USING MACHINE LEARNING TO ANALYZE CLIMATE CHANGE TECHNOLOGY TRANSFER (CCTT)

ICLR 2020 Workshop
Tackling Climate Change with Machine Learning

Presented by

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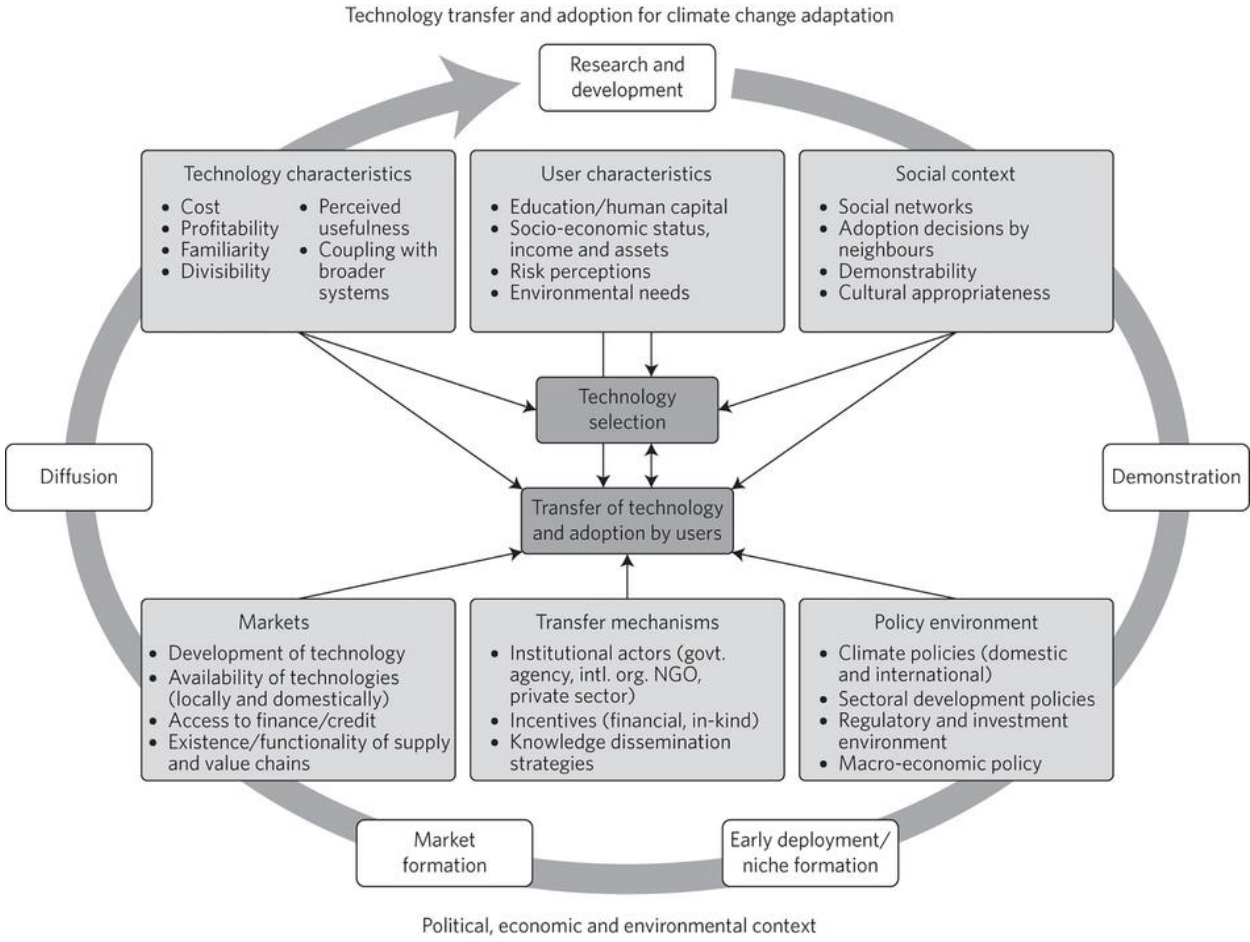
Definition: Technology transfer

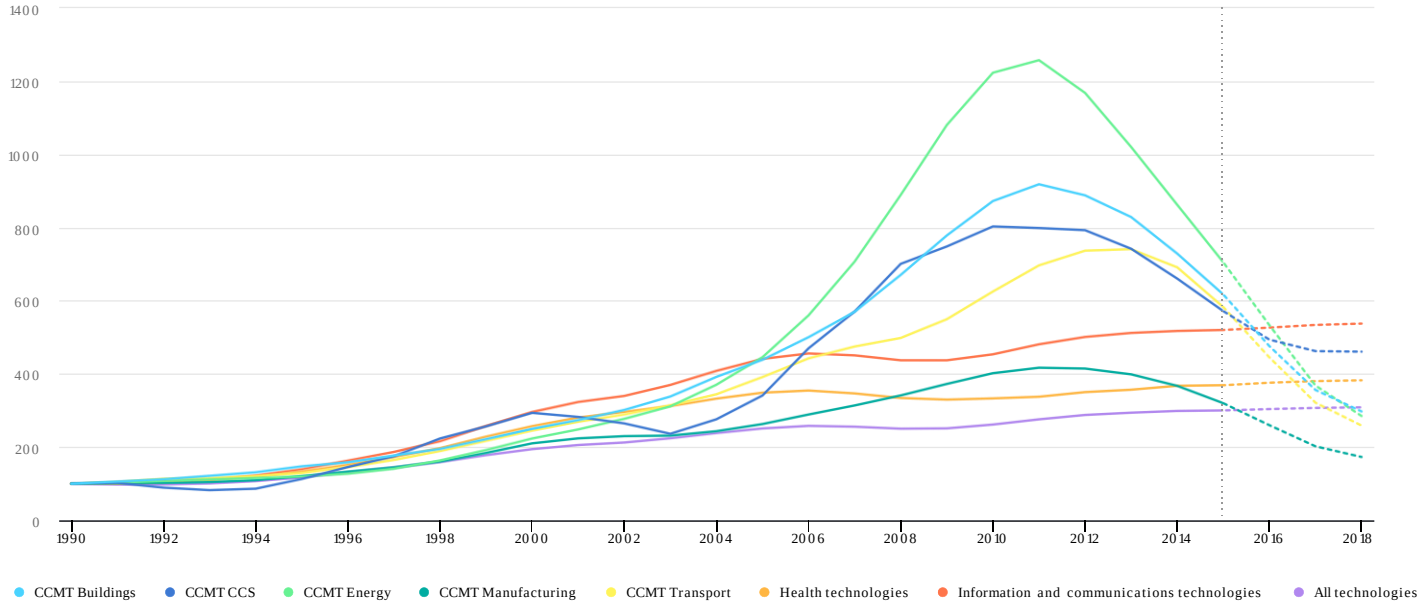
- The Intergovernmental Panel on Climate Change (IPCC) defines **technology transfer (TT)** as "a broad set of processes covering the flows of know-how, experience, and equipment for mitigating and adapting to climate change among different stakeholders such as governments, private sector entities, financial institutions, non-governmental organizations (NGOs) and research/educational institutions."(IPCC, 2000).
- Schnepp et al. (1990) define technology transfer as ‘‘A process by which expertise or knowledge related to some aspect of technology is passed from one user to another for the purpose of economic gain’’.
- The **Johannesburg Plan of Implementation** (JPOI) that resulted from the World Summit on Sustainable Development calls upon governments and relevant regional and international organizations to take action on development, dissemination and deployment of affordable cleaner energy, energy efficiency and energy conservation technologies and the transfer of these technologies to developing countries (DSD, 2015).



Technology Transfer framework for Climate Change Adaptation
(from Biagini et al 2014)

Need for CCTT: Global patent applications for climate change mitigation technologies

- Drawing upon new extractions from the Worldwide **Patent Statistical Database** (PATSTAT), The **International Energy Agency** (IEA) and **Organisation for Economic Co-operation and Development** (OECD) have found that while patenting of innovations in **climate change mitigation technologies** (CCMT) related to power generation, transport, buildings, manufacturing, and carbon capture and storage (CCS) had generally been increasing much faster than other technologies in the period up to 2011-2012, there has been a notable drop-off in the number of these patents since then. (IEA, 2019). There is no evidence of such a drop-off in patenting in general, or in other fields such as ICT, healthcare, etc. (IEA, 2019).



Global patent applications for climate change mitigation technologies – a key measure of innovation – are trending down. Source: (IEA, 2019).

Proposed Methodology

Step1

-Data collection from patent databases such as USPTO/WIPO

Step2

-Data preprocessing & Extraction of patent information

Step3

-Topic identification and exploration

Step4

-Further analyses
- Predict potential CCTT
- Competitor analysis
- Identifying leaders and patent portfolios for countries

Step 1 & 2

Data Collection

- The patent documents related to climate change technologies will be collected from the **United States Patent and Trademark Office** (USPTO)'s online database. The data source is appropriate for exploring technological trends because it is a representative patent database containing an enormous number of patents from all over the world and covers the most advanced technologies (Kim & Lee, 2015).
- The proposed search query for the data collection consists of terms dealing with climate change mitigation technologies, combined with climate change domain ontology and domain terms such as *biodiversity, carbon, climate, ecology, environment, emission, ICT for climate change mitigation, energy storage, sustainable, etc.*

Data Preprocessing & Extraction of Patent Information

- The collected patent documents represent an unstructured text format. Therefore, in the next stage the data would be pre-processed and transformed into a structured format for further analyses. The pre-processing procedure will be performed using the document parsing techniques.
- The relevant items, such as the *title, abstract, assignees, filing year, register year, classification code, and citation* will be extracted from documents. For this purpose, the abstract in a free-text format will be required for further pre-processing tasks with natural language processing techniques, including tokenization, lemmatization, stop-word removing, and vector-space representation. Among these text items, the abstract will be used as the input to LDA to identify topics because it essentially includes the main problem addressed by the patented technology.

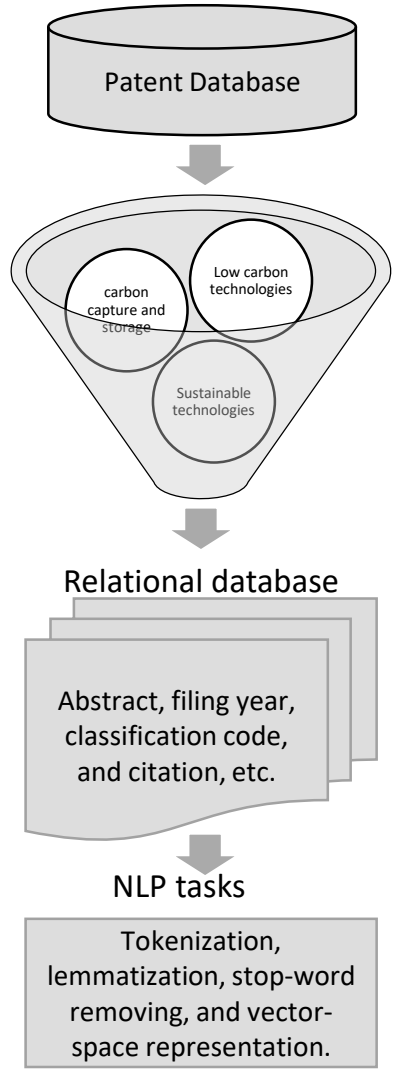


Figure: Research design for step 1

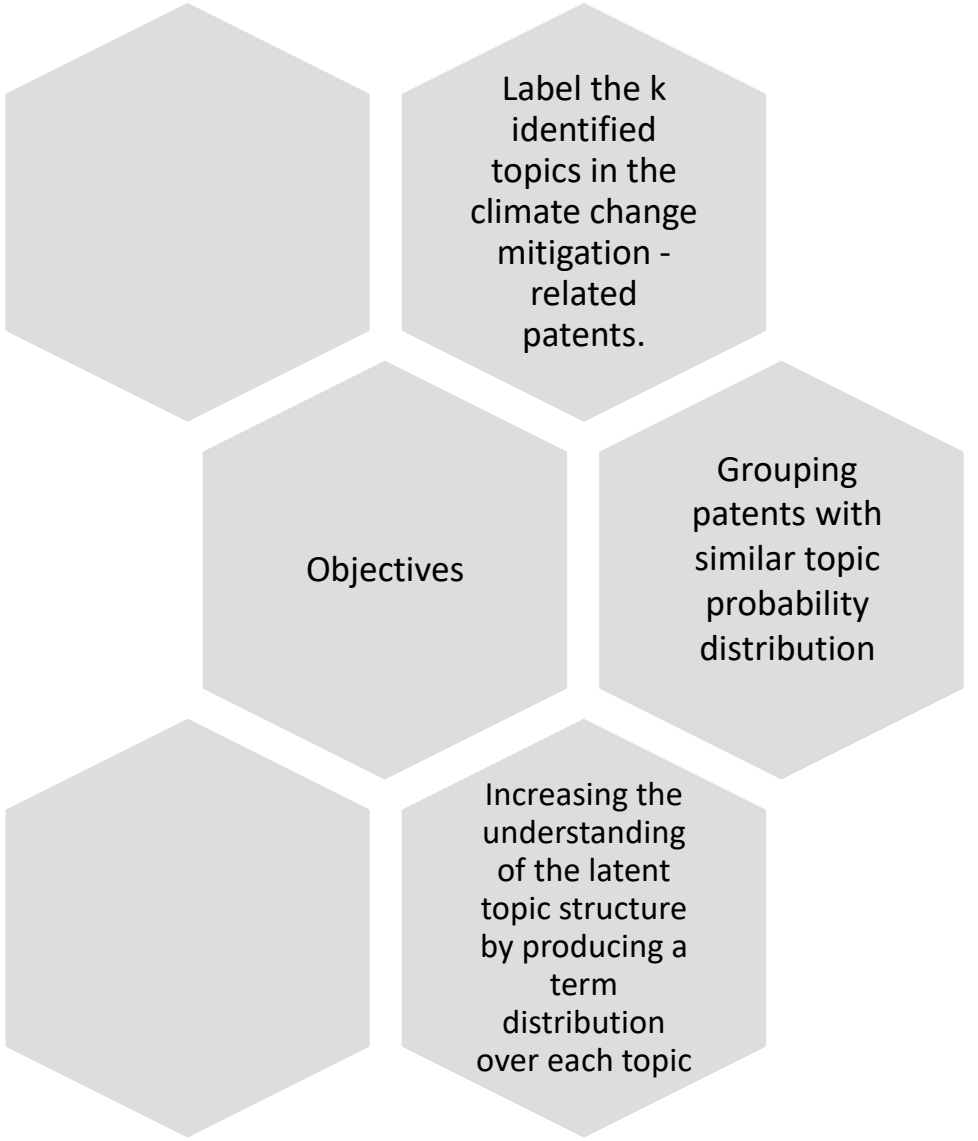
Step 3

Topic Identification & Exploration

- The research question we will be addressing by this step is:

"what is the topic landscape of patents filed for climate change mitigation technologies? "

- We propose topic identification and exploration using **lda2vec** to address the question. Topic modelling is a statistical approach for discovering topics that occur in a document corpus (Blei et al.,2003). Lda2vec (Moody, 2016) combines the power of **word2vec** (Mikolov et al., 2013) with the interpretability of **LDA.** Based on the per-topic distribution, each patent document will be assigned to one of k topics exhibiting the highest probability.



Step 4

Identifying leaders and patent portfolios for countries

In this last step, the identified topics would be further explored from two aspects: Trends in patenting activities over time and assignees in each topic. The research questions we want to address are: how have patenting activities changed over time? and who have been technological leaders (i.e. proliferous countries) in climate change related patents? The investigation of these questions can offer the technological landscape in climate change related technologies at the international-level.

Predict potential CCTT

We further propose to build predictive models based on our patent analysis for possibility of technology transfer. The predictive model can be constructed by using SNA, regression analysis, decision trees, etc. There are various techniques to analyze patent data. Among them we would use SNA, because SNA is an efficient approach to analyze the patent data (Jun & Park, 2013). Using the SNA, we can get the association between variables to construct the predictive model for technology transfer.

The information based on IPC codes, citation information, and so on will be fetched to SNA graphs. Social network structures contain a number of nodes consisting of information for a particular targeted technology such as Number of forward citations, Novelty, Number of backward citations, Number of INPADOC Family patents, Patent duration (Expiration date – Registered date), Number of forward citations, Number of IPC codes extracted, and so on. The results from the SNA will be used all together to explore meaningful factors for predictive models.

Competitor analysis

It would be very useful for countries to know what is the trend of a competitor's technology development. Based on the topic modeling results, we propose competitor analysis using following techniques:

Word-based similarity (WBS): WBS represents countries by a vector of words, and it would rank the competitors based on (Cosine) similarity between countries.

Topic-based divergence (TBD): It represents each country's patent portfolio using the topic distribution and ranks the competitors by the KL-divergence.

Projected Results

In general, the transferred technologies are important nationally and internationally for improving their technological competitiveness. Using the methodology proposed in this study, we aim to give investors, governments and policy makers recommendations based on following projections:

1. Analysis of patent portfolios regarding climate change related topics using hybrid LDA;
2. Find which countries are addressing the threat of climate change in their patent portfolios;
3. Aid developing countries for capacity building for climate change technology development and transfer;
4. Aid policy makers in creating new programs such as the Clean Development Mechanism (CDM), Asia-Pacific Partnership for positive advances in the case of international technology transfer;

In conclusion, we proposed a model that promotes developed countries to concretely pursue technology transfer with developing countries in the field of climate change related technologies. This would further open up possible domain exploration for technology transfers for climate change adaptation and mitigation.

Questions?

Thank you!

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