# Measuring the uniqueness of technological capabilities

A data driven network exploration

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# **Project Background**

This project has its roots in two initiatives:

#### AMICA:

- Stands for Advanced Mapping of Industrial Capabilities for Climate
- Answer research specific questions
- Uses a complex system view
- It's our starting point
- Exploration stage

#### EURITO:

- Stands for EU Relevant, Inclusive, Timely, Trusted, and Open Research Innovation Indicators
- Bring data to the heart of R&I research
- Improving the decision making process
- Quantitative indicators and analysis









# Main research question

How to measure the uniqueness of technological capabilities?

# **Motivation**

"There is a need for companies, countries, and organizations to improve Research and Innovation policies. Most approaches rely on methods that are not reusable, applicable to other fields and produce hard to prove results."

# Goal

"Helping decision makers understand highly interconnected technological landscapes and as a result make better R&I decisions using knowledge data. For this purpose biofuels will be used as testing ground."



## Structure of the Analysis and Research Questions



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## Some example questions

#### International Organization:

- How is this technological field evolving over time?(RQMa1)
- What's the big picture for a certain research field? (RQMa3)

#### Policy Maker:

- How can I characterize a country in terms of its capability?(RQMe1)
- Are certain countries more related to others? (RQMe7)

#### Organizational Leader (CTO, Research Executive):

- Who could I collaborate with based on my capabilities? (RQMi2)
- Where is the industry collaborating in terms of capabilities? (RQMi4)
- Are there clusters of companies and universities? (RQMi2)



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Our research questions.





# Approach

- The goal is to answer the main research question, characterize uniqueness
- A complex system view with emphasis on connections
- How do we combine technologies/resources?
- Terms Vs. Term pairs



OUTPUT

# Approach

NPUT



PROCESS



# Approach



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### Tools

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Dictionary of terms (342)

jupyter

- Numpy + Math ٠
- Matplotlib + Seaborn ٠
- Scikit + Scipy ٠

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# **Model requirements**

#### The developed model needs to:

- Accurately portray research
- Preserve complexity
- Be scalable
- Allow for analysis



#### From asset to model





## The filtering process



### An example matrix

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Capability Matrix of 2017: Annotaded version

How to characterize a year of scientific research?



## **Comparing capabilities**



This allows for the coverage for more than just pairs.

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## The Macro Level

Are all years linearly related or do research gaps exist?







## The Macro Level

Are all years linearly related or do research gaps exist?





## **Contextual Relationships at the Macro Level**

Is the price of a consumer good related with the research volume? What terms are most affected by it?



Feedstock Name	Pearson Correlation Index							
sugarcane	0.789014							
cellulosic sugars	0.775341							
jatropha	0.771713							
sorghum	0.757299							
dry biomass	0.754884							
beets	0.751165							
dedicated energy crops	0.739525							
algae	0.728562							
hybrid poplar	0.721206							
soy	0.706675							



# **Capability Correlations at the Meso Level**

Do international capability clusters exist?



Language matters Distance matters Other things might also matter



# **Capability Correlations at the Meso Level**

Do international capability clusters exist?



## GDP as context for the Meso Level

Does the amount of money of you have (GDP per capita) determine the space of possibilities or your technological freedom?



# **Collaboration at the Meso Level**

Is capability similarity related to international collaboration?



Similar tend to not collaborate EU is similar and collaborates



# **Capability Correlations at the Micro Level**

Do organizational clusters exist?



More sparse

Mostly 'pure' clusters

DTU and Univ.Minho



# **Capability Correlations at the Micro Level**

Do organizational clusters exist?





# **Typifying organizational collaborations**

Do universities collaborate more with universities or businesses? Do businesses collaborate more with universities?



Most universities collaborate with other universities.

Organizations are more 'closed to collaboration'.

The triple helix





# **Using Spectrums at the Micro Level**

Is there value in characterizing an organization's capability as a spectrum?





Organization Capability Spectral Representation: Zoom

# Studying the balance of terms

How does the volume of patenting and publishing of a certain scientific term evolve over time? Is there a bias towards patenting or publishing?





It should depend on the term.

# Validating the term pair approach

Term frequency vs term pair frequency? What characterizes better the scientific capability of a country or organization?



## **Implications for Theory**

- Volume (even normalized) of R&D is not sufficient to characterize a country value terminology
- There might not be a perfect indicator, but this helps
- Value lies in the complexity
- Triple helix can be quantified
- Engineering system approach is valuable and scalable

## Implications for the industry

- A workflow that transforms data to insights
- These are just some of the possible questions and tools to answer them
- Not only a way to help answer, but also a way of evaluating strategies (even monitor)
- Untapped areas of research and uniqueness, sandbox for exploration
- Transparent decision making

## **Further Research**

- Expand to other areas, not only biofuels
- Study more external factors (not only sugar and oil) and see if they relate. Possibly predict better areas.
- Use capability correlation and test a wide range of characteristics to improve current indicators.
- Dig deeper into uniqueness and DNA
- Investigate the collaborations (why do entities collaborate? what are the consequences in terms
  of capabilities?)
- Limitations: normalizations, data under-representation, language...

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#### Learn more

# Website: <u>https://technological-capabilities.eu</u>

Repository: <u>https://github.com/duarteocarmo/technological\_capabilities</u>



## Thank you!