assessing the socio-economic effects (e.g. employment, investment, productivity, income distribution) of climate policies. This research agenda would contribute to the analysis of the effects of environmental policies on economic and environmental outcomes.
- Investigate the effect of mitigation policies on industries, firms, and households. Country-level variation in mitigation policy stringency can be interacted with an industry-, firm- or household-level exposure to study more micro effects of mitigation policies and reinforce the identification of their causal effects.

Appendix A

See Tables 5, 6 and 7.

Table 5 Conceptual framework of the CAPMF by policy type

	Market-based instruments	Non market-based instruments	Targets, governance, climate data
Components	Carbon pricing (ETS, carbon tax, fuel excise taxes, FFS), congestion charges, Renewable electricity support (auctions, RPS, FiT), Financing mechanisms of energy efficiency, public RD&D expenditure, pricing of emissions from international aviation and maritime transport	Minimum energy performance standards, air pollution standards, fuel economy standards, building energy codes, bans and phase out of fossil fuel extraction, new coal power plants, and fossil fuel using equipment (e.g. heating, passenger cars with ICE), emission limit values, labels, planning for renewables expansion, motorway speed limits, share of rail on total surface transport public expenditure, ending export credits and public financing of fossil fuels abroad	Net-zero targets, NDCs, independent climate advisory bodies, climate education, ratification of key international climate treaties, participation in international climate initiatives, evaluation of biennial (update) reports, Submission of key documents, GHG emissions reporting and accounting

Only components of the 2022 edition of the CAPMF are considered

Table 6 Correlation across policy types

	Market-based instruments	Non-market-based instruments	Targets, governance and climate data
Market-based instruments	1		
Non-market-based instruments	0.8682***	1	
Targets, governance, and climate data	0.7344***	0.8153***	1

The table shows the pairwise correlations between the policy types

***Signify statistical significance of the coefficient at 1%

Table 7 Correlation across sectors and policy areas

	Electricity	Industry	Transport	Buildings	Cross-sectoral	International
Electricity	1					
Industry	0.8952***	1				
Transport	0.8430***	0.7752***	1			
Buildings	0.8808***	0.9030***	0.8512***	1		
Cross-sectoral	0.7503***	0.6617***	0.7513***	0.7306***	1	
International	0.8056***	0.8229***	0.7299***	0.8065***	0.6596***	1

The table shows the pairwise correlations between the policy priority areas of the CAPMF

***Signify statistical significance of the coefficient at 1%

Appendix B: Additional results and robustness checks

See Tables 8, 9, 10 and 11.

Table 8 Descriptive statistics

	Unit	N	mean	SD	min	max
GHG (excluding LUCF)	Giga grams CO_2e	993	567 898	1,609,064	1800	14,200,000
CO2 (excluding LUCF)	Giga grams CO_2	993	444 503	1,304,508	1250	11,800,000
(log) GHG (excluding LUCF)	Giga grams CO_2e	993	11.9	1.7	7.5	16.5
(log) CO2 (excluding LUCF)	Giga grams CO_2	993	11.6	1.7	7.1	16.3
(log) Energy/GDP	Mtoe/M USD	953	− 9.6	0.35	− 10.7	− 8.58
(log) GHG/Energy	$GgCO_2e$/Mtoe	953	8.08	0.36	7.01	9.19
CAPMF (standardized)		993	0.42	0.93	− 1.04	3.07
Number of policies		993	21.52	11.37	3	46
(log) GDP	M USD	993	13.1	1.55	9.27	17.0
(log) GDP squared	M USD	993	174.1	40.1	85.9	290.0
HP Filter		993	− 0.037	1.42	− 12.7	14.2
(log) Population		993	16.6	1.80	12.6	21.1
Service % of GDP	pp	993	60.5	7.86	31.1	80.1
Import % of GDP	pp	993	0.78	3.14	0.042	28.4
Rule of law		993	0.89	0.83	− 1.01	2.12

Descriptive statistics for the observations employed in the baseline specifications

Table 9 Correlation table

		(1) GHG	(2) CO2	(3) CAPMF	(4) GDP	(5) GDP^2	(6) HP-filter	(7) Population	(8) Services share	(9) Import share	(10) Rule of law	(11) Energy/GDP
(1)	GHG	1										
(2)	CO2	0.995	1									
(3)	CAPMF	0.0663	0.0861	1								
(4)	GDP	0.964	0.962	0.214	1							
(5)	GDP squared	0.965	0.963	0.204	0.997	1						
(6)	HP-filter	− 0.0833	− 0.0775	0.134	− 0.0357	− 0.0346	1					
(7)	Population	0.955	0.939	0.0322	0.943	0.946	− 0.122	1				
(8)	Services share	− 0.334	− 0.313	0.376	− 0.220	− 0.221	0.188	− 0.395	1			
(9)	Import share	0.315	0.319	− 0.0238	0.252	0.283	− 0.425	0.306	− 0.232	1		
(10)	Rule of law	− 0.390	− 0.356	0.432	− 0.287	− 0.296	0.108	− 0.513	0.567	− 0.189	1	
(11)	Energy/GDP	0.237	0.247	− 0.309	0.0630	0.0745	− 0.176	0.129	− 0.404	0.264	− 0.134	1

The table shows the correlations between the dependent variables (GHG, CO_2), the main policy variable (CAPMF) and the control variables. All dependent variables, GDP and population are in logs

Table 10 The effect of individual controls on the baseline estimate

	(1) CO_2	(2) CO_2	(3) CO_2	(4) CO_2	(5) CO_2	(6) CO_2	(7) CO_2	(8) CO_2
L.CAPMF	− 0.176**	− 0.073	− 0.131***	− 0.128***	− 0.121***	− 0.123***	− 0.122***	− 0.123***
	(0.063)	(0.051)	(0.042)	(0.041)	(0.039)	(0.039)	(0.039)	(0.039)
GDP		0.849***	− 1.354*	− 2.011**	− 1.964**	− 1.941**	− 1.936**	− 1.971***
		(0.110)	(0.770)	(0.760)	(0.804)	(0.769)	(0.773)	(0.697)
GDP squared			0.076***	0.107***	0.104***	0.103***	0.102***	0.102***
			(0.026)	(0.027)	(0.029)	(0.027)	(0.028)	(0.024)
HP Filter				− 0.032***	− 0.029***	− 0.028***	− 0.026**	− 0.025**
				(0.009)	(0.010)	(0.009)	(0.010)	(0.010)
Population					0.210	0.225	0.224	0.328*
					(0.222)	(0.212)	(0.213)	(0.175)
Service % of GDP						− 0.002	− 0.001	− 0.002
						(0.004)	(0.004)	(0.004)
Import % of GDP							0.007	0.009
							(0.007)	(0.008)
Rule of law								0.130*
								(0.072)
Observations	993	993	993	993	993	993	993	993
Year f.e	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country f.e	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Within R2	0.08	0.43	0.54	0.57	0.57	0.57	0.57	0.58

***signify statistical significance of the coefficient at 1%, **, at 5%, and * at 10% significance level. All dependent variables, GDP and population are in logs. Standard errors clustered at the country and year level. The table shows the effect of the CAPMF on $_{CO2}$ emissions. Control variables are gradually added from columns 1 to 8. Column 8 is identical as column 2 of Table 2

Table 11 Robustness checks

Description	Baseline					
	(1)	(2)	(3)	(4)	(5)	(6)
	Emissions data from CAIT (WRI)	Emission intensity	CAPMF index aggregated by averaging across modules			Pre-COVID years
L.CAPMF	− 0.090**	− 0.123***	− 0.172***			− 0.109***
	(0.038)	(0.040)	(0.040)			(0.037)
L. Market based				− 0.051**		
				(0.024)		
L. Non-market based				− 0.040		
				(0.036)		
L. Other				− 0.062**		
				(0.025)		
L. Cross sectoral					− 0.029	
					(0.020)	
L. Sectoral					− 0.105***	
					(0.037)	
L. International					− 0.076**	
					(0.034)	
GDP	− 2.038***	− 2.971***	− 1.682**	− 1.648**	− 1.634**	− 1.742**
	(0.647)	(0.713)	(0.653)	(0.705)	(0.649)	(0.738)
GDP squared	0.107***	0.102***	0.091***	0.091***	0.089***	0.095***
	(0.023)	(0.025)	(0.023)	(0.025)	(0.023)	(0.026)
HP Filter	− 0.029***	− 0.025***	− 0.021**	− 0.020**	− 0.018**	− 0.023**
	(0.008)	(0.009)	(0.008)	(0.009)	(0.008)	(0.010)
Population	0.412*	0.328*	0.228	0.295	0.163	0.339*
	(0.198)	(0.172)	(0.172)	(0.175)	(0.175)	(0.172)
Service % of GDP	0.001	− 0.002	− 0.002	− 0.000	− 0.001	− 0.001
	(0.003)	(0.004)	(0.003)	(0.004)	(0.004)	(0.004)
Import % of GDP	0.010	0.009	0.008	0.011	0.010	0.010
	(0.009)	(0.008)	(0.007)	(0.008)	(0.008)	(0.008)
Rule of law	0.128**	0.130*	0.118*	0.119*	0.109*	0.116
	(0.060)	(0.069)	(0.064)	(0.067)	(0.063)	(0.069)
Observations	908	993	993	993	993	908
Year f.e	Yes	Yes	Yes	Yes	Yes	Yes
Country f.e	Yes	Yes	Yes	Yes	Yes	Yes
Within R2	0.67	0.29	0.6	0.58	0.6	0.59

Column 1 estimates the baseline regression on log(CO_2) emissions data from Climate Watch (2022[21]). Column 2 estimates the baseline regression with emissions intensity (CO_2/GDP) as the dependent variable. Column 3 to 5 estimates the baseline regressions with the policy index obtained by averaging the policy-level values at the module level first and then averaging that. Column 6 estimates the baseline regression for the pre-Covid years before 2020

Acknowledgements This paper builds on contributions to data collection by Guendalina Bettinelli, Jonah Harris, Natália Palšová, Léo Robert and Rudy Saffar. The authors would like to thank Nathalie Girouard for strategic guidance as well as Enrico Botta, Diane Cameron, Jane Ellis, Justine Garrett, Guillaume Gruère, Ben Henderson, Tom Howes, Nick Johnstone, Britta Labuhn, Roger Martini, Yannick Monschauer, Jerome Mounsey, Mauro Migotto, Jolien Noels, Mauro Pisu, Dirk Röttgers, Jonas Teusch, Kurt van Dender, Antonio Vaya Soler, Fabian Voswinkel, and two anonymous reviewers for their helpful comments on previous versions of the paper. The authors also thank workshop participants for comments provided at the 8th International Symposium on Environment and Energy Finance Issues (ISEFI) in May 2022 in Paris, France, the 9th Atlantic Workshop on Energy and Environmental Economics (AWEEE) in June 2022 in Toxa, Spain, and the UNECE Expert Forum for Producers and Users of Climate Change-related Statistics in September 2022 in Geneva, Switzerland.

Declarations

Conflict of interest No funds, grants, or other support was received. The authors have no relevant financial or non-financial interests to disclose.

References

Best R, Burke P, Jotzo F (2020) Carbon pricing efficacy: cross-country evidence. Environ Resour Econ 77(1):69–94. https://doi.org/10.1007/s10640-020-00436-x

Botta E, Koźluk T (2014) Measuring environmental policy stringency in OECD countries: a composite index approach. OECD Economics Department Working Papers, No. 1177. OECD Publishing, Paris. https://doi.org/10.1787/5jxrjnc45gvg-en

Cerna L (2013) The nature of policy change and implementation: a review of different theoretical approaches. https://www.oecd.org/education/ceri/The%20Nature%20of%20Policy%20Change%20and%20Implementation.pdf. Accessed 22 July 2022

Climate Watch (2022) Climate watch (CAIT)— country greenhouse gas emissions data. https://www.climatewatchdata.org

D'Arcangelo F et al (2022) Estimating the CO_2 emission and revenue effects of carbon pricing: new evidence from a large cross-country dataset. OECD Economics Department Working Paper, vol. 1732. https://doi.org/10.1787/39aa16d4-en

Dechezleprêtre A, Kruse T (2022) The effect of climate policy on innovation and economic performance along the supply chain: a firm- and sector level analysis. OECD Environment Working Paper, vol 189. https://doi.org/10.1787/3569283a-en

Dechezleprêtre A, Nachtigall D, Stadler B (2020) The effect of energy prices and environmental policy stringency on manufacturing employment in OECD countries: sector- and firm-level evidence. OECD Economics Department Working Papers, vol 1625. https://doi.org/10.1787/899eb13f-en

EPA (2022) Global greenhouse gas emissions data

Eskander S, Fankhauser S (2020) Reduction in greenhouse gas emissions from national climate legislation. Nat Clim Change 10(8):750–756. 10.1038/s41558-020-0831-z

European Environment Agency (2023) EEA database on integrated national climate and energy policies and measures in Europe, URL: https://pam.apps.eea.europa.eu. Accessed 21 Sept 2023

Finnish Government (2019) Inclusive and competent Finland—a socially, economically and ecologically sustainable society. https://julkaisut.valtioneuvosto.fi/bitstream/handle/10024/161935/VN_2019_33.pdf?sequence=1%26isAllowed=y

Frohm E et al. (2023) Environmental policy stringency and CO2 emissions: Evidence from cross-country sector-level data, OECD Economics Department Working Papers, No. 1773, OECD Publishing, Paris. doi: 10.1787/53ddcef7-en.

Gachau S et al (2021) Handling missing data in a composite outcome with partially observed components: simulation study based on clustered paediatric routine data. J Appl Stat. 10.1080/02664763.2021.1895087

Gütschow J et al (2016) The PRIMAP-hist national historical emissions time series. Earth Syst Sci Data 8:571–660. https://doi.org/10.5194/essd-8-571-2016

Grantham Research Institute (2023) Climate laws of the world, URL: https://climate-laws.org/. Accessed 21 Sept 2023

IEA (2021) Policies and measures database. https://www.iea.org/policies

International Energy Agency (2023) Policies database, URL: https://www.iea.org/policies. Accessed 21 Sept 2023

IPAC (2022) International programme for action on climate—dashboard. https://www.oecd.org/climate-action/ipac/dashboard

IPCC (2022) Mitigation of climate change climate change 2022 Working Group III contribution to the sixth assessment report of the intergovernmental panel on climate change. https://www.ipcc.ch/site/assets/uploads/2018/05/uncertainty-guidance-note.pdf

ITF (2021) Transport climate action directory. https://www.itf-oecd.org/tcad

Kruse T et al (2022) Measuring environmental policy stringency in OECD countries: An update of the OECD composite EPS indicator. OECD Economics Department Working Papers, No. 1703, OECD Publishing, Paris. https://doi.org/10.1787/90ab82e8-en

Nachtigall D et al (2022) The climate actions and policies measurement framework: a structured and harmonised climate policy database to monitor countries' mitigation action. OECD Environment Working Papers, No. 203, OECD Publishing, Paris. https://doi.org/10.1787/2caa60ce-en

Nascimento et al (2021) Twenty years of climate policy: G20 coverage and gaps. Climate Policy 22(2):158–174. https://doi.org/10.1080/14693062.2021.1993776

OECD (2021) Database on policy instruments for the environment. https://pinedatabase.oecd.org

Talukder B, Hipel K, van Loon G (2017) Developing composite indicators for agricultural sustainability assessment: effect of normalization and aggregation techniques. Resources. https://doi.org/10.3390/resources6040066

UNFCCC (2022) Synthesis report for the technical assessment component of the first global stocktake