



Is the New Collective Quantitative Goal for Climate Finance a Good Deal For Developed Countries?

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Is the New Collective Quantitative Goal for climate finance a good deal for developed countries?

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Abstract

A New Collective Quantitative Goal for climate finance has been agreed, with a minimum of 300 billion USD to be provided for climate action in developing countries by 2035. A further goal was agreed to increase this value to 1.3 trillion USD. Many developing countries have emissions reductions targets that are conditional on receiving sufficient finance for those targets to be achieved. This paper considers the trade-off of an extra trillion dollars in investment for the additional emissions reductions that will be achieved as a result. It considers whether those same emissions reductions could be achieved with lower impact on the income of the source regions for the investment and finds that it cannot. Should Annex I regions attempt to achieve equivalent emissions reductions themselves, the result is that incomes are lower in almost all regions and by up to 2.7% in 2030, with even some notable free riders being worse off. Output is lower in most regions and investment is also lower in most of the Annex I regions that shoulder the additional emissions mitigation burden. Globally the impacts are similarly negative, with global investment 3.5% lower in 2030. Conversely, in the case where developing countries re-

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ceive the additional finance, impacts are significantly positive, with incomes up to 1% higher in 2030. However, even when the conditional emissions reductions are undertaken, they are insufficient to stop global emissions from continuing to rise until the end of the decade. More ambition is necessary.

Keywords: Nationally Determined Contributions, climate policy, Computable General Equilibrium, greenhouse gas emissions, climate change, climate finance

JEL: Q54, C68, O44, P18

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1. Introduction

At the 29th Conference of the Parties (COP29) to the United Nations Framework Convention on Climate Change (UNFCCC, 2024a), it was agreed that developed countries would provide “at least USD 300 billion per year by 2035 for developing country Parties for climate action”, with a goal of “scaling up of financing to developing country Parties for climate action from all public and private sources to at least USD 1.3 trillion per year by 2035”. This is referred to as the “New Collective Quantified Goal” (NCQG) on climate finance. Although this finance is for a range of activities, a significant portion will be used to enable developing countries to implement their Nationally Determined Contributions (NDCs) for emissions reduction.

Bhattacharya et al. (2024) state that the only way to meet the temperature goals of the Paris Agreement is by increasing investments in emerging markets and developing countries. Stechemesser et al. (2024) found that financing mechanisms were the most frequently used policy instruments associated with large emission reductions in two of the four categories of emission sources that they studied. NDCs are either classed as conditional or unconditional and the UNFCCC (2024b) note that conditional NDCs are mainly conditional on finance and most of the finance requirements discussed in NDCs are for mitigation (Isah et al., 2025). Conditional NDCs are more ambitious in terms of emissions reductions than unconditional NDCs.

The editors of Nature (2024) suggest that climate financing should be seen as an investment with a return. That return is the avoided damages from cli-

mate change. However, as the source of emissions does not affect the climate outcomes, a relevant research question is, are the additional emissions reductions committed to in conditional NDCs, relative to unconditional NDCs, most cheaply achieved by the provision of climate finance to developing countries, or can they be achieved more cheaply by developed countries? The question is reasonable, as to date developed countries have failed to provide the finance that developing country NDCs are conditional on (Chowdhury and Jomo, 2022). Pauw (2025) notes the importance of research contributions to improving climate finance outcomes. This article should improve those outcomes by highlighting the efficiency, or otherwise, of emissions reductions facilitated by climate finance.

The credibility of some existing climate financing mechanisms needs to be enhanced (Bolton et al., 2023) and it is reasonable to suggest that developed countries might prefer to finance additional emissions reductions efforts domestically when faced with a lack of certainty regarding the outcome of the provision of climate finance. This is especially the case when subsidising substitutes for products from emissions-intensive industries is more politically feasible than taxing those industries (van der Ploeg, 2025).

Kerr and Hu (2025) highlighted issues with existing climate finance schemes that need to be overcome, which lead to a “mismatch of mitigation opportunities and capital flows”. An assessment of where emissions reductions may most cheaply be achieved would highlight such a mismatch.

Antimiani et al. (2017) demonstrated the capabilities of Computable General Equilibrium (CGE) models when it comes to assessing the benefits of climate financing. Their focus was the Green Climate Fund. A similar approach could be used to assess the impacts of the NCQG on climate finance.

Garaffa et al. (2022) proposed a method for disaggregating climate finance from other investment in the Global Trade Analysis Project (GTAP) database. They proposed the use of CGE modelling to investigate the impacts of emissions reduction pathways on investment, though the modified database and models they discussed are not publicly available. As the TEA model they proposed to use is based on the EPPA model (Chen et al., 2022), which has a time step of five years, it would not be appropriate to use it to answer the research question posed here, as the relevant time scale is short.

Norman-López et al. (2023) also tackled the problem of disaggregating investment by sector to more accurately assess the economic impacts of climate policies, using the JRC-GEM-E3 model. That model is not publicly available and no evidence could be found that it has been used to assess the impacts of the NCQG on climate finance being discussed here.

The Network for Greening the Financial System (NGFS, 2024) made a number of recommendations about climate finance for COP29, but their subsequent publication (NGFS, 2025) did not comment on the NCQG on climate finance. The models used do appear to have the ability to assess the economic impacts of the NCQG on climate finance, but the focus of the institution is

on financial risk and the models are not publicly available.

It has been found that the receipt of climate financing does have a small effect on how ambitious emissions reduction commitments are in developing countries (Rashid et al., 2023). However, that assessment focussed on the response of countries to the receipt of finance, rather than what happens if the emissions reductions and finance commitments are made as a deal. Explicitly making emissions reductions more ambitious, as is the case when moving from unconditional to conditional NDCs, also avoids the problem of “finance blending”, a problem associated with climate financing being used to purchase emissions offsets with no corresponding increase in ambition by either party (Strand, 2023). Importantly in democratic countries, investments that result in lower emissions also last beyond the term of the current government, as opposed to emissions reduction commitments that can be easily changed by the subsequent government (Fuest and Meier, 2023).

Hatton et al. (2025) estimated how the minimum amount of climate financing agreed to in the NCQG (300 billion USD) might be distributed based on financing needs outlined in recipient countries’ NDCs. They also assessed how responsibility for contributions might be best allocated based on historical emissions and the ability of potential financiers to provide funds. They did not assess the goal of providing an additional trillion dollars nor link that to conditional emissions reductions included in developing countries’ NDCs.

Bolton and Kleinnijenhuis (2024) conclude that there is an economic case

for developed countries to provide climate finance. What has not been made clear is whether the providers of that finance can make the emissions reductions received in exchange for the finance more cheaply themselves.

Although the OECD/UNDP (2025) do not make specific reference to the NCQG, they do highlight the economic benefits of climate finance and discuss ways to ensure it is sufficient to meet the temperature goals of the Paris Agreement. They use the ENV-Linkages CGE model to do so.

Marginson (2024) undertook an assessment of the economic impacts of the 100 billion USD of climate finance committed to in climate agreements prior to COP29. To the best of my knowledge, an assessment has not been undertaken of whether the mitigation achieved by the finance presents good value for money. The analysis undertaken here fills that gap by building on the work of Marginson (2024), first by calculating unconditional and conditional emissions pathways, then estimating the difference between regional incomes in two cases:

1. When developed countries provide, by 2035 and in addition to the 300 billion USD agreed to as a minimum, 1 trillion dollars to developing countries, who then follow conditional pathways instead of unconditional ones; and,
2. When developed countries do not provide that additional trillion dollars to developing countries. Instead, developed countries collectively further reduce their own emissions by the difference between the conditional and unconditional commitments made by developing countries.

The remainder of the paper is structured as follows. Section 2 discusses the construction of the emissions pathways used in this modelling. Section 3 contains details of the modelling, including how the historical period is represented and the various policy cases. Results are presented in Section 4 and conclusions are outlined in Section 5.

2. Emissions

The creation of scenarios with unconditional and conditional emissions pathways requires the estimation of emissions in both of those scenarios in 2030, as that is the year that most emissions mitigation commitments had been made for at the time this work was undertaken. It also requires estimation of emissions over the historical period. The UNFCCC (2024b) have undertaken an assessment of unconditional and conditional emissions reduction commitments in NDCs, but do not provide the data for each country, which is necessary to assess economic impacts at a country or regional scale. Such data is provided by Fenhann (2024). For CGE modelling, it is required that we also know emissions at the start of simulations, which, if we are to use the economic database constructed by GTAP (Aguiar et al., 2023), is 2017. Another important year is 2019, the year before the NDCs come into effect. Finally we want data for the most recent year with data for all countries. For this the best data is the database compiled by the Crippa et al. (2024), which has emissions until 2023. However, there are some discrepancies between the estimates of Crippa et al. (2024) and the data submitted by parties to the UNFCCC. In China's Fourth National Communication on Climate Change (The People's Republic of China, 2024), they reported emissions of approx-

imately 12.8 Gigatonnes of carbon dioxide equivalent ($\text{GtCO}_2\text{-e}$), excluding emissions from Land Use, Land Use Change and Forestry (LULUCF). Crippa et al. (2024) estimate China's emissions excluding those from LULUCF (exc. LULUCF) in that year to be $13.4\text{GtCO}_2\text{-e}$, approximately 7% higher. This is an unacceptable discrepancy for the world's largest emitter. Similarly, the United States of America (USA) reported $6.56\text{GtCO}_2\text{-e}$ of emissions exc. LULUCF in 2017 (EPA, 2023), but Crippa et al. (2024) estimate their emissions exc. LULUCF to have been $6.15\text{GtCO}_2\text{-e}$ - a 6% discrepancy. Given these discrepancies for the two largest emitters, let's consider the most appropriate use of the data produced by Crippa et al. (2024) to be as a source of relative changes over time. An alternative source of data is the World Resources Institute (2025). However, their data is similarly problematic, with their estimate of China's emissions exc. LULUCF in 2017 being $11.9\text{GtCO}_2\text{-e}$, 7% too low. They do provide estimates of emissions including emissions from LULUCF (inc. LULUCF), which are useful as many countries submit emissions mitigation commitments that include emissions from LULUCF, but, again, let's consider the most appropriate use of their data to be as a source of relative changes over time.

In summary, we need to estimate emissions in key historical years (2017, 2019 and 2023), as well as emissions in 2030 for both unconditional and conditional NDCs. First, let us define the set of countries that we need to estimate emissions for. As we are using data from Fenhann (2024), let's refer to the set of countries included in that data as R_{UN} . This is the set of countries that we need to estimate emissions for. As the economic model we will

use does not represent LULUCF emissions, emissions exc. LULUCF need to be estimated for all countries. For countries that have submitted NDCs with mitigation targets for emissions inc. LULUCF, we also need to estimate emissions inc. LULUCF.

2.1. Emissions in 2017

Fenhann (2024) includes emissions data for some regions for 2017. In some cases it was necessary to augment the data provided by Fenhann (2024) with additional data from party-authored reports provided to the UNFCCC. Data for 2017 for the countries listed below was obtained directly from such reports.

- Democratic Republic of Congo - Ministère de l'Environnement et Développement Durable (2023)
- Gabon - Republic Gabonaise Conseil National Climat (2024)
- Mali - Republic du Mali (2023)
- Mexico - Gobierno de México. Secretaría de Medio Ambiente y Recursos Naturales (2022)
- Australia - Department of Climate Change, Energy, the Environment and Water (2024)
- China - The People's Republic of China (2024)
- India - MoEFCC (2024)
- Japan - Greenhouse Gas Inventory Office of Japan and Ministry of the Environment, Japan (2024)

- Micronesia - The Federated States of Micronesia (2023)
- South Korea - The Government of the Republic of Korea (2023)
- The European Union (EU) - European Environment Agency (2024)
- Andorra - Govern d'Andorra (2023)
- Monaco - Direction de l'Environnement (2023)
- Russia - Russian Federation (2023)
- Serbia - Republic of Serbia (2024)
- Türkiye - Türkiye (2023)

Let us refer to the set of countries with data from United Nations (UN) sources for 2017, that is, the union of the list of countries above with the set of countries that Fenhann (2024) provides data for, as R_{UN}^{2017} . Let us refer to the subset of R_{UN}^{2017} that have data on emissions exc. LULUCF in 2017 as $R_{UN}^{2017exc}$.

2.1.1. Countries with UN data before and after 2017, but not for 2017

Some countries have data for emissions exc. LULUCF from UN sources in years before and after 2017, but not for 2017 itself. Let's refer to this set as $R_{UN}^{BA2017exc}$. For countries in $R_{UN}^{BA2017exc}$, let's estimate emissions exc. LULUCF in 2017 as a linear interpolation of emissions exc. LULUCF in the years before and after 2017. That is, $\forall r \in R_{UN}^{BA2017exc}$:

$$M_r^{2017exc} = M_r^{B2017exc} + (2017 - Y_r^{B2017exc}) \frac{M_r^{A2017exc} - M_r^{B2017exc}}{Y_r^{A2017exc} - Y_r^{B2017exc}}, \quad (1)$$

where, for country r :

- $M_r^{2017exc}$ are emissions exc. LULUCF in 2017;
- $M_r^{B2017exc}$ are emissions exc. LULUCF in the most recent year with data before 2017;
- $Y_r^{B2017exc}$ is the most recent year with data for emissions exc. LULUCF before 2017;
- $M_r^{A2017exc}$ are emissions exc. LULUCF in the next year with data after 2017; and,
- $Y_r^{A2017exc}$ is the next year with data for emissions exc. LULUCF after 2017.

Now we need to calculate emissions exc. LULUCF in 2017 for regions that do not have any data for emissions exc. LULUCF from UN sources in or after 2017. For countries that have data from UN sources in or after 2017 for emissions inc. LULUCF but not for emissions exc. LULUCF, we can simply subtract LULUCF emissions from emissions inc. LULUCF to estimate emissions exc. LULUCF. However, as we do not know emissions exc. LULUCF, we cannot estimate LULUCF emissions after 2017, so we need to make an assumption about what is happening to LULUCF emissions in these countries. Firstly, we need to estimate LULUCF emissions in countries where historical emissions and targets are not reported exc. LULUCF. Let's do so by subtracting emissions exc. LULUCF from emissions inc. LULUCF in the most recent year that has data for both, for each country. Then let's make the following assumptions:

1. If LULUCF emissions are negative, they remain constant.

2. If LULUCF emissions are positive, they grow proportionally to emissions inc. LULUCF.

Let's refer to the set of countries with data on emissions exc. LULUCF prior to 2017 but only data from the UN for emissions inc. LULUCF after 2017 as $R_{UN}^{A2017incLU-}$ if their emissions from LULUCF are negative in the most recent year with data from the UN. $\forall r \in R_{UN}^{A2017incLU-}$:

$$M_r^{2017exc} = M_r^{B2017inc} - M_r^{LU} + (2017 - Y_r^{B2017inc}) \frac{M_r^{A2017inc} - M_r^{B2017inc}}{Y_r^{A2017inc} - Y_r^{B2017inc}}, \quad (2)$$

where, for country r :

- $M_r^{2017exc}$ are emissions exc. LULUCF in 2017;
- $M_r^{B2017inc}$ are emissions inc. LULUCF in the most recent year with data before 2017;
- M_r^{LU} are emissions from LULUCF;
- $Y^{B2017inc}$ is the most recent year with data for emissions inc. LULUCF before 2017;
- $M_r^{A2017inc}$ are emissions inc. LULUCF in the next year with data after 2017; and,
- $Y^{A2017inc}$ is the next year with data for emissions inc. LULUCF after 2017.

Let's refer to countries with data from the UN on emissions exc. LULUCF prior to 2017 but only data from the UN for emissions inc. LULUCF after

2017 as $R_{UN}^{A2017incLU+}$ if their emissions from LULUCF are zero or positive in the most recent year with data from the UN. For these countries, let's scale up emissions exc. LULUCF prior to 2017 by the same ratio that emissions inc. LULUCF grew by. That is, $\forall r \in R_{UN}^{A2017incLU+}$:

$$M_r^{2017exc} = M_r^{B2017exc} \left(M_r^{B2017inc} + (2017 - Y_r^{B2017inc}) \frac{M_r^{A2017inc} - M_r^{B2017inc}}{Y_r^{A2017inc} - Y_r^{B2017inc}} \right) \times \frac{1}{M_r^{B2017inc}}, \quad (3)$$

where, for country r :

- $M_r^{2017exc}$ are emissions exc. LULUCF in 2017;
- $M_r^{B2017exc}$ are emissions exc. LULUCF in the most recent year with data before 2017;
- $M_r^{B2017inc}$ are emissions inc. LULUCF in the most recent year with data before 2017;
- $Y_r^{B2017inc}$ is the most recent year with data for emissions inc. LULUCF before 2017;
- $M_r^{A2017inc}$ are emissions inc. LULUCF in the next year with data after 2017; and,
- $Y_r^{A2017inc}$ is the next year with data for emissions inc. LULUCF after 2017.

2.1.2. Countries with UN data before 2017, but not after 2017

Let's define the set of countries that have data for emissions exc. LULUCF from UN sources for a year before 2017, but not after, as $R_{UN}^{B2017exc}$. For countries in $R_{UN}^{B2017exc}$ that are also covered by the EDGAR dataset (Crippa et al., 2024), let's use relative changes in emissions from the EDGAR dataset to calculate emissions exc. LULUCF. Firstly, let's define the set of countries in the EDGAR dataset as R_{ED} . Now the set of countries that we can use this method for, which we will denote $R_{UNED}^{B2017exc}$, is defined as the intersection of $R_{UN}^{B2017exc}$ and R_{ED} . That is, $R_{UNED}^{B2017exc} = R_{UN}^{B2017exc} \cap R_{ED}$.

$$\forall r \in R_{UNED}^{B2017exc} : M_r^{2017exc} = M_r^{y,exc} \frac{M_r^{2017,ED}}{M_r^{y,ED}}, \quad (4)$$

where:

- $M_r^{2017exc}$ are emissions exc. LULUCF in 2017;
- $M_r^{y,exc}$ are emissions exc. LULUCF in the most recent year (y) with data from UN sources before 2017;
- $M_r^{2017,ED}$ are emissions in the EDGAR database in 2017; and,
- $M_r^{y,ED}$ are emissions in the EDGAR database in year y .

For countries still lacking an estimate for 2017 that are covered by the Climate Watch (World Resources Institute, 2025) database (i.e. for countries not covered by the EDGAR database but included in the Climate Watch database), we use the same approach as in Equation 4, but with references to the EDGAR database replaced by references to the Climate Watch database.

2.1.3. Countries estimated by interpolation using target values

The Marshall Islands are covered by the Climate Watch (World Resources Institute, 2025) data. However, the Climate Watch data does not align well with the data in the Marshall Islands' 2050 Climate Strategy (The Republic of the Marshall Islands, 2018), so we estimate their emissions in 2017 by interpolating between data points for 2015 and 2020 in that report, noting that the report was written prior to 2020.

San Marino is not covered by any other dataset and they have an unconditional target for emissions inc. LULUCF in 2030 (Fenhann, 2024). We interpolate emissions inc. LULUCF in 2017 by assuming a linear trajectory between the most recent year that Fenhann (2024) provides data for (2010) and 2030. Subtracting LULUCF emissions from emissions inc. LULUCF in 2017 produces the emissions exc. LULUCF for 2017. Although linearly interpolating from 2010 to 2017 is not the most realistic approach, their emissions are extremely small and this assumption will have almost no effect on the outcomes of this study.

2.1.4. Countries estimated using emissions intensity of Gross Domestic Product (GDP)

Three countries (Kosovo, Palestine and South Sudan) have no future targets that can be used to estimate emissions in 2017 by interpolation. For these countries, we calculate the emissions intensity of GDP using the most recent UN data, or, in the case of Kosovo, the average of emissions intensities in the two most recent years, 2008 and 2009, due to relatively large changes in emissions intensities during that unstable period. Assuming constant emis-

sions intensities of GDP, we then calculate emissions in 2017 based on GDP data from the International Monetary Fund (2024) using Equation 5.

$$M_r^{2017exc} = GDP_r^{2017} \frac{M_r^{y,exc}}{GDP_r^y}, \quad (5)$$

where, for each region r in the set of three countries (Kosovo, Palestine and South Sudan),:

- $M_r^{2017exc}$ are emissions exc. LULUCF in 2017;
- GDP_r^{2017} is the GDP in 2017;
- $M_r^{y,exc}$ are emissions exc. LULUCF in the most recent year (y) with data from UN sources before 2017; and,
- GDP_r^y is the GDP in year y .

Note that the values for GDP used here are in constant US dollars.

2.2. Emissions in 2019

Having estimated emissions exc. LULUCF for all countries in 2017, we can use relative changes in emissions in the EDGAR (Crippa et al., 2024) database to estimate emissions exc. LULUCF for all countries that do not have more recent data in the dataset produced by Fenhann (2024). Where it is necessary to estimate emissions inc. LULUCF, we can do so by maintaining the assumption that LULUCF emissions grow proportionally to emissions exc. LULUCF where they are positive and remain constant where they are negative.

The list of countries where the data from Fenhann (2024) has been augmented by data from party-authored reports to the UNFCCC is slightly different to that in 2017 and is as follows.

- Gabon - Republic Gabonaise Conseil National Climat (2024)
- Canada - Environment and Climate Change Canada (2024)
- USA - EPA (2024)
- Australia - Department of Climate Change, Energy, the Environment and Water (2024)
- China - Emissions in 2019 were interpolated between the emissions in 2018 and 2020 reported by The People's Republic of China (2024)
- India - MoEFCC (2024)
- Japan - Greenhouse Gas Inventory Office of Japan and Ministry of the Environment, Japan (2024)
- EU - European Environment Agency (2024)
- Liechtenstein - INFRAS, Meteotest and CSD (2024)
- Monaco - Direction de l'Environnement (2023)
- Russia - Russian Federation (2023)
- Serbia - Republic of Serbia (2024)
- Türkiye - Türkiye (2023)

- Saudi Arabia - Kingdom of Saudi Arabia (2024)

When a country has emissions data in 2018, we can use that to estimate emissions in 2019. For all countries where the most recent data is in 2018 and that data is for emissions exc. LULUCF, let's use the same method as in Equation 4 to estimate emissions exc. LULUCF, but for 2019 instead of 2017. That is, let's scale emissions exc. LULUCF from 2018 using the ratio of emissions exc. LULUCF in 2019 to those in 2018 from the EDGAR database (Crippa et al., 2024).

For countries that report emissions inc. LULUCF in 2018, the approach depends on whether LULUCF emissions are positive or negative. Let's refer to the set of countries where the most recent data is emissions inc. LULUCF in 2018 and LULUCF emissions are positive as $R_{UNED}^{2018inc+}$. Let's use EDGAR data (Crippa et al., 2024) to scale these emissions, so $R_{UNED}^{2018inc}$ is a subset of the countries covered by the EDGAR data, R_{ED} .

$$\forall r \in R_{UNED}^{2018inc+} : M_r^{2019inc} = M_r^{2018,inc} \frac{M_r^{2019,ED}}{M_r^{2018,ED}}, \quad (6)$$

where:

- $M_r^{2019inc}$ are emissions inc. LULUCF in 2019;
- $M_r^{2018,inc}$ are emissions inc. LULUCF in 2018;
- $M_r^{2019,ED}$ are emissions in the EDGAR database in 2019; and,
- $M_r^{2018,ED}$ are emissions in the EDGAR database in 2018.

The implicit assumption in this approach is that, in countries with positive LULUCF emissions, LULUCF emissions grow at the same rate as emissions exc. LULUCF, so to estimate emissions exc. LULUCF, we subtract the scaled LULUCF emissions.

$$\forall r \in R_{UNED}^{2018inc+} : M_r^{2019exc} = M_r^{2019inc} - M_r^{LU} \frac{M_r^{2019,ED}}{M_r^{2018,ED}}, \quad (7)$$

where:

- $M_r^{2019exc}$ are emissions exc. LULUCF in 2019;
- $M_r^{2019inc}$ are emissions inc. LULUCF in 2019;
- M_r^{LU} are LULUCF emissions in the most recent year with data;
- $M_r^{2019,ED}$ are emissions in the EDGAR database in 2019; and,
- $M_r^{2018,ED}$ are emissions in the EDGAR database in 2018.

Let's refer to countries where the most recent data is emissions inc. LULUCF in 2018 and LULUCF emissions are negative as $R_{UNED}^{2018inc-}$. In these countries, we assume LULUCF emissions remain constant and subtract them from emissions inc. LULUCF in 2018 to get emissions exc. LULUCF, which are then scaled, as follows.

$$\forall r \in R_{UNED}^{2018inc-} : M_r^{2019exc} = (M_r^{2018inc} - M_r^{LU}) \frac{M_r^{2019,ED}}{M_r^{2018,ED}}, \quad (8)$$

where:

- $M_r^{2019exc}$ are emissions exc. LULUCF in 2019;
- $M_r^{2018inc}$ are emissions inc. LULUCF in 2019;

- M_r^{LU} are LULUCF emissions in the most recent year with data;
- $M_r^{2019,ED}$ are emissions in the EDGAR database in 2019; and,
- $M_r^{2018,ED}$ are emissions in the EDGAR database in 2018.

Most countries do not have emissions data for 2018 and their emissions in 2017 were scaled using the relative change in their emissions in the EDGAR database (Crippa et al., 2024) to estimate their emissions in 2019. For countries still lacking an estimate for 2019 that are covered by the Climate Watch (World Resources Institute, 2025) database, let's use the relative change in their emissions from the Climate Watch database.

This leaves only two regions remaining to estimate emissions for in 2019 - the Marshall Islands and San Marino. The methods for calculating their emissions in 2019 are the same as those used to estimate their emissions in 2017, which were discussed in Section 2.1.3.

2.3. Emissions in 2022

For a small number of countries, the most recent data reported to the UN, at the time this work was undertaken, was for 2022. The list of countries where emissions data for 2022 was sourced directly from party-authored reports to the UNFCCC is as follows.

- Gabon - Republic Gabonaise Conseil National Climat (2024)
- Canada - Environment and Climate Change Canada (2024)
- USA - EPA (2024)

- Australia - Department of Climate Change, Energy, the Environment and Water (2024)
- India - MoEFCC (2024)
- Japan - Greenhouse Gas Inventory Office of Japan and Ministry of the Environment, Japan (2024)
- EU - European Environment Agency (2024)
- Liechtenstein - INFRAS, Meteotest and CSD (2024)

For most other countries, let's estimate emissions exc. LULUCF using relative changes from the EDGAR database (Crippa et al., 2024). There are a small number of countries not covered by the EDGAR database (Crippa et al., 2024) but that we have UN data for emissions exc. LULUCF for in a year after 2017. They are the Federated States of Micronesia, Andorra, Monaco, Montenegro and Serbia. For Andorra, Monaco and Montenegro, let's performed a linear interpolation between emissions in the most recent year with UN data and their unconditional 2030 emissions target. In the EDGAR database, Serbia and Montenegro are a single region. However, the majority of that region's emissions are from Serbia, so let's apply the relative change in emissions by Serbia and Montenegro in the EDGAR database to Serbia. Fenhann (2024) does not report an NDC for the Federated States of Micronesia, so let's assume a constant emissions intensity of GDP and calculate their emissions using the same approach as that in Equation 5, but using the GDP for 2022 instead of 2017.

There is a small set of countries that have reported to the UN emissions inc. LULUCF after 2017 but before 2022 and more recently than they have reported emissions exc. LULUCF. All such countries are included in the EDGAR database (Crippa et al., 2024). To estimate emissions exc. LULUCF in 2022 for these countries, let's assume (again) that LULUCF emissions grow proportionally to emissions exc. LULUCF if they are positive, or remain constant if they are negative. This allows us to estimate emissions exc. LULUCF in the year that the countries report emissions inc. LULUCF for, then scale emissions exc. LULUCF using relative changes from the EDGAR database. We can then use the same assumptions about LULUCF emissions to estimate emissions inc. LULUCF in 2022.

The Marshall Islands and San Marino are lacking estimates of emissions in 2022, but both countries have submitted unconditional NDCs. Let's assume they will meet the emissions targets therein and use those targets to interpolate emissions in 2022. In the same way that we estimated emissions for these countries in 2017 and 2019, let's use these countries' targets to interpolate emissions in 2022, i.e. let's assume their emissions will follow a linear trajectory to their targets.

There are three countries that we still need to estimate emissions for in 2022 but that do not have unconditional, economy-wide emissions reduction targets in the NDCs documented by Fenhann (2024). They are the Federated States of Micronesia, Nauru and Tuvalu. For these countries, let's assume the emissions intensity of their GDP is constant at 2017 levels and use GDP

to estimate emissions in 2022 in the same way as shown in Equation 5, but using data for the appropriate years.

There is one country, Niue, that is not in the EDGAR database (Crippa et al., 2024), the International Monetary Fund (2024) do not provide data for and they have no economy-wide emissions reduction target documented by Fenhann (2024). As they are included in the Climate Watch database (World Resources Institute, 2025), let's assume that the relative change over the three years from 2019 to 2022 is the same as the relative change over the period from 2016 to 2019 as documented in that database.

2.4. Emissions in 2023

As the final year in the EDGAR database (Crippa et al., 2024), 2023 is the final year of what is considered to be the historical period in this modelling. We must estimate emissions exc. LULUCF for all countries in the data produced by Fenhann (2024) and, for countries with NDCs that state their emissions reduction target in terms of emissions inc. LULUCF, we must estimate emissions inc. LULUCF. For the EU only, let's use historical data from the European Environment Agency (2024).

For all countries in the Fenhann (2024) data that are in the EDGAR database (Crippa et al., 2024), let's estimate emissions exc. LULUCF in 2023 by scaling the estimate of emissions exc. LULUCF for 2022 using the relative change in emissions from 2022 to 2023 in the EDGAR database. Where we need to estimate emissions inc. LULUCF for these countries, let's do so by assuming that they grow proportionally to emissions exc. LULUCF if LULUCF emis-

sions are positive, or we assume LULUCF emissions are constant where they are negative.

For countries not covered by the EDGAR database but with an unconditional, economy-wide emissions reduction target in their NDC, let's assume that their emissions follow a linear path to the unconditional target in their NDC for 2030. These countries are the Marshall Islands, San Marino, Andorra, Monaco, Montenegro and Liechtenstein. Let's assume that the relative change in Serbia's emissions exc. LULUCF from 2022 to 2023 is the same as for the Serbia and Montenegro region in the EDGAR database. Again, where an estimate of LULUCF emissions is necessary, let's assume they are constant where they are negative and grow proportionally to emissions exc. LULUCF where they are positive.

For the Federated States of Micronesia, Nauru and Tuvalu, let's again assume that the emissions intensity of GDP is constant and use GDP to estimate emissions in 2023, as described at the end of Section 2.3. For Niue, let's assume that the relative change over the four years from 2019 to 2023 is the same as the relative change over the period from 2015 to 2019 as documented in the Climate Watch (World Resources Institute, 2025) database.

2.5. Emissions from 2024 to 2030

We now have emissions for key years in the historical period for all countries included in the Fenhann (2024) data, which is the source for data for both unconditional and conditional emissions targets in most NDCs. In a small number of cases, the data from Fenhann (2024) was augmented or

updated directly from countries' NDCs. For countries that do not have an emissions target, emissions exc. LULUCF were assumed to grow with real GDP from the International Monetary Fund (2024), or, if no real GDP forecasts were available, they were assumed to continue growing as they did over the historical period. For countries that have an unconditional target but not a conditional one, emissions in the conditional scenario were assumed to be the same as in the unconditional scenario.

2.5.1. Emissions when targets exclude LULUCF emissions

Let's consider the set of countries that have submitted unconditional emissions targets for 2030 in their NDC that exclude LULUCF emissions. Let's refer to this set as $R_{UN}^{U2030exc}$. For these countries, to estimate emissions during the period from 2024 to 2029 for the unconditional emissions scenario, let's linearly interpolate from their emissions exc. LULUCF in 2023 to their unconditional target for emissions exc. LULUCF in 2030. That is,

$$\forall r \in R_{UN}^{U2030exc} : M_r^{U,y,exc} = M_r^{2023exc} + (y - 2023) \frac{M_r^{U2030exc} - M_r^{2023exc}}{2030 - 2023}, \quad (9)$$

where:

- $M_r^{U,y,exc}$ are emissions exc. LULUCF in region r in year y ;
- $M_r^{2023exc}$ are emissions exc. LULUCF in region r in 2023; and,
- $M_r^{U2030exc}$ is the unconditional target for emissions exc. LULUCF for region r in 2030.

For countries where Fenhann (2024) documented a conditional target for emissions exc. LULUCF, emissions exc. LULUCF in the conditional emissions scenario are estimated using the same form as in Equation 9, but with

the conditional target in place of the unconditional one. For countries that did not submit a conditional target for emissions in 2030 but did submit an unconditional target for emissions exc. LULUCF in 2030, let's assume that their emissions in the conditional scenario follow the same path as in the unconditional scenario.

2.5.2. Emissions when targets include LULUCF emissions

As the model used in this study does not include theory for LULUCF emissions, all targets expressed in terms of emissions inc. LULUCF need to be converted to emissions exc. LULUCF. Let's consider the set of countries that have submitted an unconditional emissions target for 2030 in their NDC and where LULUCF emissions are negative, a set that we will refer to as $R_{UN}^{U2030inc-}$. For these countries, let's assume LULUCF emissions will remain constant and estimate emissions exc. LULUCF by subtracting them from the target for emissions inc. LULUCF. That is, $\forall r \in R_{UN}^{U2030inc-}$:

$$M_r^{U,y,exc} = M_r^{2023exc} + (y - 2023) \frac{(M_r^{U2030inc} - M_r^{LU}) - M_r^{2023exc}}{2030 - 2023}, \quad (10)$$

where:

- $M_r^{U,y,exc}$ are emissions exc. LULUCF in region r in year y ;
- $M_r^{2023exc}$ are emissions exc. LULUCF in region r in 2023;
- $M_r^{U2030inc}$ is the unconditional target for emissions inc. LULUCF for region r in 2030; and,
- M_r^{LU} are LULUCF emissions as in the most recent data for region r .

For countries that have submitted an unconditional emissions target for 2030 in their NDC and where LULUCF emissions are positive, let's assume LULUCF emissions grow proportionally to emissions exc. LULUCF. Let's refer to this set of countries as $R_{UN}^{U2030inc+}$ and linearly interpolate to calculate emissions exc. LULUCF from 2023 to 2030. $\forall r \in R_{UN}^{U2030inc+}$:

$$M_r^{U,y,exc} = M_r^{2023exc} + (y - 2023) \left(\frac{M_r^{U2030inc}}{M_r^{2023inc}} - 1 \right) \frac{M_r^{2023exc}}{2030 - 2023}, \quad (11)$$

where all definitions are the same as for Equation 10.

In the conditional emissions scenario, the method for estimating emissions exc. LULUCF in countries with positive LULUCF emissions and a conditional target specified in terms of emissions inc. LULUCF is the same as shown in Equation 11, but with the unconditional target replaced by the conditional one. For countries that have specified a conditional target in terms of emissions inc. LULUCF that have negative LULUCF emissions, the method for calculating emissions exc. LULUCF is the same as shown in Equation 10, but, again, with the unconditional target replaced by the conditional one. Let's assume that emissions only begin to deviate from emissions in the unconditional scenario from 2025, so in these equations emissions in 2023 are replaced by emissions in the unconditional scenario in 2024 and the year 2024 replaces 2023. There are two countries that receive special treatment, because their conditional emissions reduction target is so ambitious that using a method equivalent to that in Equation 10 to estimate emissions results in negative emissions exc. LULUCF. These countries are Gabon and Mali. Let's treat each of these individually.

For Gabon, let's assume that emissions exc. LULUCF grow with real GDP as forecast by the International Monetary Fund (2024) and that they achieve their conditional target for emissions inc. LULUCF by more ambitious changes to their LULUCF emissions. Mali specify emissions by sector in their NDC (Republic du Mali, 2023), so let's use that information to calculate emissions exc. LULUCF in their conditional 2030 target and linearly interpolate from 2024 to 2030.

2.5.3. Comparisons to GDP growth forecasts

Some countries submit NDCs with emissions targets that are so lacking in ambition that they will be achieved without any mitigation efforts. As most countries will be aggregated together into regional groupings for the economic modelling, these excessively high emissions targets would potentially result in the emissions of some aggregate regions being unrealistically high. To minimise the impact of this, we can compare emissions growth rates in the EDGAR database (Crippa et al., 2024) to real GDP growth rates from the International Monetary Fund (2024) over the period since 1990. The highest ratio of emissions growth to real GDP growth was 1.824 for Turkmenistan over the six years to 1998, after filtering out countries where the EDGAR data is a poor match with UN data and countries with exceptional circumstances (e.g. civil war). There were 40 countries with unconditional targets for emissions exc. LULUCF that required a rate of growth in emissions more than 1.824 times the rate of real GDP growth forecast by the International Monetary Fund (2024). In those countries, the rate of growth in emissions was limited to 1.824 times the rate of real GDP growth. A similar limit was applied to a smaller number of countries in the conditional scenario.

2.5.4. Unconditional targets

The calculated global emissions in 2030 when unconditional targets are met are 48.5GtCO₂-e, which is within the range of 48.3 to 54.7GtCO₂-e reported by the UNFCCC (2024b), with an average of 51.5.

2.5.5. Conditional targets

The calculated global emissions in 2030 when conditional targets are met are 46.0GtCO₂-e. The difference between this and emissions with unconditional targets is similar to that reported by the UNFCCC (2024b).

2.6. Calculation of shocks for economic modelling

Now that we have estimates of emissions for all countries covered by the Fenhann (2024) data for key years, we need to aggregate those into the same regions as the economic data, which is as used by Marginson (2024) and shown in Table A.1 in Appendix A. Having done so, we must calculate how emissions change from year to year. From 2024 onwards, we have estimated emissions exc. LULUCF for all countries in all years, so we can aggregate these estimates and calculate the percentage changes from year to year. Over the historical period, we will smooth changes in emissions from 2017 to 2019 and from 2019 to 2023. Let's assume that emissions decline linearly in regions where they are declining and grow exponentially in regions where they are increasing.

Two countries that are modelled individually (i.e. they are not part of regional aggregates) and that have emissions intensity targets, rather than targets for emissions, are treated differently. They are China and India, where

we will shock emissions intensities directly.

3. Economic modelling

The economic modelling uses the modified versions of the GTAP database (GTAP, 2020) and GDyn-E model (Golub, 2013) documented by Marginson (2024). Most notably, substitution between energy sources is expanded using methods similar to those described by Peters (2016). The regional aggregation is shown in Table A.1 and the sectoral aggregation is shown in Table A.2. Simulations are run from the period beginning in 2017 and ending in 2030.

3.1. Base case

Unless mentioned in this section, all changes in the base case are as documented by Marginson (2024). The base case is driven by GDP and population forecasts by the International Monetary Fund (2024). Changes in the labour force originally come from Golub (2013), but have been adjusted for differences between population growth rates used by Golub (2013) and those published by the International Monetary Fund (2024). Changes in fossil fuel prices over the period from 2017 to 2022 also come from the International Monetary Fund (2024). Changes in oil production during the period from 2017 to 2022 come from the International Energy Agency (IEA, 2018, 2020a, 2024) and the Organization of the Petroleum Exporting Countries (OPEC, 2021, 2023). Changes in coal and gas production from 2019 to 2022 come from the IEA (2020b, 2023, 2025); Department of Industry, Science, Energy and Resources (2021); Australian Government Department of Climate Change, Energy, the Environment and Water (2023). Changes in electricity generation during the period from 2019 to 2022 come from the IEA (2025).

A number of changes were made to represent the effects of policies implemented in 2022 in response to Russia’s invasion of Ukraine. Seaborne imports of crude oil and petroleum from Russia into the EU were reduced to negligible levels, as were imports of all energy commodities from Russia into the USA. Coal imports from Russia into the EU were also reduced to negligible levels. Pipeline imports of gas from Russia into the EU were reduced in line with data reported by Keliauskaitė et al. (2025).

Up to and including 2023, emissions follow the trajectories calculated using the methods described in Section 2, with two exceptions: China and India. In these two regions, emissions follow the trajectories calculated using the methods described in Section 2 until 2019. As these two regions have unconditional emissions intensity targets in 2030, emissions intensity becomes the exogenous variable from 2020. It’s assumed that they will meet their targets in 2030. In the base case, emissions are only exogenous until 2023. It’s assumed that China’s carbon dioxide emissions intensity follows a linear trajectory from 2019 to 2030 and it follows that trajectory until 2023 in the base case. A similar assumption is made about the path to India’s emissions intensity in 2030. However, their target is so weak that their emissions intensity is lower than the linearly interpolated intensity until 2022, so the only year when India’s emissions intensity is exogenous in the base case is 2023, when it follows a linear trajectory towards their 2030 target.

3.2. Unconditional emissions targets scenario

This scenario represents a world where all regions meet their unconditional emissions targets and investment is fully endogenous, i.e. no additional climate financing is imposed on the model. Emissions or, in the case of China and India, emissions intensities follow linear trajectories from their 2023 levels to the 2030 targets. It is assumed that in 2024 the USA was following a linear trajectory towards their 2030 target and then from 2025 their emissions are endogenous. In regions where emissions or emissions intensities are exogenous, the model solves for the tax on emissions that results in the change in emissions being imposed and the revenue from that tax contributes to regional income. The distribution of that income between public and private expenditure is determined by GTAP's utility function.

The main purpose of this scenario is to determine how much lower emissions are in each region than they are in the base case. Two regions, Russia and the Rest of Asia and the Pacific, have emissions targets that are so weak that their emissions remain below their targets even in the absence of a tax.

3.3. Unconditional emissions targets with minimal climate financing scenario

In this scenario, climate financing is provided to non-Annex I regions, which for the purposes of this study are considered to be:

- China;
- India;
- Rest of Asia and the Pacific, as most emissions from this region are from non-Annex I countries;

- Rest of the Americas, as most emissions from this region are from non-Annex I countries;
- Middle East; and,
- Africa.

Let's refer to this as the set R_{XAI} . As the Rest of Asia and the Pacific does not have a binding emissions reduction target, let's define a subset of R_{XAI} where emissions are lower in the unconditional emissions target scenario than in the base case. That is,

$$R_{XAI,y}^* = \{r \in R_{XAI} | M_{r,y}^U < M_{r,y}^B\}, \quad (12)$$

where:

- $M_{r,y}^U$ are emissions in region r in year y in the unconditional emissions targets scenario; and,
- $M_{r,y}^B$ are emissions in region r in year y in the base case.

Note that the definition of $R_{XAI,y}^*$ changes by year depending on the emissions from each region in each year. Let's assume that climate financing is provided to non-Annex I regions in proportion to their share of the reduction in emissions from all non-Annex I regions where emissions are lower in the unconditional climate targets scenario (described in Section 3.2) than in the base case. That is,

$$\forall r \in R_{XAI,y}^*, \forall y \in \mathbb{N} | 2024 \leq y \leq 2030 : F_{r,y} = F_y \frac{M_{r,y}^U - M_{r,y}^B}{\sum_{i \in R_{XAI,y}^*} (M_{i,y}^U - M_{i,y}^B)}, \quad (13)$$

where:

- $F_{r,y}$ is the value of additional investment in region r in year y from climate financing; and,
- F_y is the total value of additional investment in year y from climate financing. It begins at \$100 billion in 2024 and increases linearly to \$200 billion in 2030 (as the NCQG is for 2035 and 2030 is roughly the halfway point from 2024, it's assumed that financing rises to half the target by 2030).

This additional investment $F_{r,y}$ is imposed in the model by adding it to investment in the unconditional emissions targets scenario and making investment in the unconditional emissions scenario with climate financing equal the target value. This is facilitated in the model by making the shift variable for the expected rate of return, $srorge$, endogenous. That is, rather than investment being determined by the expected rate of return, the rate of return is determined by the investment that we impose on the model. This can be interpreted as investors accepting a lower rate of return to achieve climate goals.

Another change was necessary to ensure that financing comes from outside regions $R_{XAI,y}^*$. In the base case and the unconditional emissions targets scenario, investment in the model follows a lagged adjustment path that targets a constant wealth to income ratio by solving for the parameter in the utility function that controls savings, $sdpsavereg$. In $R_{XAI,y}^*$ in the unconditional emissions targets with climate financing scenario, this variable is forced to follow the same path that it did in the unconditional emissions targets scenario by letting the variable $dpsaveslack$ adjust, which stops the model from

minimising changes to the wealth to income ratio of those regions.

3.4. Conditional emissions targets with minimal climate financing scenario

The purpose of this scenario is much the same as the unconditional emissions targets scenario - to ascertain the difference between emissions in non-Annex I regions in this scenario and the unconditional emissions scenario with climate financing. The scenario begins in 2025. Emissions for all Annex I regions are the same as in the unconditional emissions targets scenario described in Section 3.2, except for emissions from the USA and Russia, which are endogenous. Emissions intensities in China and India follow the same paths as in the unconditional emissions targets scenario, as neither country have a conditional emissions target. Emissions in other non-Annex I regions follow the paths calculated using the method described in Section 2.5. The values for *srorge* and *dpsaveslack* are the same as in the unconditional emissions targets with minimal climate financing scenario.

3.5. Conditional emissions targets with increased climate financing scenario

This scenario is the same as that described in Section 3.4, but non-Annex I regions with conditional emissions targets receive increased climate financing. The formula used to calculate the increased climate financing is the same as Equation 13, but the difference between emissions in the conditional and unconditional scenarios are used to calculate the weights. The value of additional investment increases linearly from zero in 2024 to \$500 billion in 2030. This additional investment is distributed only to non-Annex I regions with conditional emissions targets. That is, China and India do not receive

increased climate financing, as they do not have conditional targets. The only regions that receive increased climate financing are:

- Rest of Asia and the Pacific;
- Rest of the Americas;
- Middle East; and,
- Africa.

Let's refer to these regions as the set R_{XAI}^C . The additional investment that these regions receive is on top of the investment in those regions in the unconditional emissions targets with minimal climate financing scenario. For all other regions, the values for $srorge$ and $dpsaveslack$ are the same as in the unconditional emissions targets with minimal climate financing scenario. For Annex I regions, those values are zero, meaning investment and savings are fully endogenous, with no shifts imposed.

3.6. More ambitious Annex I emissions targets with minimal climate financing scenario

In this scenario, Annex I regions reduce their emissions in total by the same amount as the difference between conditional and unconditional emissions in non-Annex I regions that, due to their more ambitious emissions reduction targets, received additional climate financing in the conditional emissions targets with increased climate financing scenario, i.e. the set of regions R_{XAI}^C . Specifically, the difference between emissions in the uncondi-

tional and conditional emissions scenarios in regions in the set R_{XAI}^C is:

$$dM_y^{R_{XAI}^C} = \sum_{i \in R_{XAI}^C} (M_{i,y}^C - M_{i,y}^U), \quad (14)$$

where:

- $dM_y^{R_{XAI}^C}$ is the total change in emissions from all regions in the set R_{XAI}^C in year y , in MtCO₂-e;
- $M_{r,y}^C$ are emissions in region r in year y in the conditional emissions targets scenario in MtCO₂-e; and,
- $M_{r,y}^U$ are emissions in region r in year y in the unconditional emissions targets scenario in MtCO₂-e.

To achieve the same climate outcomes as in the conditional emissions scenarios without providing sufficient climate financing for non-Annex I regions to commit to their conditional emissions targets, Annex I regions could reduce their emissions by an additional amount equivalent to $dM_y^{R_{XAI}^C}$. As the basis for a burden sharing rule, let's assume that emissions reductions below base case in the unconditional scenario are representative of the political will for climate action in each region and therefore representative of the political will for more ambitious emissions reductions. That is, $\forall r \in R_{AI}^*, \forall y \in \mathbb{N} | 2025 \leq y \leq 2030$:

$$M_{r,y}^* = M_{r,y}^U + \frac{M_{r,y}^U - M_{r,y}^B}{\sum_{i \in R_{AI}^*} (M_{i,y}^U - M_{i,y}^B)} dM_y^{R_{XAI}^C}, \quad (15)$$

where:

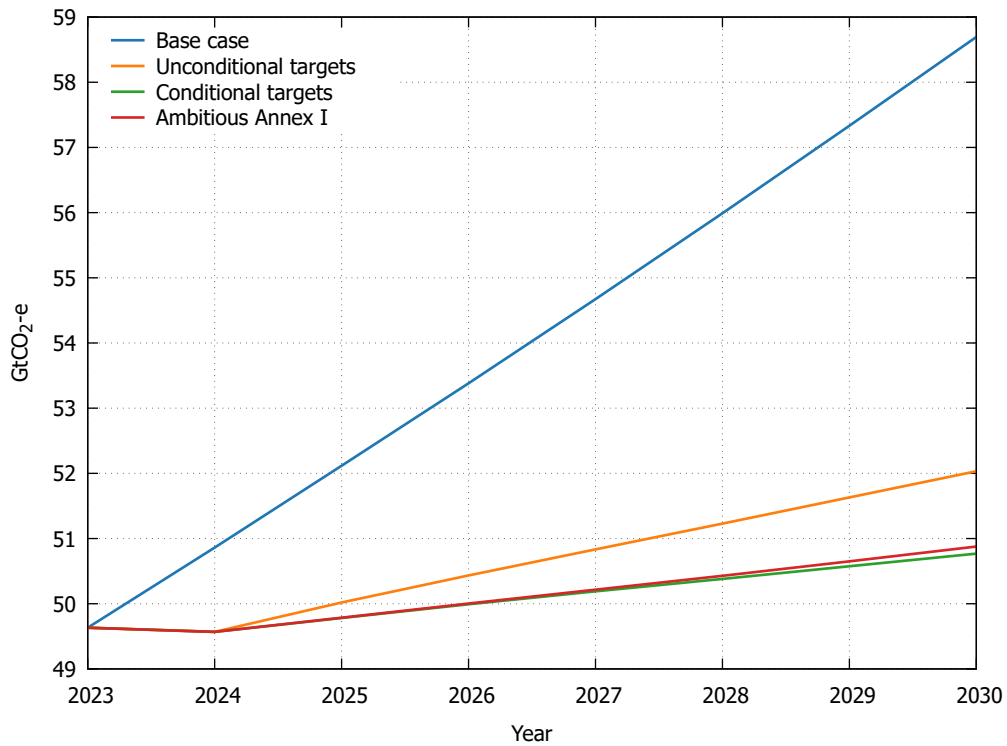
- R_{AI}^* is the set of Annex I regions with emissions in the unconditional emissions targets scenario below those in the base case, namely the EU, Japan, Australia and the Rest of Europe and former Soviet Union;
- $M_{r,y}^U$ are emissions in region r in year y in the unconditional emissions targets scenario in MtCO₂-e; and,
- $M_{r,y}^B$ are emissions in region r in year y in the base case in MtCO₂-e.

As savings behaviour will be different in this scenario, we do not want investment in regions that receive climate financing in the unconditional emissions targets with minimal climate financing scenario to be identical in the two scenarios. However, we do want climate financing in this scenario to approximate that in the unconditional emissions targets with minimal climate financing scenario, so changes in *srorge* in this scenario follow those in that scenario for recipients of climate financing in that scenario (the set $R_{XAI,y}^*$), as that would cause investment to be the same in those two scenarios if all else were equal. Furthermore, we want savings behaviour in regions that received additional climate financing in the conditional emissions targets with increased climate financing scenario to be more like that in the unconditional emissions targets with minimal climate financing scenario than in the scenario with additional funding, so we shock the variable *dpsaveslack* with the values that the model produced for it in the unconditional scenario.

4. Results

Figure 1 shows annual emissions in the base case and in each of the scenarios that include climate financing. In all scenarios, emissions continue to increase. In the three scenarios with climate action, emissions decrease in 2024, but, with the USA abandoning the Paris Agreement under the Trump administration in 2025, global emissions begin to rise again. Note that all emissions in this section are exc. LULUCF.

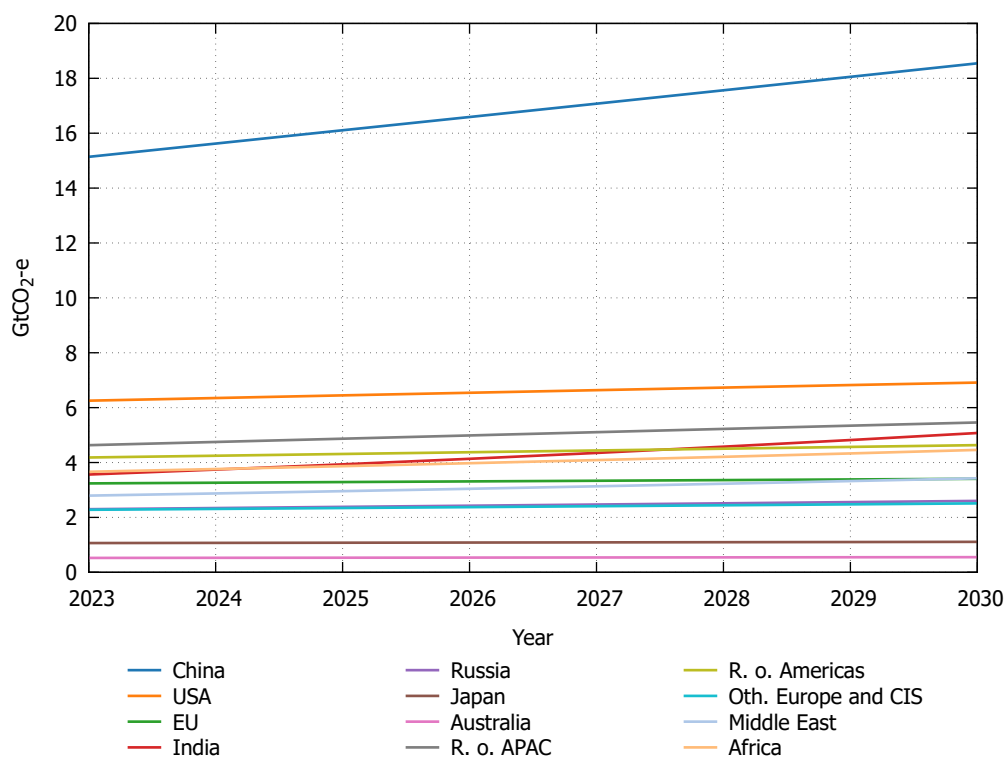
Figure 1: Global greenhouse gas emissions



Emissions from each region in the base case are shown in Figure 2. In

three regions, the EU, Japan and Australia, policies already implemented are sufficient to result in a reduction in emissions initially, but, by the end of the decade, emissions have grown in all regions.

Figure 2: Regional greenhouse gas emissions in base case



4.1. Unconditional emissions targets scenario

As discussed in Section 3.3, the difference between emissions in the base case and those in the unconditional emissions targets scenario (described in Section 3.2) in non-Annex I regions were used to determine how much climate financing each region receives in the unconditional emissions targets with minimal climate financing scenario. Those differences are shown in Figure 3. As mentioned in Section 3.3, the unconditional emissions targets of countries in the Rest of Asia and the Pacific sum to more than emissions from that region rise to in the base case, so they remain endogenous. As a result, emissions there rise and they do not received any climate financing.

Figure 3: Difference in regional emissions with unconditional targets relative to base case

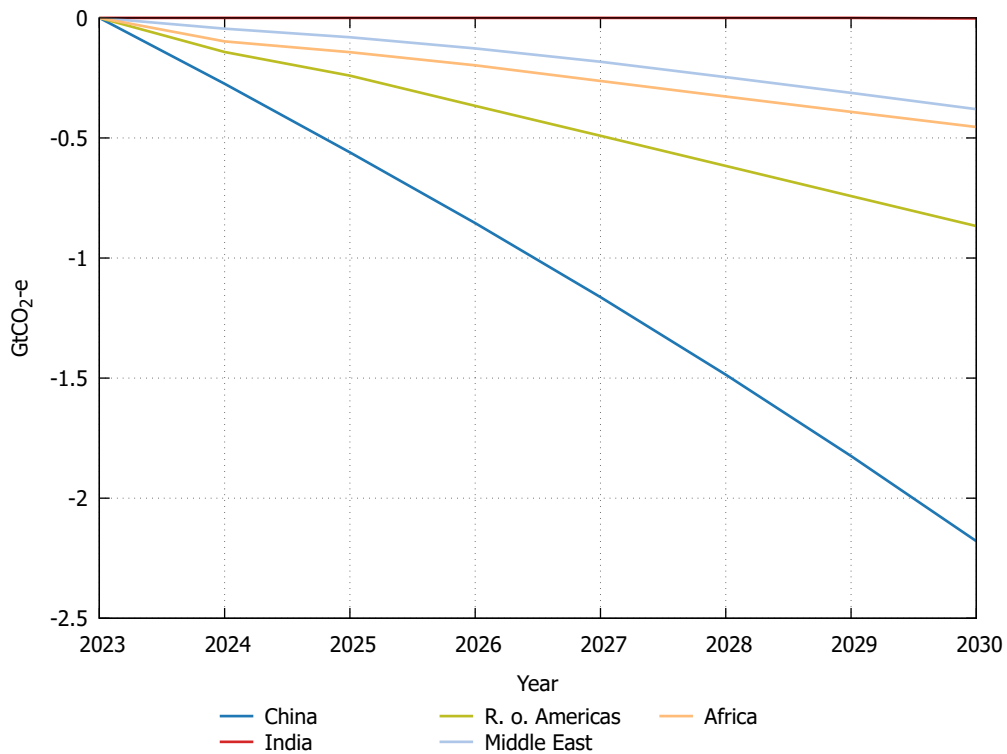
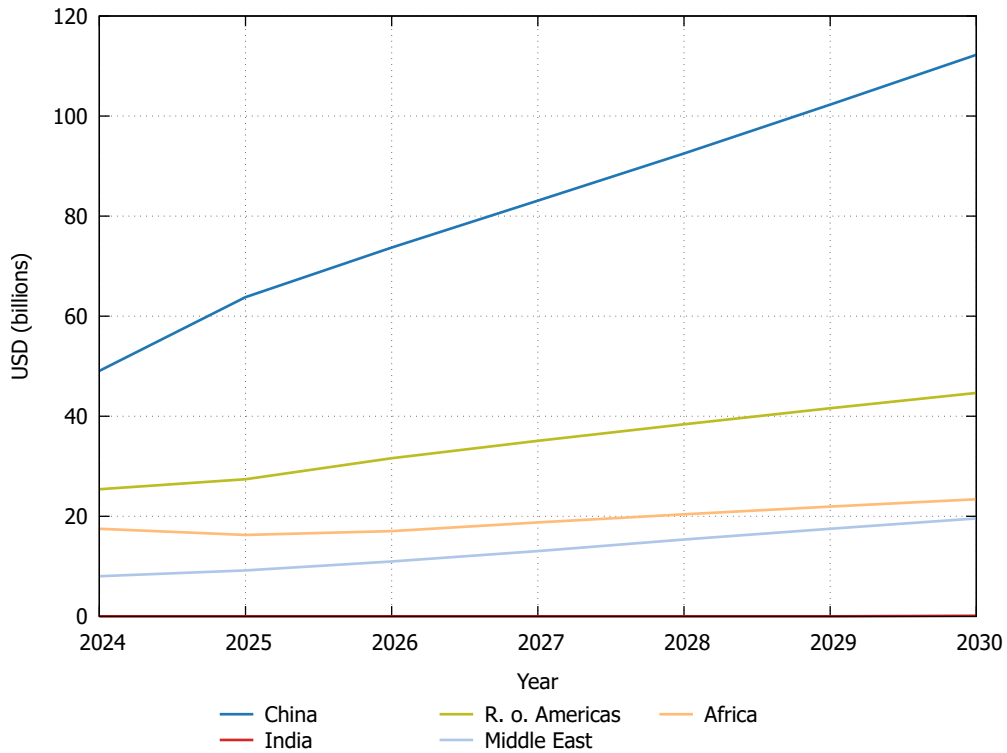


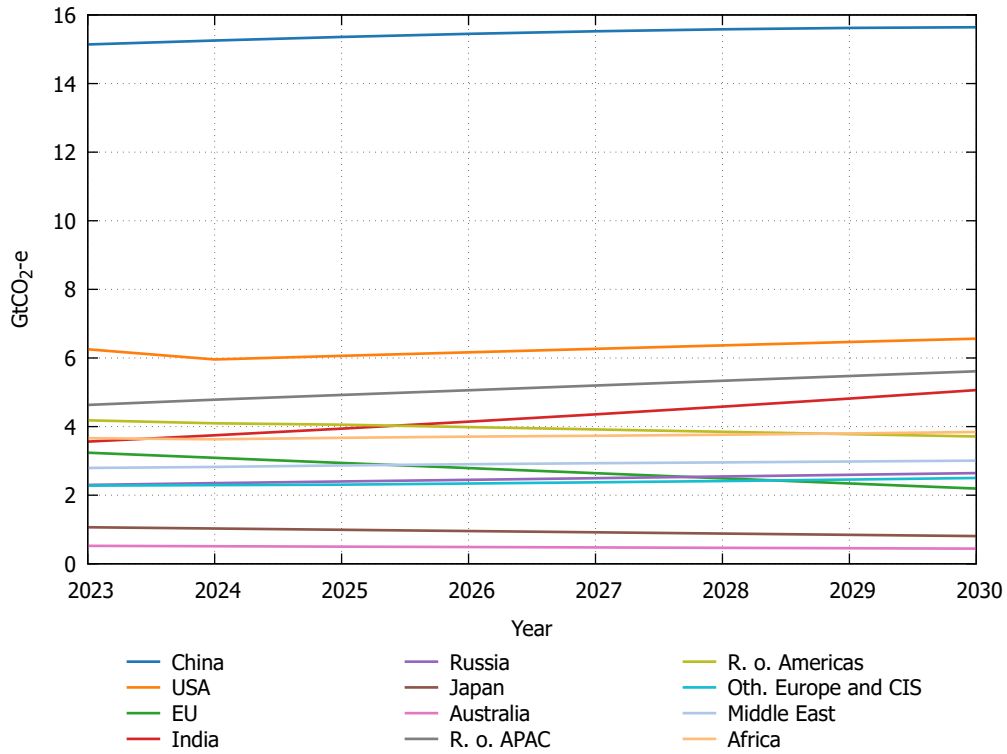
Figure 4 shows the results of Equation 13 when the deviations in emissions shown in Figure 3 are used as inputs. As emissions in India are only lower than in the base case in 2030, values in all other years are zero and they are barely distinguishable from zero even in 2030 - India's lack of ambition results in it receiving very little climate financing this decade.

Figure 4: Value of climate financing in unconditional emissions scenario



With this additional investment, emissions in this scenario are shown in Figure 5. Note the growth in emissions in regions where they are endogenous: USA, Russia and the Rest of Asia and the Pacific, as well as in India, where the emissions intensity target is weak and the growth in GDP is strong.

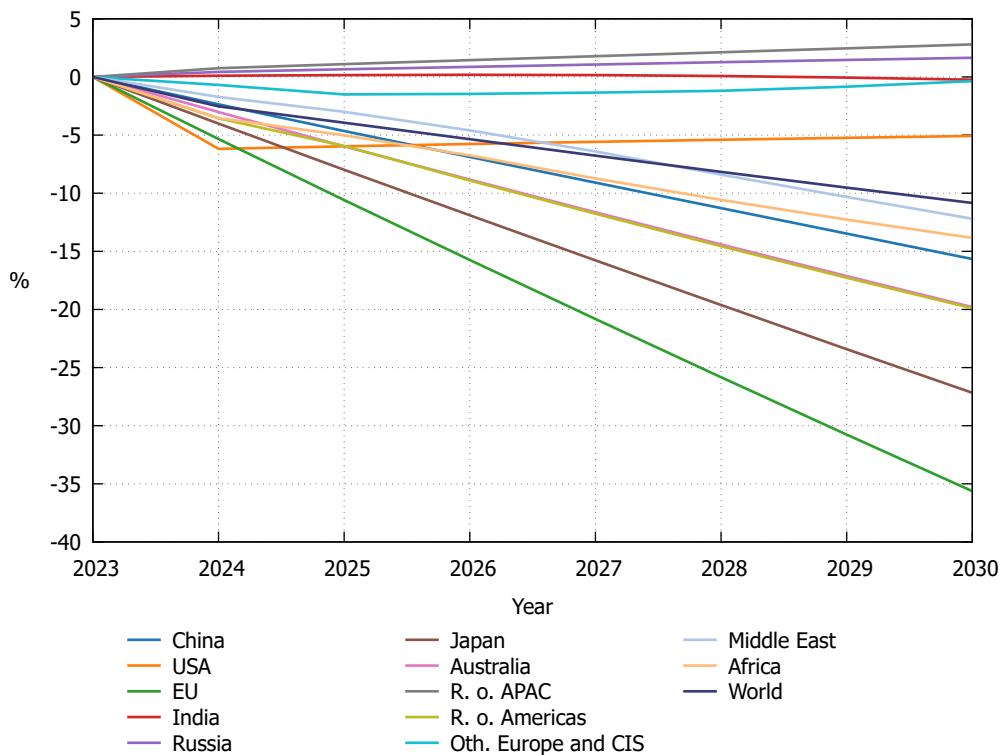
Figure 5: Regional emissions in unconditional emissions with climate financing scenario



With these emissions reductions, by the end of the decade the only modelled regions with lower emissions than the EU are Japan and Australia. In per capita terms, the USA, after leaving the Paris Agreement, quickly overtakes Australia to have the highest emissions per capita of the regions modelled, with 19.0tCO₂-e per person in 2030. The second highest emissions per capita of the regions modelled is Russia 18.9tCO₂-e per person in 2030, followed by Australia with 15.1. Fourth highest will be China with 11.2tCO₂-e per person, then the Middle East at 9.8. Only three regions will have lower emissions per capita than the EU with 4.8tCO₂-e per capita - Africa at 2.3, India at 3.4 and the Rest of Asia and the Pacific at 4.0.

Figure 6 shows the change in emissions in the unconditional scenario with climate financing, shown in Figure 5, relative to those in the base case, shown in Figure 2. Also shown is the difference, in relative terms, between emissions at the global level in this scenario, relative to the base case, which are shown in Figure 1. In 2030, global emissions are more than 10% lower in this scenario than they are in the base case. As shown in Figure 1, they are still rising, but not by as much.

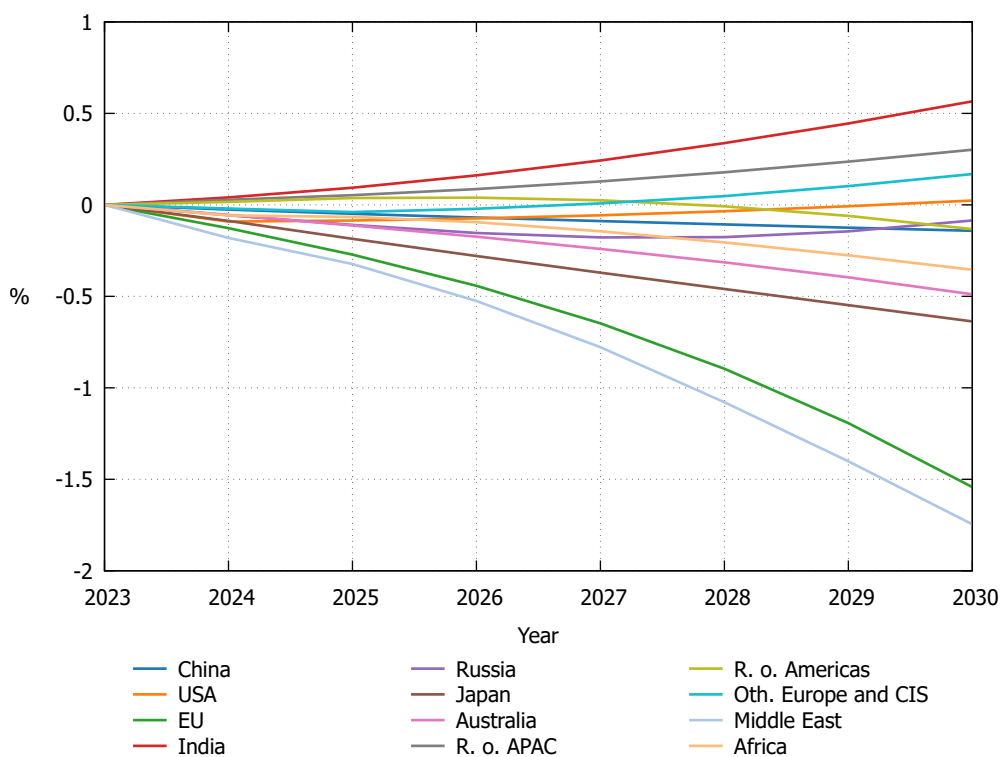
Figure 6: Deviation in emissions with unconditional targets and climate financing



Impacts on real GDP are shown in Figure 7. Production in the Middle East is worst affected, with their hardest hit sectors (oil and gas production)

being capital-intensive, resulting in a reduction in the contribution of capital to factor income of over 4% in 2030. This, combined with more lost income from labour and natural resources, is not fully offset by the increase in tax revenue due to emissions pricing, resulting in the fall in GDP shown here. The next largest impact is in the EU, where labour income is the biggest contributor to the decline. India's GDP is higher in this scenario, driven largely by income from labour. As India has an emissions intensity target, increasing GDP allows them to emit more and emissions-intensive industries increase their production in India as emissions prices increase by more in most other regions, making India more competitive.

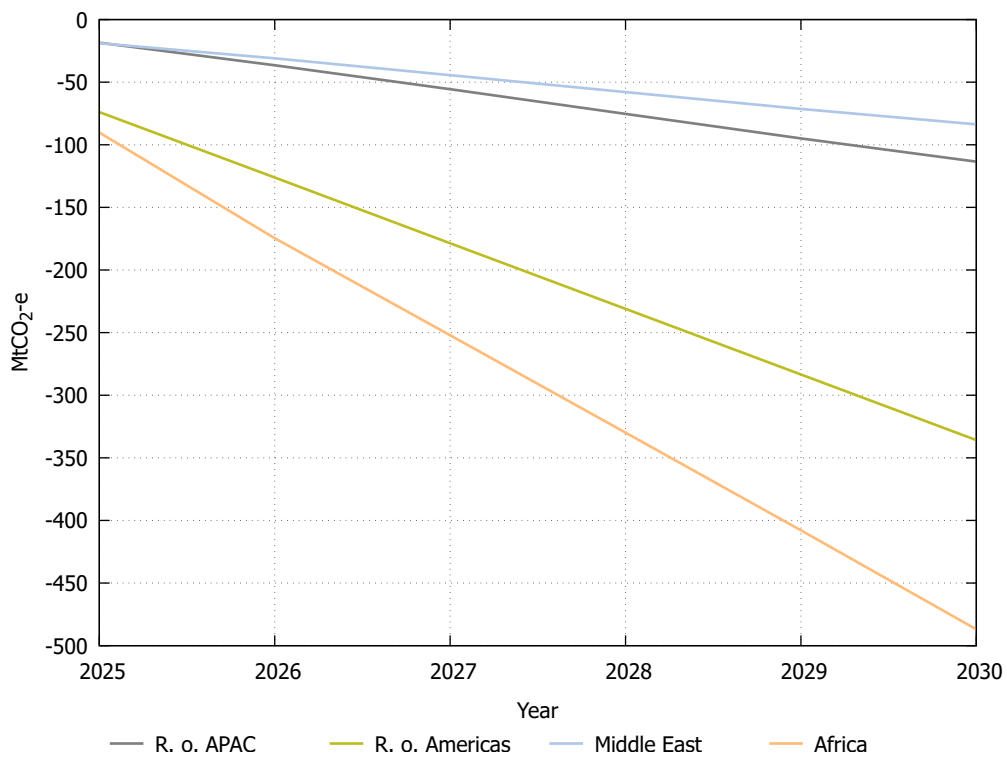
Figure 7: Deviation in real GDP with unconditional targets and climate financing



4.2. Conditional emissions targets scenario

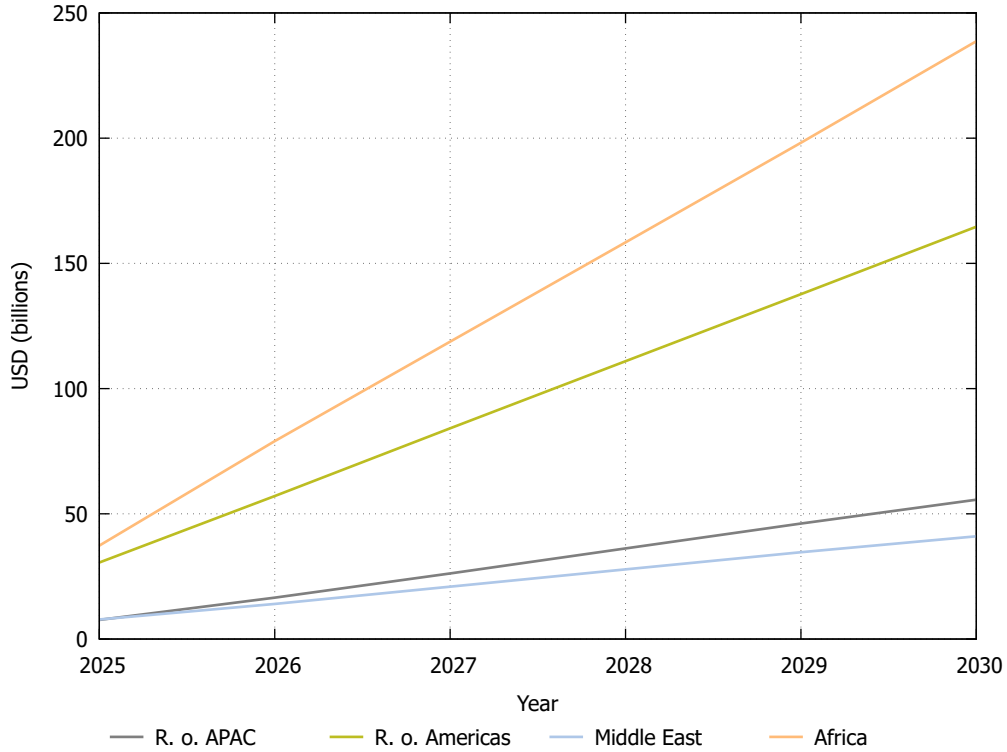
The difference between emissions in the conditional and unconditional emissions targets scenarios in non-Annex I regions, used to calculate additional climate financing as discussed in Section 3.5, are shown in Figure 8.

Figure 8: Difference between regional emissions in conditional and unconditional scenarios



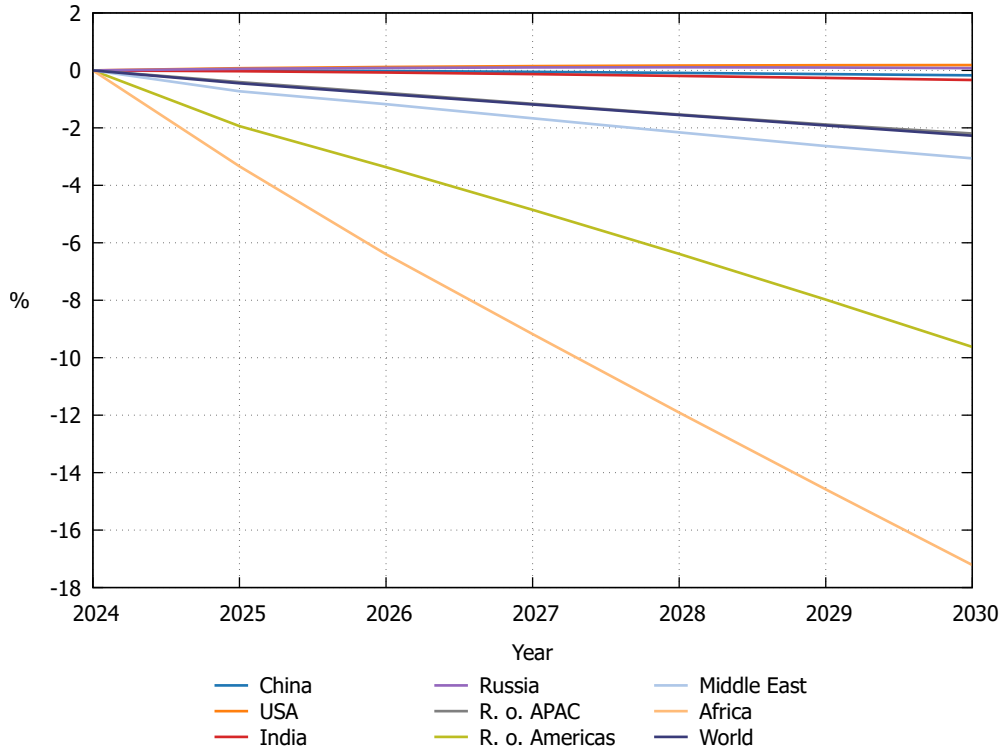
The differences in emissions shown in Figure 8 were used to calculate how additional climate financing was distributed, as described in Section 3.5. The additional investment in the conditional emissions targets with increased climate financing scenario are shown in Figure 9. In these regions, this investment is in addition to investment in the unconditional emissions targets with minimal climate financing scenario.

Figure 9: Value of additional climate financing in conditional emissions scenario



The change in emissions in this scenario relative to those in the unconditional emissions with minimal climate financing scenario are shown in Figure 10. Not shown are the EU, Japan, Australia and Other Europe and CIS, as emissions are unchanged in those regions. Changes in emissions in China, the USA, India and Russia are in response to endogenous changes in investment and shifting patterns of global production due to the deeper emissions cuts shown in Figure 8. There is an increase in emissions in the USA and Russia, which should be considered carbon leakage. The reduction in emissions in China and India is due to lower investment there.

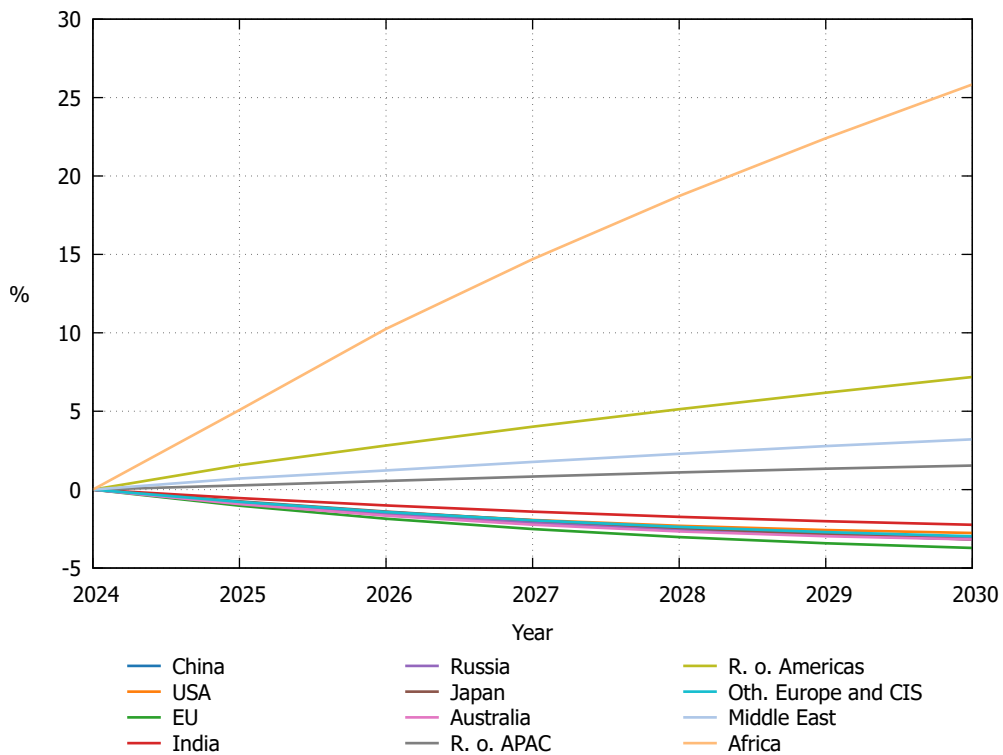
Figure 10: Deviation in emissions between conditional and unconditional scenarios



It should be noted just how significant the emissions reductions are in Africa. Given the assumptions in this work, Africa will reduce their emissions by a further 17% in 2030, relative to emissions with their unconditional targets (shown in Figure 5) and receive just under 240 billion USD in additional investment. Globally emissions are a little over 2% lower in this scenario than in the unconditional emissions with minimal climate financing scenario, which we can consider to be the environmental return on the investments shown in Figure 9.

Deviations in investment in each region are shown in Figure 11. We can see that the additional financing represents a considerable increase in investment in Africa. Regions that are not recipients of the additional financing all see investment decline by less than 4% and reductions are fairly evenly distributed in relative terms. Reductions are greatest in the EU and smallest in India.

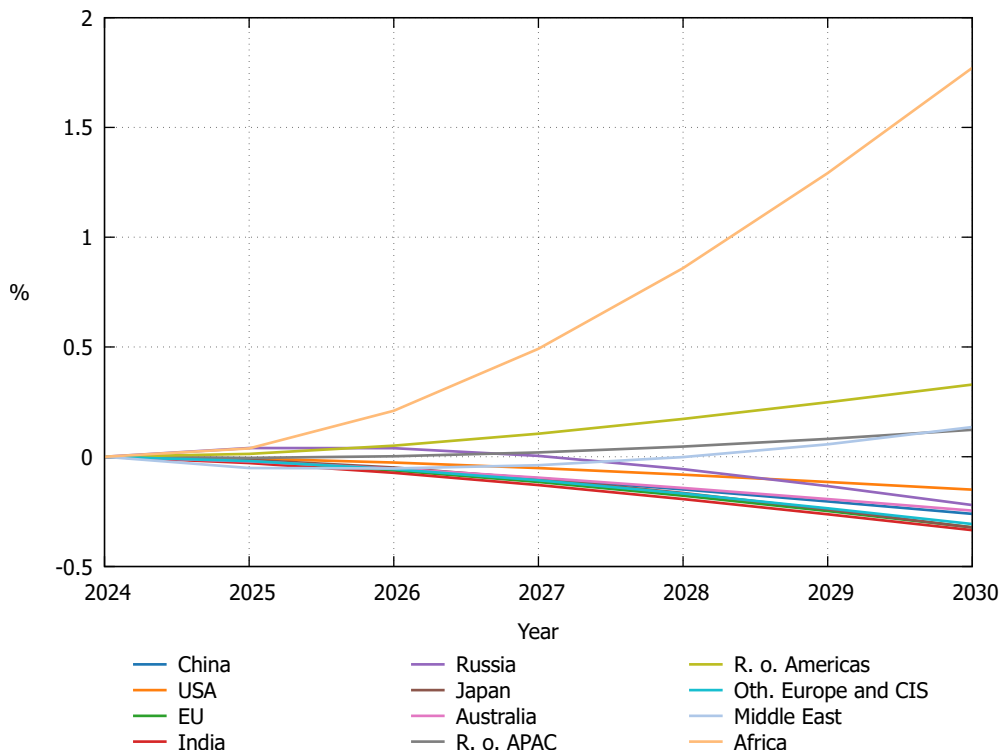
Figure 11: Deviation in real investment with conditional targets and increased financing



The impact of the shocks to emissions and investment on real GDP in the conditional emissions targets with increased financing scenario are shown, relative to that in the unconditional emissions targets with minimal financing scenario, in Figure 12. The shapes of these deviations roughly mirror those

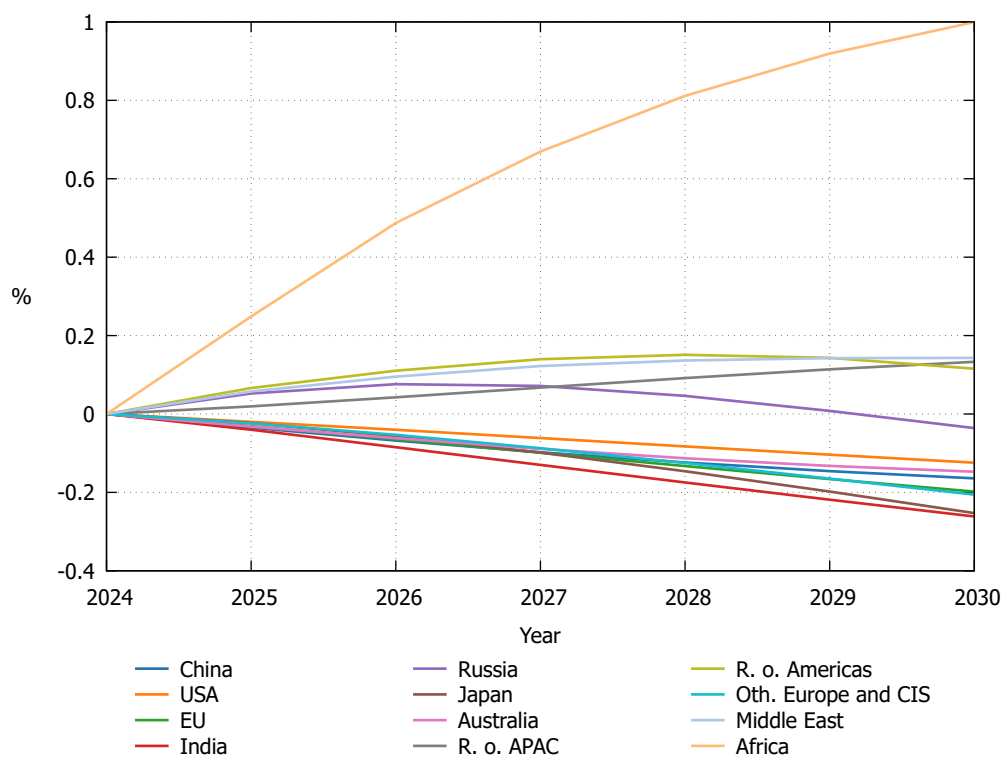
for investment, shown in Figure 11, but are smaller in magnitude due to investment only constituting a portion of GDP.

Figure 12: Deviation in real GDP with conditional targets and increased climate financing



It is important to note that the benefits of the increased economic activity generated by the additional investment are not entirely retained within the regions where the investment takes place. We can see by comparing the deviations in real Gross National Income (GNI), shown in Figure 13, to those of GDP in Figure 12 that the impacts on income do not increase at the same rate as impacts on GDP. This is due to increasing foreign capital ownership shares.

Figure 13: Deviation in GNI with conditional targets and increased climate financing



In this scenario, increased zero-emissions electricity generation crowds out economic activity in other sectors and the additional investment also results in higher consumer prices, as shown in Table 1. Most notably, consumer prices are more than 4% higher in Africa in 2030 in the conditional emissions targets with increased climate financing scenario.

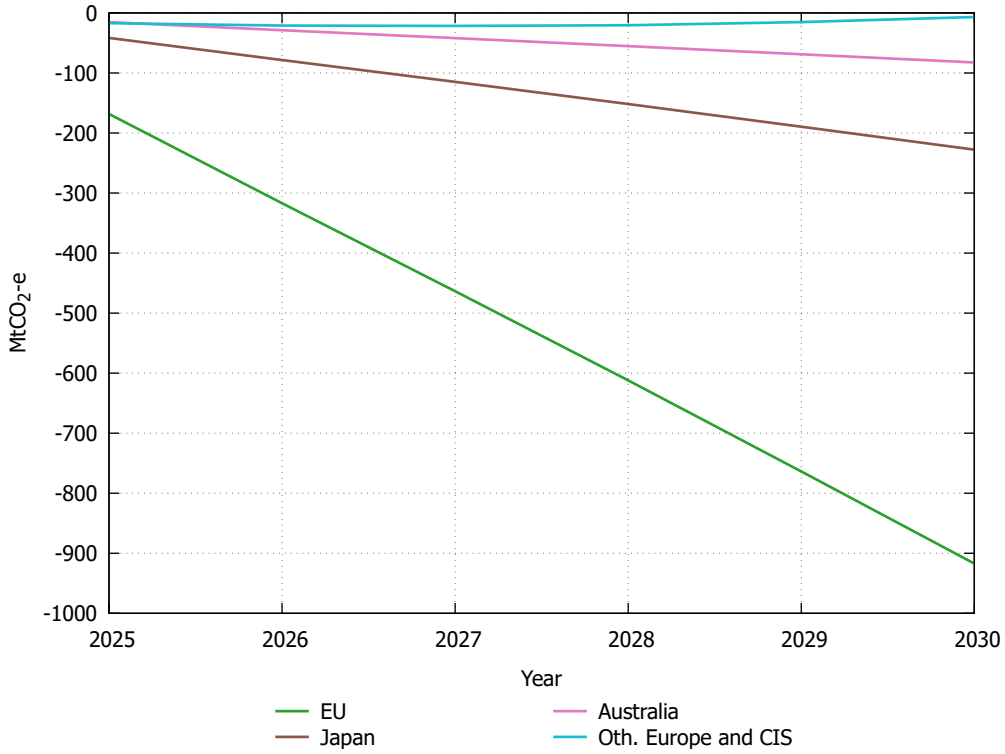
Table 1: Deviation in consumer prices for recipients of additional climate financing in 2030

Region	Deviation
Rest of Asia and the Pacific	0.3%
Rest of the Americas	1.1%
Middle East	1.1%
Africa	4.2%

4.3. More ambitious Annex I emissions targets scenario

The differences in emissions in non-Annex I regions between the conditional and unconditional scenarios, shown in Figure 8, are summed to get the total difference in emissions from those regions between the two scenarios, as shown in Equation 14. To achieve the same level of emissions reduction, these were distributed amongst Annex I regions with binding emissions targets in the unconditional emissions targets scenario, as described by Equation 15. The additional reductions in these regions that are produced by that equation are shown in Figure 14.

Figure 14: Difference between emissions in more ambitious and unconditional scenarios



These additional reductions in emissions result in the deviations in emissions shown in Figure 15. Not shown are the non-Annex I regions that received additional climate finance in the conditional scenario, as the deviations there are approximately the opposite of those shown in Figure 10. The reductions in the EU are significant, with emissions there in 2030 almost 42% lower than their unconditional target.

Figure 15: Deviation in emissions between unconditional and ambitious Annex I scenarios

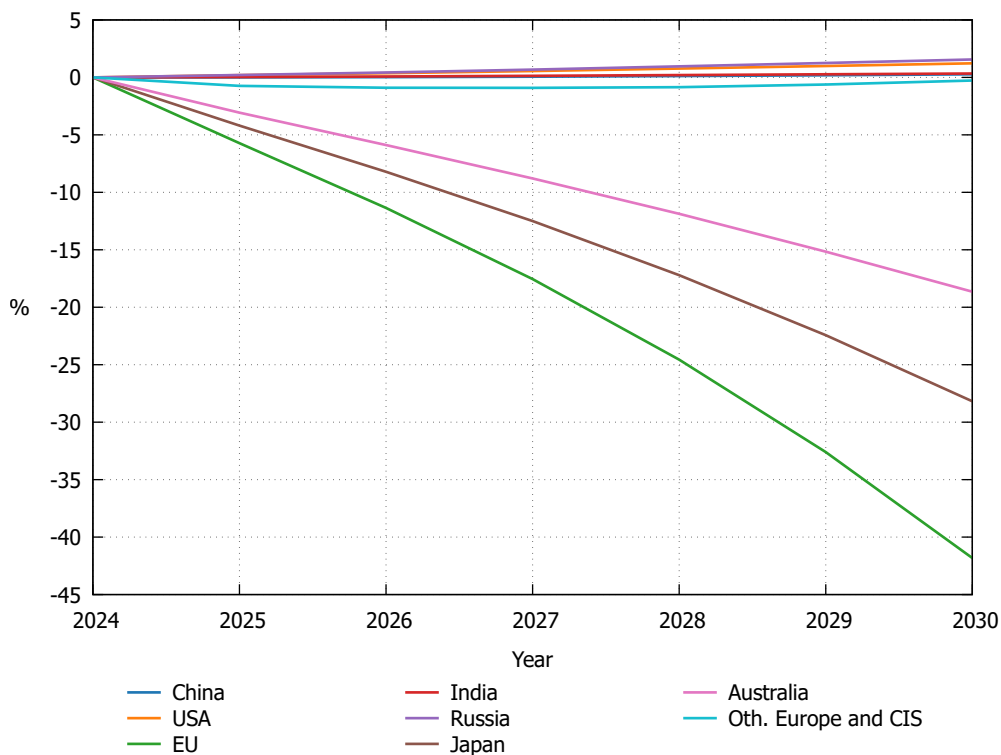
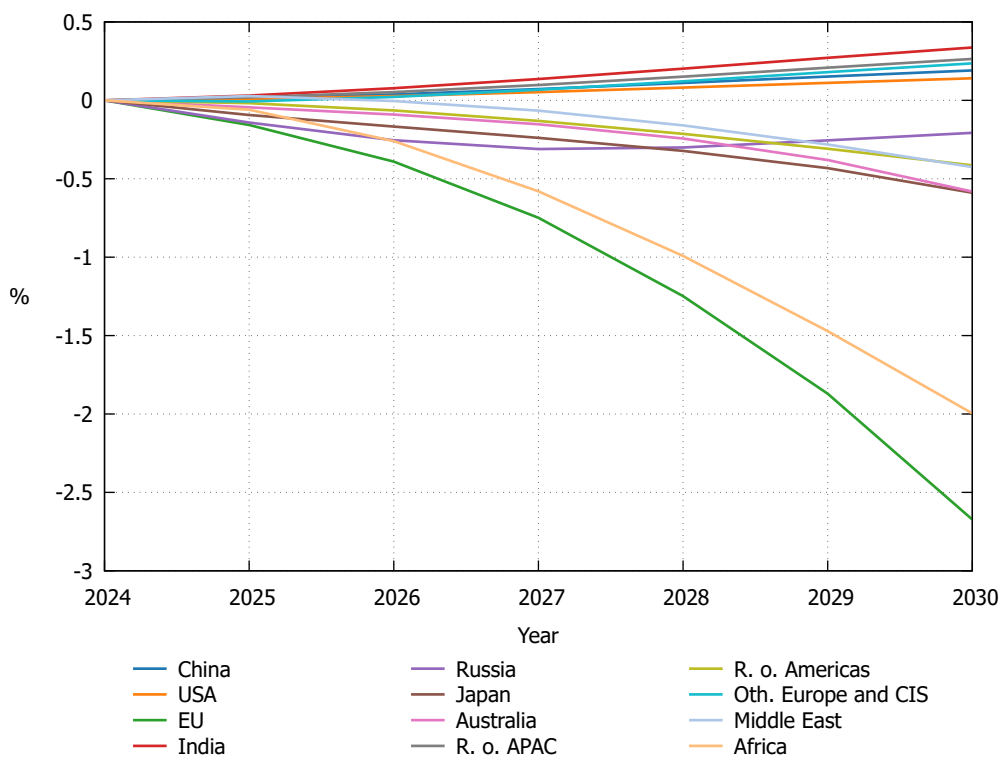


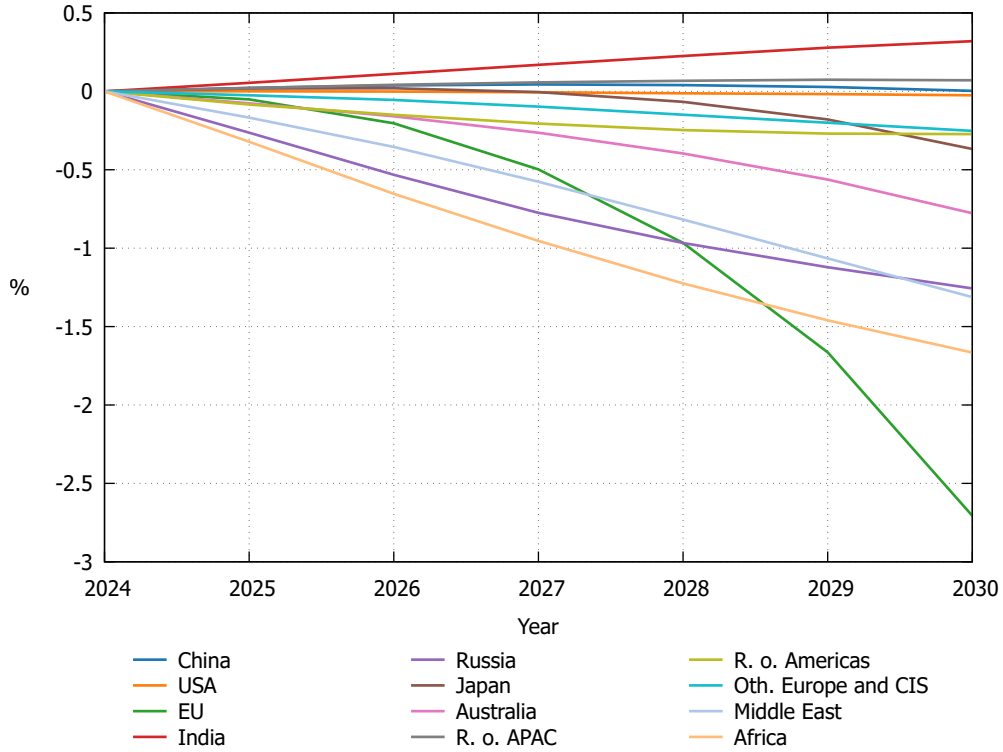
Figure 16 shows deviations in regional production between the conditional emissions targets with increased climate financing scenario and this more ambitious Annex I emissions targets with minimal climate financing scenario. Production declines in all regions that have absolute and binding emissions targets in the unconditional emissions targets scenario. In regions with emissions-intensity or non-binding emissions targets, production increases, with the exception of Russia, where production declines due to lost fossil fuel sales to a much more ambitious EU. Increasing production results in carbon leakage, as emitters increase production in regions where targets are non-binding or where there are emissions intensity targets.

Figure 16: Deviation in real GDP with conditional targets and increased climate financing



Impacts on real GNI, shown in Figure 17, are much the same as those on GDP, with some exceptions. Impacts on income in Russia and the Middle East are worse than those on GDP when additional emissions reductions are in Annex I regions. The differences in Russia and the Middle East are largely due to price effects, with the terms of trade falling by more in these two regions than in all regions other than Africa, as shown in Figure 18.

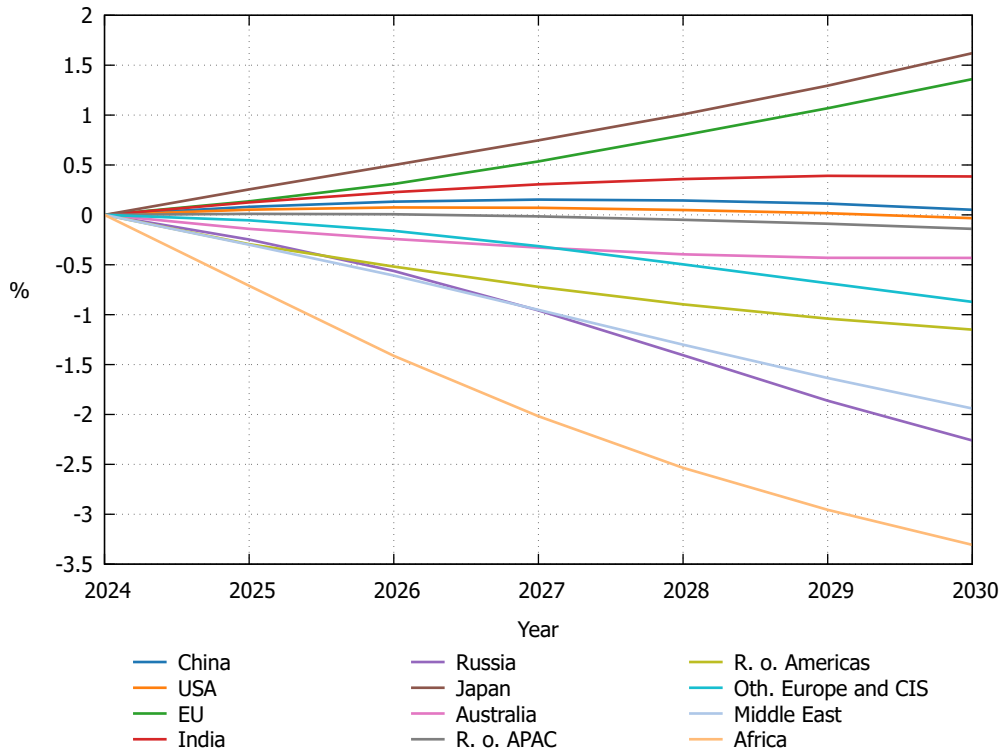
Figure 17: Deviation in GNI with more ambitious Annex I vs conditional scenario



Importantly, Annex I regions that undertake additional emissions reductions (to make up for the less ambitious reductions in non-Annex I regions when they don't receive climate financing) are significantly worse off. Even the USA, a free rider in all scenarios, sees its income decline by 0.03% in real terms due to a reduction in demand for its exports. Real GNI in the EU is more than 2.7% lower in 2030 due to the cost of additional emissions reductions. Those additional costs push up production costs significantly, resulting in the positive impact on the terms of trade shown in Figure 18, but also resulting in a significant worsening of the trade balance due to a reduction in exports - the increase in costs makes them significantly less competitive.

Although no attempt is made here to simulate the effects of the EU’s Carbon Border Adjustment Mechanism (CBAM), that omission will not have a significant effect on the impact on exports estimated here. If anything, the CBAM would exacerbate the increase in production costs by driving up the costs of imported intermediate inputs.

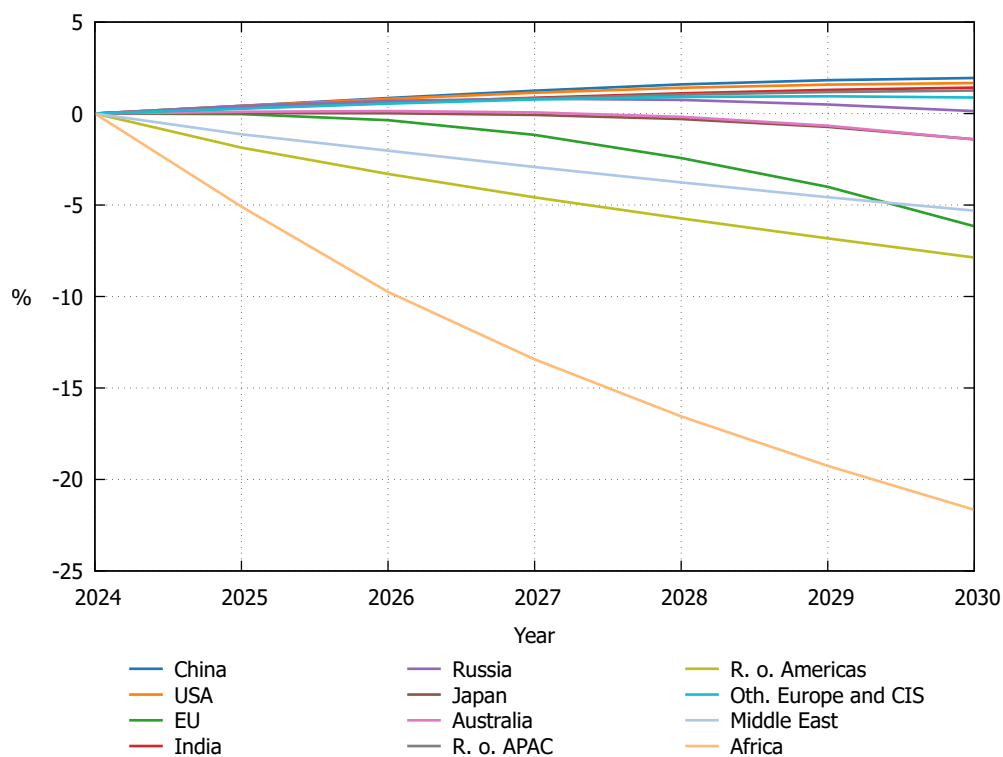
Figure 18: Deviation in terms of trade between more ambitious Annex I and conditional scenarios



Income from labour and capital both fall in the EU in this scenario, relative to the conditional emissions with increased climate financing scenario. A drop in factor income from the services sector makes up the bulk of the reduction in income. This is largely caused by the drop in investment shown

in Figure 16. Despite the EU being the worst affected in terms of lost investment in the conditional emissions targets with increased climate financing scenario, as shown in Figure 11, investment there is significantly lower when they attempt to do a significant share of those same emissions reductions (as shown in Figure 14) themselves. The impacts on investment are shown in Figure 19.

Figure 19: Deviation in real investment with more ambitious Annex I vs conditional scenario



Investment is driven down by the rate of return, which is 2.7% lower in the EU in 2030 in the more ambitious Annex I emissions targets with minimal climate financing scenario. In Africa, on the other hand, the rate

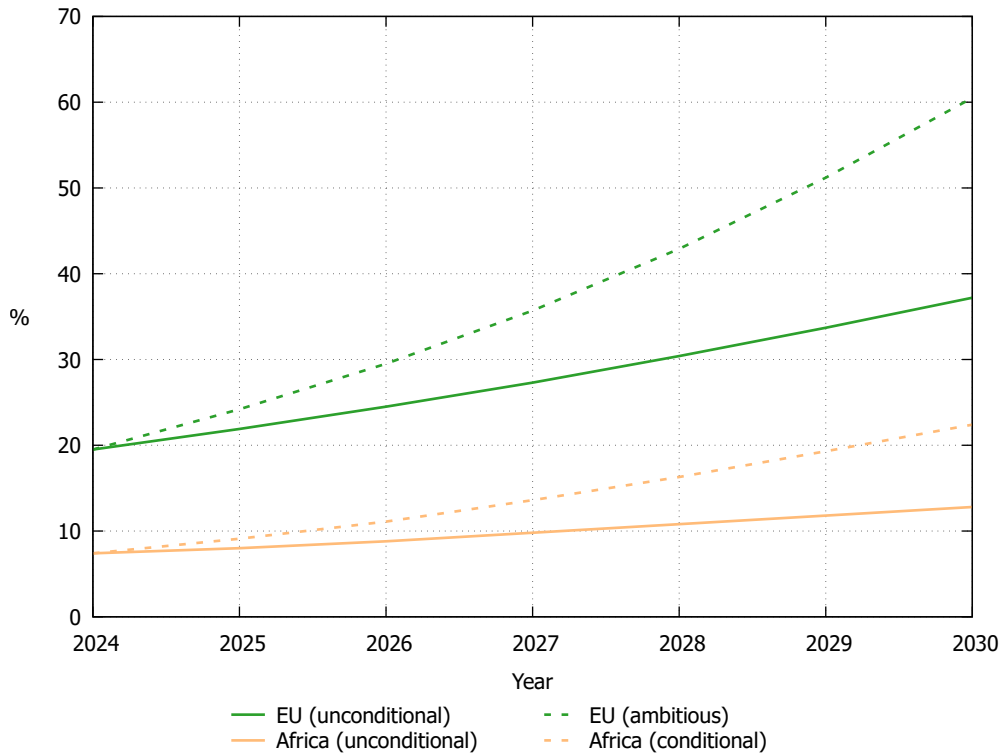
of return is 4.4% higher, though investors accept a lower rate of return to achieve our climate goals in the conditional emissions targets with increased climate financing scenario.

Increases in energy prices are the main reason for the increases in the costs of production in the EU in this scenario. Energy-intensive industries, for example, are paying 28% more for energy relative to the conditional emissions targets with increased climate financing scenario. In Africa, energy costs for energy-intensive industries are 12% lower, which also contributes to the higher rate of return there in this scenario.

Energy prices are driven by emissions pricing. As the only way to reduce emissions in this model is to substitute emissions-intensive energy commodities for those with lower emissions, emissions prices must rise so that they result in the changes in emissions being imposed. Figure 20 shows the effect of the emissions prices on the combined shares of nuclear, solar, wind and other renewable electricity generation in the Total Final Consumption (TFC) of energy in the EU and Africa. These two regions are shown as examples as emissions reductions are largest there in the conditional and ambitious scenarios. The starting share in the EU is more than double that in Africa. As the shares get higher, the marginal cost of abatement rises, so abatement is cheaper in regions where historical abatement has been less ambitious. This explains why Annex I regions see their incomes decline, as shown in Figure 17, in the more ambitious Annex I emissions with minimal climate financing scenario relative to those in the conditional emissions targets with

increased climate financing scenario - the increased cost of local abatement outweighs any potential gains from not providing additional finances to non-Annex I regions with conditional targets.

Figure 20: Shares of low- and zero-emissions electricity in TFC of energy



At the global level the results are negative impacts on all key measures in 2030: global average rates of return are 4.5 basis points lower and global investment is 3.5% lower; prices received for factor inputs are 0.6% lower; the average world price of trade is 0.4% higher and the volume of trade is 2.0% lower; world incomes are between \$543 and \$580 billion lower depending on the method used for calculating equivalent variation.

5. Conclusion

This analysis finds that, at the global level, it is beneficial for Annex I countries to commit to increase climate financing from the minimum level of \$200 billion in 2030 to \$700 billion, which are approximately linear trajectories to the NCQG on climate finance. The associated reductions in emissions by non-Annex I regions, as per conditional emissions targets in their NDCs, cannot be achieved by Annex I regions without negative impacts on their incomes, beyond what would occur if they provided the additional climate finance. At the regional level, if Annex I regions reduce their emissions by the same amount as the difference between conditional and unconditional emissions reduction commitments by non-Annex I regions, all Annex I regions see their incomes decline as a result of the additional costs involved, including the USA, which, even as a free rider, suffers due to decreased demand for their exports by other regions. Conversely, investing in non-Annex I regions significantly increases production and incomes there. However, there are issues to be managed in recipient regions - rising shares of foreign capital ownership, increased inflation and the crowding out of economic activities not focussed on emissions mitigation.

From an environmental perspective, more ambition is necessary. Globally, emissions continue to grow over the rest of the decade in all scenarios, setting the world on a path to exceed the temperature goals of the Paris Agreement. There is scope for increased ambition, with negative impacts on real incomes in the scenario with conditional emissions targets and increased climate financing smaller than -0.3% in all regions, relative to the scenario with

unconditional emissions targets and minimal climate financing. Large discrepancies between emissions per capita persist and higher income countries with high emissions per capita should be subjected to pressure to contribute to global emissions mitigation efforts.

Appendix A. Aggregation

Table A.1: Regional aggregation

Region	GTAP regions
China	chn, hkg
USA	usa
India	ind
Russia	rus
Japan	jpn
The European Union (EU)	aut, bel, bgr, hrv, cyp, cze, dnk, est, fin, fra, deu, grc, hun, irl, ita, lva, ltu, lux, mlt, nld, pol, prt, rou, svk, svn, esp, swe
Australia	aus
Rest of the Americas	can, mex, xna, arg, bol, bra, chl, col, ecu, pry, per, ury, ven, xsm, cri, gtm, hnd, nic, pan, slv, xca, dom, jam, pri, tto, xcb
Rest of Asia and the Pacific	nzl, xoc, kor, mng, twn, xea, brn, khm, idn, lao, mys, phl, sgp, tha, vnm, xse, bgd, npl, pak, lka, xsa, xtw
Rest of Europe and the former Soviet Union	gbr, che, nor, xef, alb, blr, ukr, xee, srb, xer, kaz, kgz, tjk, xsu, arm, aze, geo, tur
The Middle East	bhr, irn, isr, jor, kwt, omn, qat, sau, are, xws
Africa	egy, mar, tun, xnf, ben, bfa, cmr, civ, gha, gin, nga, sen, tgo, xwf, xcf, xac, eth, ken, mdg, mwi, mus, moz, rwa, tza, uga, zmb, zwe, xec, bwa, nam, zaf, xsc

Table A.2: Sectoral aggregation

Sector	GTAP sectors
Primary and secondary rice production	pdr, pcr
Wheat, cereal and grain farming	wht, gro
Vegetables, fruit, nuts	v_f
Production of vegetable and seed oils	osd, vol
Farming and processing of sugar	c_b, sgr
Plant-based fibers	pfb
Crops nec	ocr
Grazing and processing of all grazing animals	ctl, cmt
Animal products nec	oap
Raw milk	rmk
Wool, silk-worm cocoons	wol
Forestry	frs
Fishing	fish
Coal mining	coa
Crude oil	oil
Natural gas extraction, manufacture and distribution	gas, gdt
Other mining	oxt
Meat products nec	omt
Dairy products	mil
Other food, beverage and tobacco products	ofd, b_t
Refined oil products	p_c

Table continues on next page

Table A.2: (continued)

Sector	GTAP sectors
Energy-intensive industries	chm, nmm, i_s, nfm
Electricity	ely
Water	wtr
Sea transport	wtp
Air transport	atp
Other transport	otp
Services	cns, trd, afs, whs, cmn, ofi, ins, rsa, obs, ros, osg, edu, hht, dwe
Other industry	tex, wap, lea, lum, ppp, bph, rpp, fmp, ele, eeq, ome, mvh, otn, omf

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