Global Policy Analysis Using the Toy IGSM

Problem Set #4

Question #1. Economic and Climatic Uncertainty
Your task in this part is to perform three no-policy runs of the EPPA model, and analyze their impacts on temperature change, taking into account uncertainty in the climate system. Each run is based on different values of the uncertain economic parameters:

1. **RR** Reference economic growth and energy efficiency in all regions
2. **HL** High economic growth and Low energy efficiency in all regions
3. **LH** Low economic growth and High energy efficiency in all regions

For each run you will construct a probability density function (PDF) of global mean temperature change in the years 2050 and 2100. To do this, you will input combinations of values for the three uncertain climate parameters–ocean diffusivity (Kv), climate sensitivity (S) and aerosol forcing (Faer), and record the resulting temperature changes in 2050 and 2100 shown on the graph at the bottom of the **EPPA Graphs** spreadsheet in the workbook **eppa.xls**. The list of parameter combinations is shown below:

Kv	S	Faer
1	2	0.5
4	4	1
7		

These parameter combinations are not thought to occur with equal probability. Using data and expert judgment, the following prior probability distribution over the three parameters has been developed. Based on their work, assign the following probabilities to the inputs above:

Kv	Prob.	S	Prob.	Faer	Prob.
1	0.04	2	0.29	0.5	0.31
4	0.70	4	0.71	1	0.69
7	0.26				

These combinations are shown in the event tree at the end of this note, which has only event nodes. To run the model unconstrained to 2100, set Brazil's emission constraint in 2100 to 750 and leave all other cells blank.)

Part 1A. Using the event tree as a guide, systematically vary the climate parameters in the model, and for each combination record the temperature change and calculate the probability of its occurrence. (Hint: check that all of the probabilities sum to one!) Then, for 2050 and 2100 draw separate graphs of the resulting probability density functions (probability on the y-axis, warming on the x-axis) for the three no-policy cases RR, HL and LH. In constructing the PDFs, use a temperature range of 0°C to 7°C with 0.5°C increments. (Excel provides convenient functionality for this task.) The probabilities on the y-axis will be the aggregated probability that the occurrence of warming falls into each 0.5°C "bin". To facilitate comparison, plot three cases together on each graph.

Part 1B. On the assumption that the three economic scenarios are equally likely, explain which contributes more to uncertainty about global warming in a no-policy world: economic uncertainty or climatic uncertainty. Show your analysis and explain briefly.

Question #2. Discounting, and the Costs and Benefits of Abatement Under Certainty
One important factor in the global climate negotiations is the extent to which countries differ in their perceptions of the costs and benefits of abating GHGs. For this question the task is to analyze how regional climate damages—and the costs of avoiding those damages—can change a region's decision to accede to a GHG control regime.

Assume that climate damages (*D*) in each region of the world due to average global temperature change (*T*) can be accurately represented by damage functions of the form $D = \alpha T + \beta T^2$, where *D* measures the percentage GDP loss in each year. Assume also that, for the EPPA regions, the parameters α and β vary as follows:

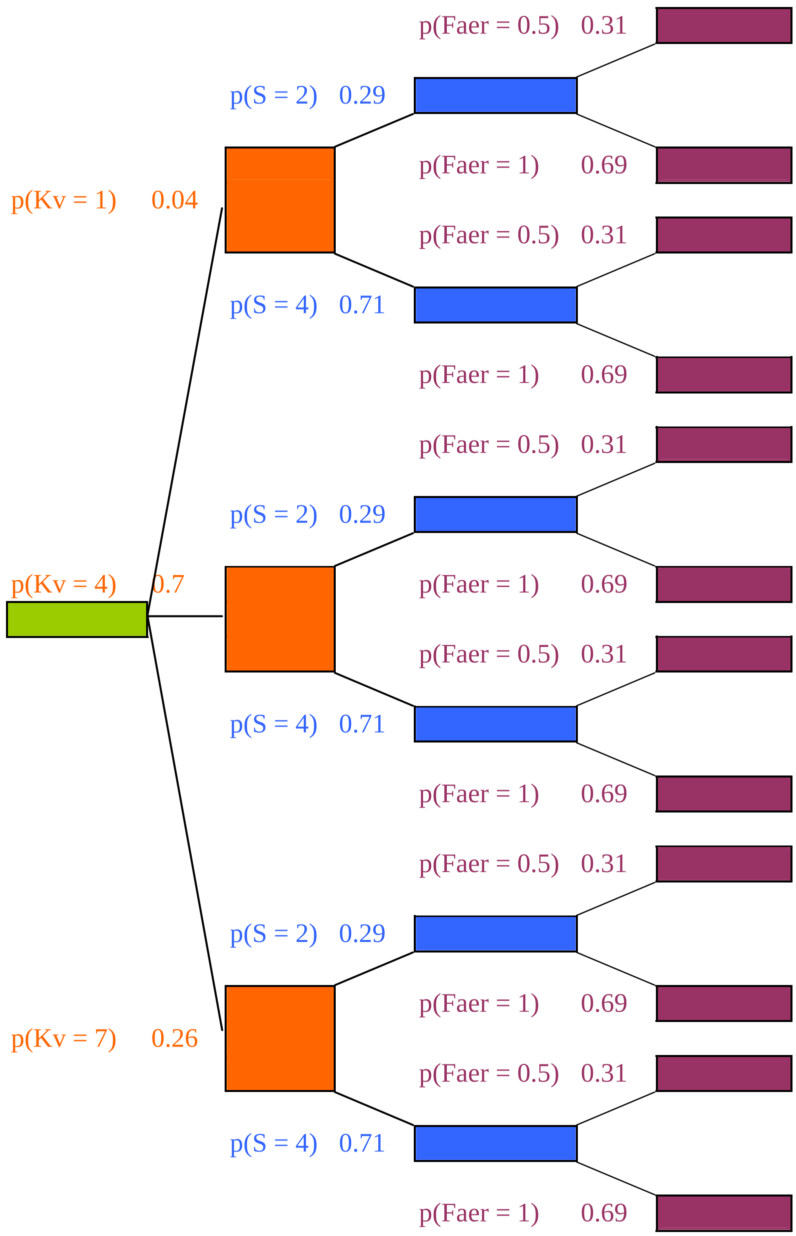
Region	α	β
USA	-0.013	0.0085
JPN	-0.021	0.0125
EEC	-0.005	0.0245
OOE	-0.054	0.0185
EET	-0.026	0.0095
FSU	-0.054	0.0165
EEX	0.0435	0.0085
CHN	-0.0205	0.01
IND	0.037	0.0245
DAE	0.0195	0.0065
BRA	0.0195	0.0065
ROW	0.0785	0.005

Further assume that the relevant climate parameters are the means of those in Part 1, which (to the accuracy of the Toy model choices) is S = 3.5; Faer = 0.75; Kv = 3.0.

Part 2A. Under the no-policy emissions scenario, calculate the present value of GDP, adjusted for climate damages, in each region for discount rates of 3% and 1%. To do this, run the EPPA model without policy constraints (again, set Brazil to 750 in 2100 in order to do this). Save the regional GDP series from the **EPPA Results** spreadsheet, and save the resulting global mean temperature series which can be extracted from the temperature change graph in the **EPPA Graphs** window. Calculate *D*, the percentage of GDP lost in each period due to climate damages. Finally, calculate the present value of adjusted GDP under business-as-usual conditions (i.e., the present value of the time-path of $(1 - D) \times$ GDP).

Part 2B. One proposal in the international climate negotiations is for all regions to reduce their emissions at 1% per year from the year 2010—i.e., by 5% in each 5-year commitment period from 2010 to 2100 (use the "Reset Display to Reference Values" button to determine what the 2010 emissions will be). Run this case in the EPPA model (with trading among all regions) and calculate the present value of the change in GDP from the no-policy case, considering both the costs of GHG control and climate damages, for annual discount rates of 3% and 1%. To do this, follow the same procedure as before.

Explain which regions would support the proposal, on the assumption that all others would follow it (i.e., no region would free-ride on the abatement efforts of others), and further assuming that their policy choices are driven purely by the domestic economic implications.


p(Faer = 0.5) 0.31
p(S = 2) 0.29
p(Faer = 1) 0.69
p(Kv = 1) 0.04
p(Faer = 0.5) 0.31
p(S = 4) 0.71
p(Faer = 1) 0.69
p(Faer = 0.5) 0.31
p(S = 2) 0.29
p(Kv = 4) 0.7
p(Faer = 1) 0.69
p(Faer = 0.5) 0.31
p(S = 4) 0.71
p(Faer = 1) 0.69
p(Faer = 0.5) 0.31
p(S = 2) 0.29
p(Faer = 1) 0.69
p(Kv = 7) 0.26
p(Faer = 0.5) 0.31
p(S = 4) 0.71
p(Faer = 1) 0.69

Question #3. Stabilization of Atmospheric CO_2

In this part you will examine what is needed to achieve stabilization of atmospheric CO_2. Remember that the CO_2 concentration in the atmosphere is stable if emissions equal total uptake.

Use the new version of the EPPA model in Excel[1], which has an additional spreadsheet that calculates the atmospheric CO_2 concentration as well as the total uptake of carbon from the atmosphere by the ocean and land sinks.

Part 3A. Set emissions contraints for the United States, Japan, The European Union, and the rest of the OECD (the first four columns) at a constant 1990 value from 2005 through 2100. Allow all other countries to emit according to the reference run. Describe what happens to the global mean temperature, the atmospheric CO_2 concentration, and the uptake of carbon by the ocean and land sinks. Does this emissions scenario achieve stabilization of atmospheric CO_2 by 2100? If not, how far off is it (in Gt/year)?

Part 3B. Let us see what happens if ALL countries have to keep their emissions stable throughout the coming century. For all regions, set their emissions from 2005 through 2100 at the 1990 value. Describe what happens to the global mean temperature, the atmospheric CO_2 concentration, and the uptake of carbon by the ocean and land sinks. Does this emissions scenario achieve stabilization of atmospheric CO_2 by 2100? If not, how far off is it (in Gt/year)? Describe briefly any political, social, and moral problems and consequences of adopting such an emissions scenario.

Part 3C. Suggest a **fair** way of achieving the stabilization of atmospheric CO_2 concentrations at approximately 550 ppm. Do this by imposing emissions constraints on individual countries and regions in a way that you consider to be fair. The constraints may vary in time. Explain your reasoning, and justify the constraints you impose on individual countries and regions. (You do not need to successfully achieve 550 ppm stabilization according to the Toy Model in order to gain full credit on this problem as long as the emissions profile is believable).

[1] Concentration and uptake are both predicted using regressions on the full IGSM – again, this means that outside the bounds of the regression the model may not give realistic results.