Climate Change Economics  
Assignment 2

UC Berkeley  
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# Overview

This week’s assignment has two sections. First you will extend your Excel model from last week to include a component that computes emissions (Section 1). Second, you will construct an option for emissions reduction policies (Section 2).

# Section 1: Compute Emissions

# Part I: Modeling

## Overview

You will add a component that computes anthropogenic CO2 emissions over time to your model.

The output of the emissions component will replace the forcing for the carbon cycle component you built last week, i.e. instead of using a forcing provided by me for emissions, you will couple the carbon cycle component to the emissions component.

The new component will rely on various forcings, and those are provided to you in the Excel file “CCE – Assignment 2 – Forcings.xlsx.”

This week’s assignment will have less detailed descriptions of what to do and more things for you to figure out yourself. If you are stuck at any point, please ask for help in class!

## Emissions model

The emissions component starts out with the Kaya identity:

are industrial CO2 emissions in Mt C at time , is population at time , is output (or GDP or income) at time and is energy use in EJ (exajoule) at time .

I will provide you with forcings for all components of the Kaya identity. But, the forcings are not provided in a way that you can input into equation (1) straight away. There are two issues you need to be careful about: a) units and b) levels vs. growth rates.

The forcing for population is provided as the initial level for 2010, and then yearly growth rates of population for all future years. The initial population level for 2010 is 6900 million people. Growth rates are given in the usual format, i.e. a value of 0.1 corresponds to 10%, 0.01 is 1% and 1.0 is 100%.

The initial level of per capita income in 2010 is 8.5 thousand dollars per capita, for later years you need to compute the levels yourself from the yearly growth rate of per capita income that is provided as a forcing.

The initial level of energy intensity for the year 2010 is 5.98 EJ per trillion $ of output. Careful with units at this point, you will have to adjust the Kaya identity a bit to make units match. For years later than 2010, I provide you with yearly growth rates of energy intensity which allows you to compute energy intensity levels for future years.

The initial level of carbon intensity is 18.62 Mt C per EJ of energy for the year 2010. You need to use the growth rate of emission intensity provided to you as a forcing to compute the carbon intensity for future years.

At this point we have computed emissions from industrial activities, assuming no specific climate policy is implemented. There is a second source of anthropogenic CO2 emissions that we are not going to model explicitly, but instead include as another forcing: Land use emissions, which are provided to you as a forcing in Mt C. This category mostly covers extra emissions caused by deforestation. Total business as usual (BAU) emissions are therefore given as:

## Coupling

The last step is to couple the carbon cycle component with the emissions component; instead of using a forcing for the carbon cycle, you now use the emissions computed in the emissions component.

# Part II: Policy Analysis

## Question 1: Decompose the main drivers of climate change in the scenario used in the model and rank their relative contribution to future climate change.

First create four copies of the model, so that altogether you now have five copies of the model. Each copy of the model should be a separate Excel sheet in the same Excel file.

Now change each of the four copies such that one of the Kaya identity factors is kept constant at 2010 levels in a sheet. This amounts to assuming that e.g. population stays constant, or per capita output stays constant etc.

Finally, create another empty sheet and add a graph that plots world average temperature above pre-industrial levels over time for each of the five cases: BAU, population constant, per capita output constant, energy intensity constant and emission intensity constant.

Briefly describe the effect each of these has on average temperatures, and rank them in terms of the size of their effect

# Section 2: Emissions Reduction Policies

This section has two parts: 1) you will extend your Excel model to include an option for emission reduction policies and 2) then analyze two different climate policies.

# Part I: Modeling

## Overview

The model from Section 1 computes emissions assuming that no climate policy is implemented. Now you will add a component for emission reductions due to climate policy.

This section’s modification once again requires some external forcings, which are provided in the Excel file “CCE – Assignment 2 – Forcings.xlsx.”

## Emission reduction option

This section’s new component is an option for climate policy. In order to model this, we will have to introduce a so-called choice variable: the emission control rate. This is a new type of variable; unlike a forcing that is provided as part of the exercise, or a normal variable, which is computed by some given equation, a choice variable is something we want to find a good value for by using our model. The emission control rate is such a choice variable; later we want to use our model to compute the amount by which we should reduce CO2 emissions per year in order to reach a given objective (and most often that objective will be some balancing act of costs and benefits of reducing emissions). For now, just introduce a new row in your Excel spreadsheet for this choice variable, it will have a value for each year and you’ll initially set the control rate to 0% (i.e. no climate policy). We will designate the emission control rate by .

The new final equation for emissions therefore is

Make sure you now couple the carbon cycle model to this new variable !

We assume throughout our model that carbon policy is costly. So any choice of larger than 0% will impose a burden on the economy. We compute the size of this burden, also called abatement cost, by a simple cost function:

is the cost of climate policy at time as a share of GDP at time , is a parameter that changes over time (so in our nomenclature really a forcing) that is provided to you, and is another parameter that you should set to 2.8. You should add another row for the variable to your model.

Finally, in addition to , you should add one more variable to your Excel sheet that computes the cost of climate policy in trillion dollars for each year.

# Part II: Policy Analysis

## Question 1: You will look at two different carbon policy time profiles today and analyze how they affect environmental outcomes and economic cost. The first policy assumes that no climate mitigation is done until the year 2030. Starting in the year 2100 all emissions are mitigated until the end of the model time horizon. The years 2030-2100 see a gradual tightening of climate policy: each year the emission control rate is increased by the same number of percentage points. You should pick the yearly increase such that the emission reduction starts out at 0% in 2030 and ends at 100% in 2100 with equal steps in between. The second policy you analyze starts to tighten in 2010 already, and again reaches a 100% in 2100. Again you should pick the yearly increase in the control rate such that the point increase from year to year of the emission control rate is constant.

You should create a separate sheet for each of these policies by making copies of the original model. Hint: to create the smooth increasing emission control rates you can use Excel’s Fill Series feature.

Finally, create another sheet in Excel with two graphs. The first should plot temperature for the base case and the two policy cases, the second should plot abatement costs for the same set of scenarios.