How delayed learning about climate uncertainty impacts decarbonization investment strategies

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Reproduction code package for "How delayed learning about climate uncertainty impacts decarbonization investment strategies"

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To cite our working paper that uses these codes: Bauer, A. M., F. McIsaac, S. Hallegatte. *How Delayed Learning about Climate Uncertainty Impacts Decarbonization Investment Strategies.* World Bank Policy Research Working Paper No. WPS10743, World Bank Group, Washington DC, 2024.

General package overview

This set of codes reproduces all of the figures and analysis carried out in *How delayed learning about climate uncertainty impacts decarbonization investment strategies.* This package uses Gurobi, a commerical nonlinear programming solver that is free for academics, but may not be free for everyone. (It is unclear to me if it's freely available for *all* researchers or just researchers *at universities.* I imagine Gurobi will handle this on a case-by-case basis, so just shoot their customer support staff an email and they can help.)

Each code is assigned a number corresponding to the figure it creates; the number matches the working paper figures. So code `01_xxx.py` makes Figure 1, which shows our calibration of the marginal abatement cost curves, and so on. Here is the full table for both versions:

Figure Desired	Code to Run
Figure 1: Calibrating marginal abatement costs	`01_mac_calibration.sh`
Figure 2: Effect of delayed learning on aggregate policy cost	`02_effect_of_learning_low_linear.sh`
Figure 3: Effect of delayed learning on the temporal distribution of spending	`03_temporal_redistribution_low_linear.sh`
Figure 4: Effect of delayed learning on sectoral allocation of abatement investment	`04_sectoral_response.sh`
Figure 5: Effect of delayed learning on the carbon price	`05_carbon_price_response.sh`
Figure 6: Effect of delayed learning on aggregate policy cost including direct air capture technologies	`06_dac_effect_of_learning.sh`
Figure 7: Impact of delayed learning on sectoral allocation of abatement investment when direct air capture technologies are present	`07_dac_vs_no_dac_comp.sh`
Figure 8: Effect of delayed learning on aggregate policy cost, growing emissions baseline	`08_effect_of_learning_emis.sh`
Figure 9: Effect of delayed learning on the temporal distribution of spending, growing emissions baseline	`09_temporal_redistribution_emis.sh`
Figure 10: Effect of delayed learning on aggregate policy cost, high-bound calibration	`10_effect_of_learning_high_linear.sh`

Figure Desired	Code to Run
Figure 11: Effect of delayed learning on the temporal distribution of spending, high-bound calibration	`11_temporal_redistribution_high_linear.sh`
Figure 12: Effect of delayed learning on aggregate policy cost, nonlinear calibration	`12_effect_of_learning_pow.sh`
Figure 13: Effect of delayed learning on the temporal distribution of spending, nonlinear calibration	`13_temporal_redistribution_pow.sh`

If you're an academic, you can email Gurobi customer support to get a free academic license. It's easy to install, and once it's installed, I believe you'll be good to go to run the codes.

A final note is that you should consider using the `.yml` file provided in this directory to establish a virtual python environment that should include all of the necessary dependencies for the code to run smoothly. I recommend using `conda` to do this.

How to run the code

To run the codes, simply navigate to the `codes` directory and run the numbered code to recreate the desired figure. If you want to run the program `script_name`, you may need to execute:

```
chmod +x script_name
```

to grant execution permissions (hence the `+x`) to the script you want to run.

As an example, if you want to recreate Figure 1 which shows our calibration of the marginal abatement cost curves, you would simply run:

```
./01_mac_calibration.sh
```

Notice the first bit of the above program name, `01_mac_calibration.sh`, matches the figure number we wanted to create, Figure 1.

All figures will be deposited into the `codes/figs` folder. To run indiviudal simulations, you can run any of the files in `simulation_mains`, and to make individual figures, you can run any file in the `figure_mains` folder. **Note:** You should run all scripts from the `codes` directory. As an example, let's say you want to run the `invBase_cvxpy_main.py` file in the `ar6_15` calibration, but not save the output. Then in your command line, you'd use:

```
python simulation_mains/invBase_cvxpy_main.py ar6_15 1 0
```

Note: You should be operating in the Python environment provided at the head directory. Without it, I make no guarantees any of this will run on your machine (and even then, well, mileage may vary...).

Data Availability Statement for "How delayed learning about climate uncertainty impacts decarbonization investment strategies"

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All of the data used in our study is taken and/or interpreted from publically available publications and reports. Raw data is used to calibrate the numerical model. Individual numbers used in the simulations can

be found in the `codes/data/cal/` files for each simulation. All values are taken from the following papers or reports:

- Data for the remaining carbon budget and its uncertainty is taken from Dvorak *et al.*, 2022, see Table 2, the "No cessation" rows.
- Marginal abatement costs and abatement potentials in each economic sector we considered is taken from the Intergovernmental Panel on Climate Change's Sixth Assessment Report, specifically the contributions of Working Group III, Figure SPM.7 on p. 38 of the *Summary for Policymakers*. An excel spreadsheet of this data was provided to AMB by one of the authors of the IPCC Report, and is available upon request.
- Capital depreciation rates are taken from Philibert, C., 2007, see Figure 8. The capital depreciation rate is the inverse of the capital lifetime.
- The social discount rate is taken from Drupp *et al.*, 2018, their median estimate.

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