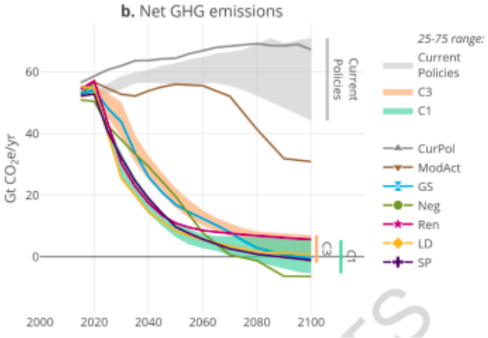
What is the evidence on climate mitigation policies, and to what extent can it be identified and classified using Machine Learning?

Max Callaghan

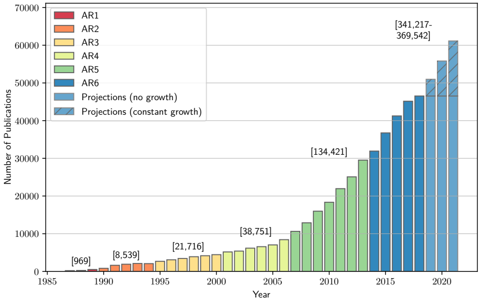
Context



AR6 WGIII Fig 3.6

- Meeting Paris goals requires an extremely rapid reversal of >100 years of rising emissions, going far beyond existing policies

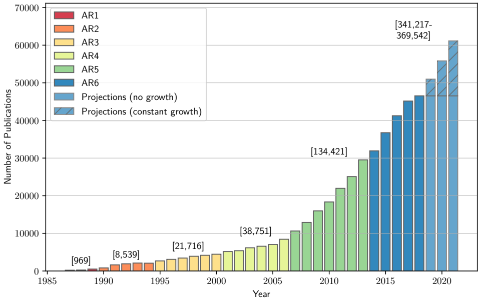
Context



Callaghan et al. (2020)

- Meeting Paris goals requires an extremely rapid reversal of >100 years of rising emissions, going far beyond existing policies
- The amount of climate policies, and the size of the scientific literature on policies is growing fast

Context



Callaghan et al. (2020)

- Meeting Paris goals requires an extremely rapid reversal of >100 years of rising emissions, going far beyond existing policies
- The amount of climate policies, and the size of the scientific literature on policies is growing fast

What instruments are studied where? How does this match with enacted instruments and emissions data?

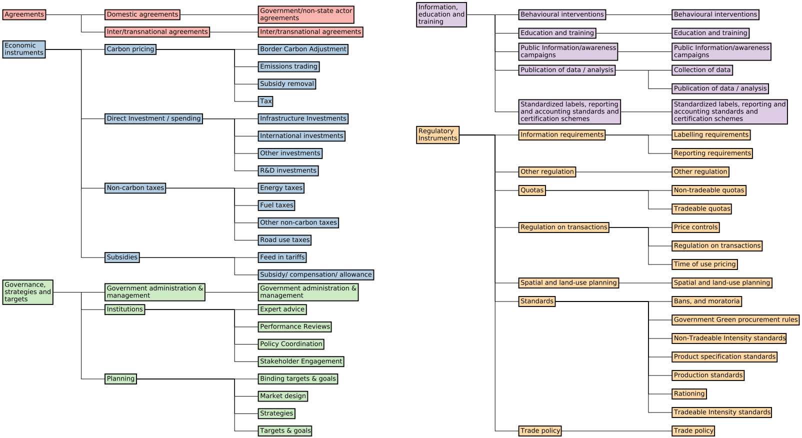
Plan

What is the evidence on climate mitigation policies, and to what extent can it be identified and classified using Machine Learning?

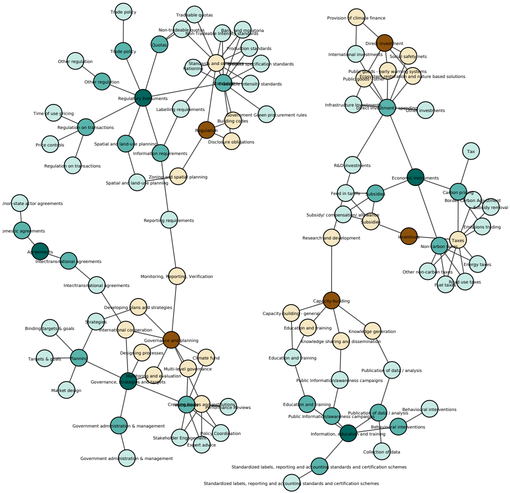
A machine-learning-assisted systematic map

- Develop a typology of climate policy instruments
- Screen and code documents by hand
- Predict labels for all other documents
- Extract geolocations
- Produce a map of what types of instruments we study in what places
- Bring this information together with policy databases / emissions

Typology

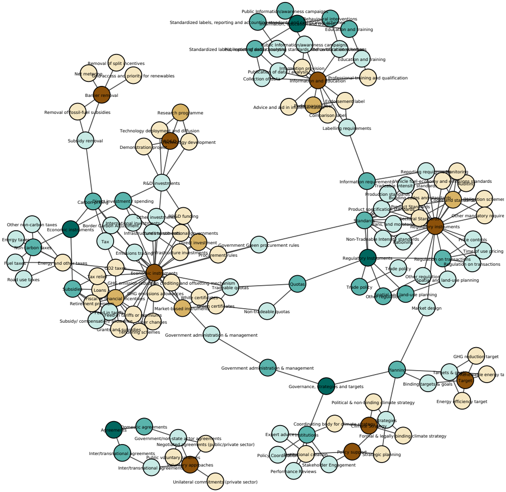

Agreements
Domestic agreements
Government/non-state actor agreements
Inter/transnational agreements
Inter/transnational agreements
Economic instruments
Carbon pricing
Border Carbon Adjustment
Emissions trading
Subsidy removal
Tax
Direct Investment / spending
Infrastructure Investments
International investments
Other investments
R&D investments
Non-carbon taxes
Energy taxes
Fuel taxes
Other non-carbon taxes
Road use taxes
Subsidies
Feed in tariffs
Subsidy/ compensation/ allowance
Governance, strategies and targets
Government administration & management
Government administration & management
Institutions
Expert advice
Performance Reviews
Policy Coordination
Stakeholder Engagement
Planning
Binding targets & goals
Market design
Strategies
Targets & goals
Information, education and training
Behavioural interventions
Behavioural interventions
Education and training
Education and training
Public Information/awareness campaigns
Public Information/awareness campaigns
Publication of data / analysis
Collection of data
Publication of data / analysis
Standardized labels, reporting and accounting standards and certification schemes
Standardized labels, reporting and accounting standards and certification schemes
Regulatory Instruments
Information requirements
Labelling requirements
Reporting requirements
Other regulation
Other regulation
Quotas
Non-tradeable quotas
Tradeable quotas
Regulation on transactions
Price controls
Regulation on transactions
Time of use pricing
Spatial and land-use planning
Spatial and land-use planning
Standards
Bans, and moratoria
Government Green procurement rules
Non-Tradeable Intensity standards
Product specification standards
Production standards
Rationing
Tradeable Intensity standards
Trade policy
Trade policy

Typology in context



- Our typology is more detailed than (Grantham Research Institute on Climate Change and the Environment and for Climate Change Law, 2022)

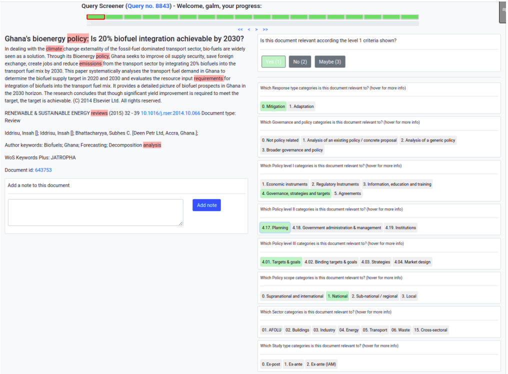
Typology in context



- Our typology is more detailed than (Grantham Research Institute on Climate Change and the Environment and for Climate Change Law, 2022)
- We provide slightly more detail than (New Climate Institute, 2020) with a [subjectively] clearer hierarchy

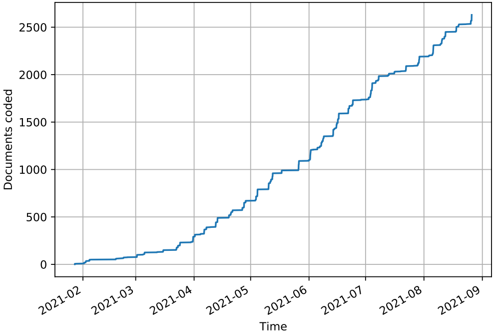
Screening

- In addition to the policy type, we coded sector, scale, and study type (ex-post/ex-ate + qual/quantitative)



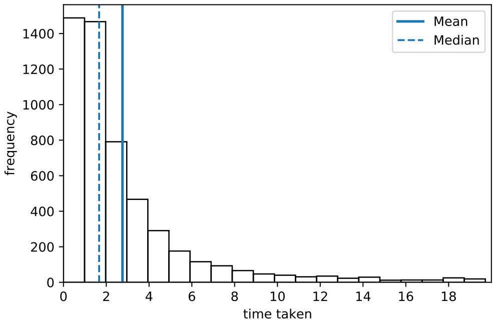
Screening

- In addition to the policy type, we coded sector, scale, and study type (ex-post/ex-ate + qual/quantitative)
- We double coded around 2,500 documents



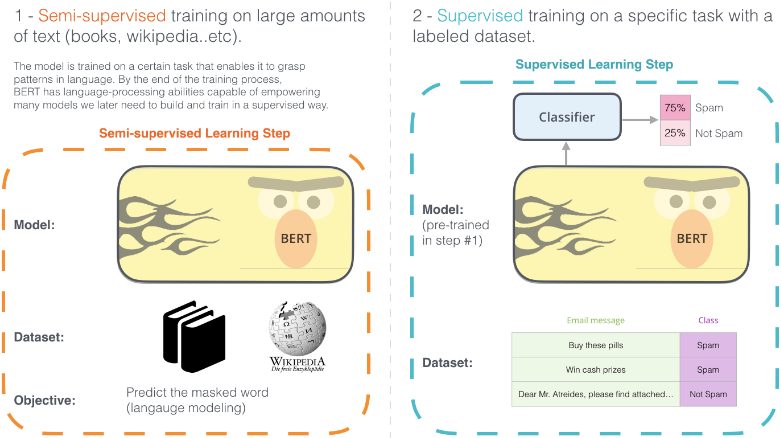
Screening

- In addition to the policy type, we coded sector, scale, and study type (ex-post/ex-ate + qual/quantitative)
- We double coded around 2,500 documents
- Each document took on average <3 minutes to code, total work is 310 person hours (just initial coding)



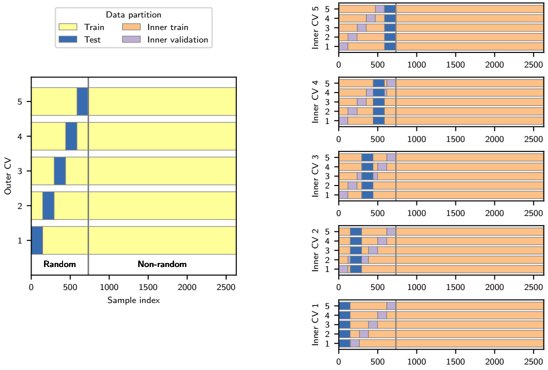
ClimateBert

BERT (Bidirectional Representations from Transformers) is trained (by Google) on huge text corpora, and can be **"fine tuned"** on custom tasks. Webersinke et al. (2021) perform additional pre-training on texts from the climate domain.



Source: `https://jalammar.github.io/illustrated-bert/`

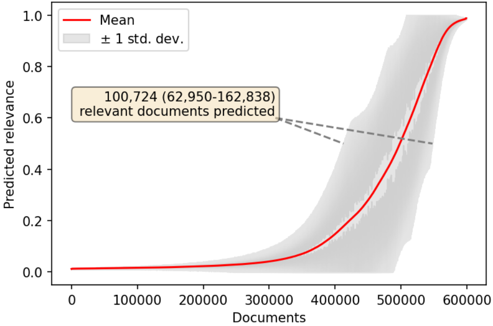
Validation



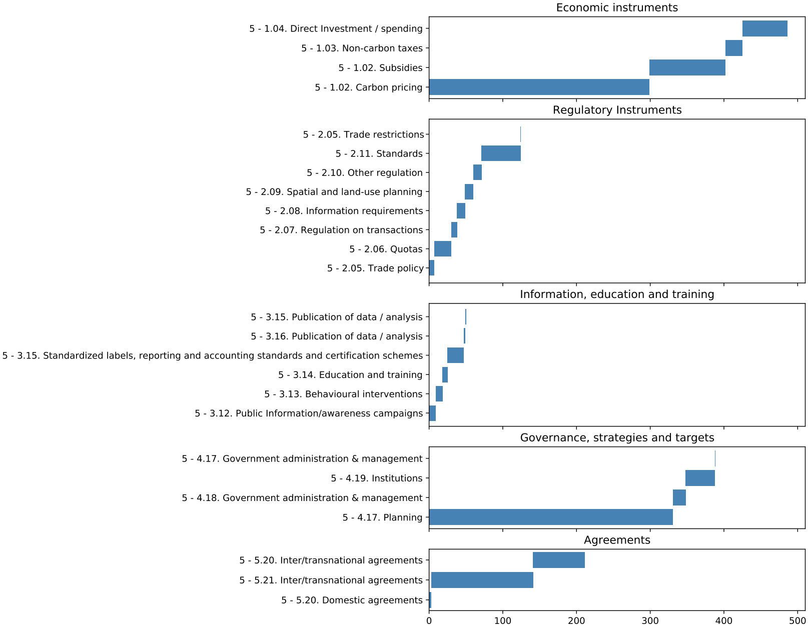
- Nested cross-validation separates hyperparamter optimisation from evaluation
- Less subject to random selection of test set in a test-validation-train setting
- Allows use of more data in a data-scarce setting

Uncertain predictions

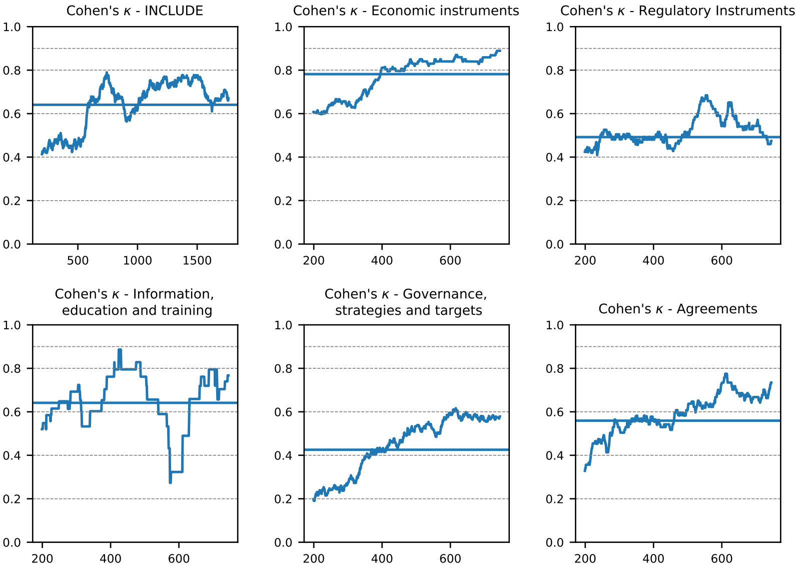
- In a previous study we made multiple predictions with multiple subsets of the data, and calculated the mean $\pm$ standard deviation for each sample.
- This captures some uncertainty from sensitivity of model to training data, but uses no information about model performance
- How to express uncertainty about model performance?



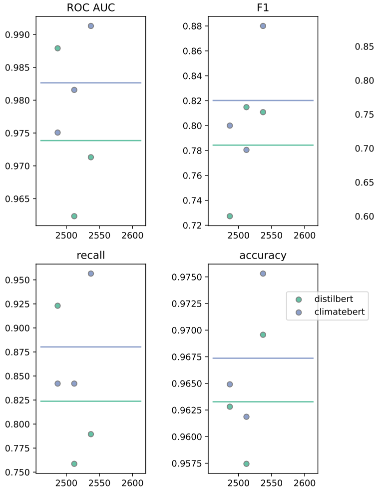
Results


Economic instruments
5 - 1.04. Direct Investment / spending
5 - 1.03. Non-carbon taxes
5 - 1.02. Subsidies
5 - 1.02. Carbon pricing
Regulatory Instruments
5 - 2.05. Trade restrictions
5 - 2.11. Standards
5 - 2.10. Other regulation
5 - 2.09. Spatial and land-use planning
5 - 2.08. Information requirements
5 - 2.07. Regulation on transactions
5 - 2.06. Quotas
5 - 2.05. Trade policy
Information, education and training
5 - 3.15. Publication of data / analysis
5 - 3.16. Publication of data / analysis
5 - 3.15. Standardized labels, reporting and accounting standards and certification schemes
5 - 3.14. Education and training
5 - 3.13. Behavioural interventions
5 - 3.12. Public Information/awareness campaigns
Governance, strategies and targets
5 - 4.17. Government administration & management
5 - 4.19. Institutions
5 - 4.18. Government administration & management
5 - 4.17. Planning
Agreements
5 - 5.20. Inter/transnational agreements
5 - 5.21. Inter/transnational agreements
5 - 5.20. Domestic agreements
0
100
200
300
400
500

Human accuracy

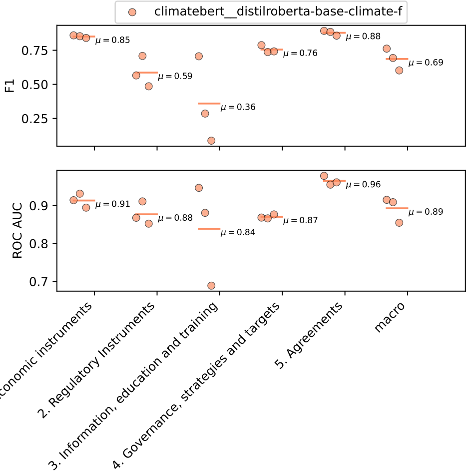


CV results



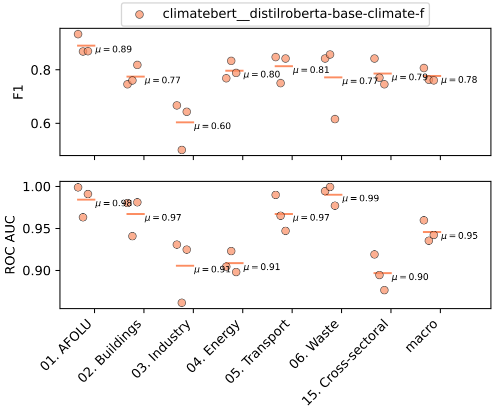
- Inclusion is pretty well predicted

CV results



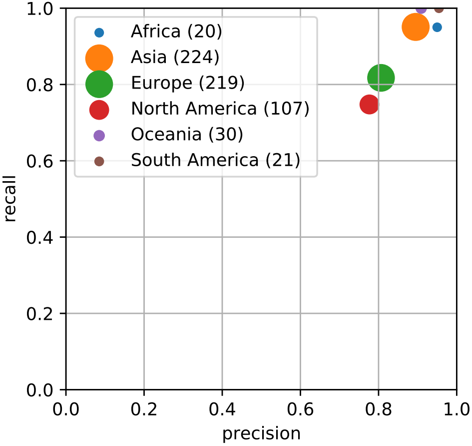
- Inclusion is pretty well predicted
- We are poor at predicting classes with fewer samples

CV results



- Inclusion is pretty well predicted
- We are poor at predicting classes with fewer samples
- Sectors are relatively well predicted

Geoparsing accuracy



- A combination of a geoparser for places, and a simple dictionary of country adjectives achieves good results
- That results are more accurate for Africa and Asia than Europe and North America is a pleasant surprise

Possible questions

- How does policy literature relate to policy databases?
- How does policy literature (+ policy databases) relate to emissions?
- Can learning across domains (policy + scientific docs) improve classifiers?

Bibliography and further resources

Callaghan, M. W., Minx, J. C., and Forster, P. M. (2020). A topography of climate change research. *Nature Climate Change*, 10(2):118–123. Number: 2 Publisher: Nature Publishing Group.

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Webersinke, N., Kraus, M., Bingler, J. A., and Leippold, M. (2021). ClimateBert: A Pretrained Language Model for Climate-Related Text. *arXiv:2110.12010 [cs]*. arXiv: 2110.12010.