Researchers’ migration across Europe

What is guiding the flow of highly skilled workers?

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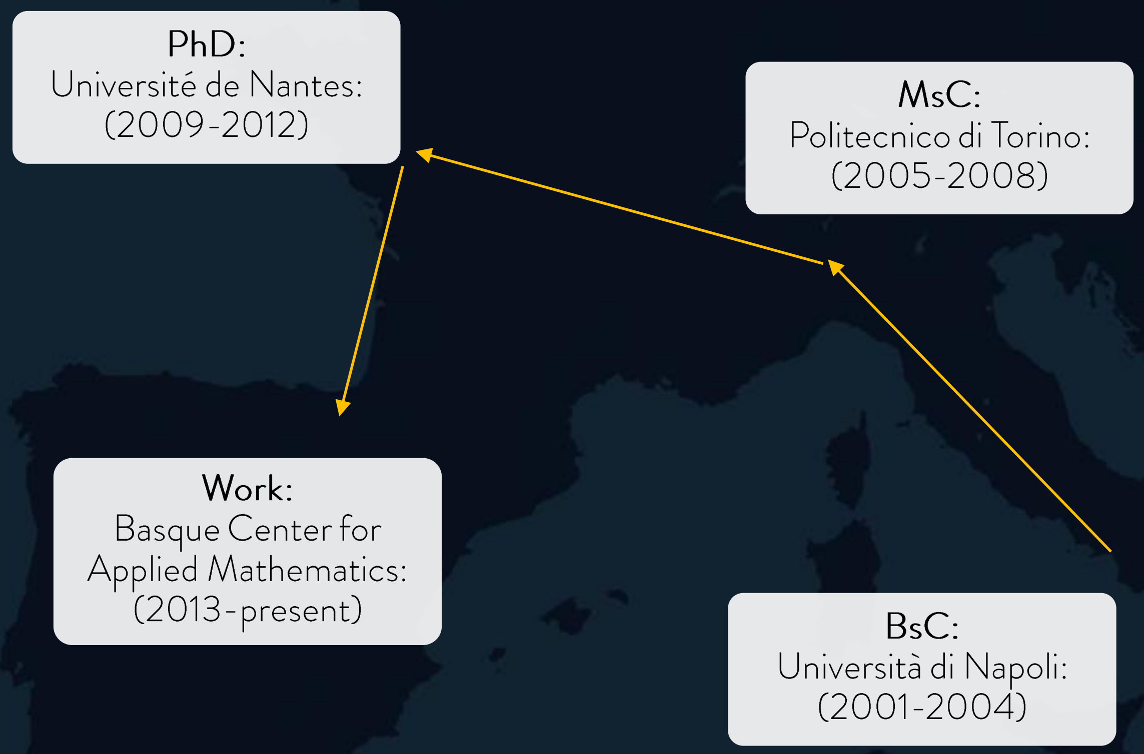
ORCiD Data



Open Researcher and Contributor ID (ORCiD) associates with each researcher a numeric code.

Keeps track of all publications, academic and working career.

1. Migration trajectories of all enrolled researchers;
2. Academic migration flows across 35 European countries during 2006-2015.

Data for each country

Migration flows by year:

- Inflow
- Outflow

University score:

- Ad-Hoc designed indicator of the overall quality of universities

Education-specific:

- Expense in R&D over GDP
- Teachers for student ratio
- …

Socio-economic:

- GDP per capita
- Human Development Index
- …

University Score

COUNTRY: *ITALY*

(QS World University Rankings 2018)

- class 1 [1, 100]: 0
- class 2 [101, 200]: 4
- class 3 [201, 300]: 2
- ...
- class 9 [801, 900]: 0
- class 10 [901, 1000]: 5

UniScore = 0.248

University Score is a **weighted sum** of the number of universities in specific positions of the **QS World University Ranking**.

$$UniScore = \sum_{c=1}^{10} \frac{1}{c} n(c)$$

with $n(c)$ the **number of universities** in the c^{th} class for the country.

It is an indicator of the **overall academic prestige** of a country.

Goal of the analysis

The research question can be declined into:

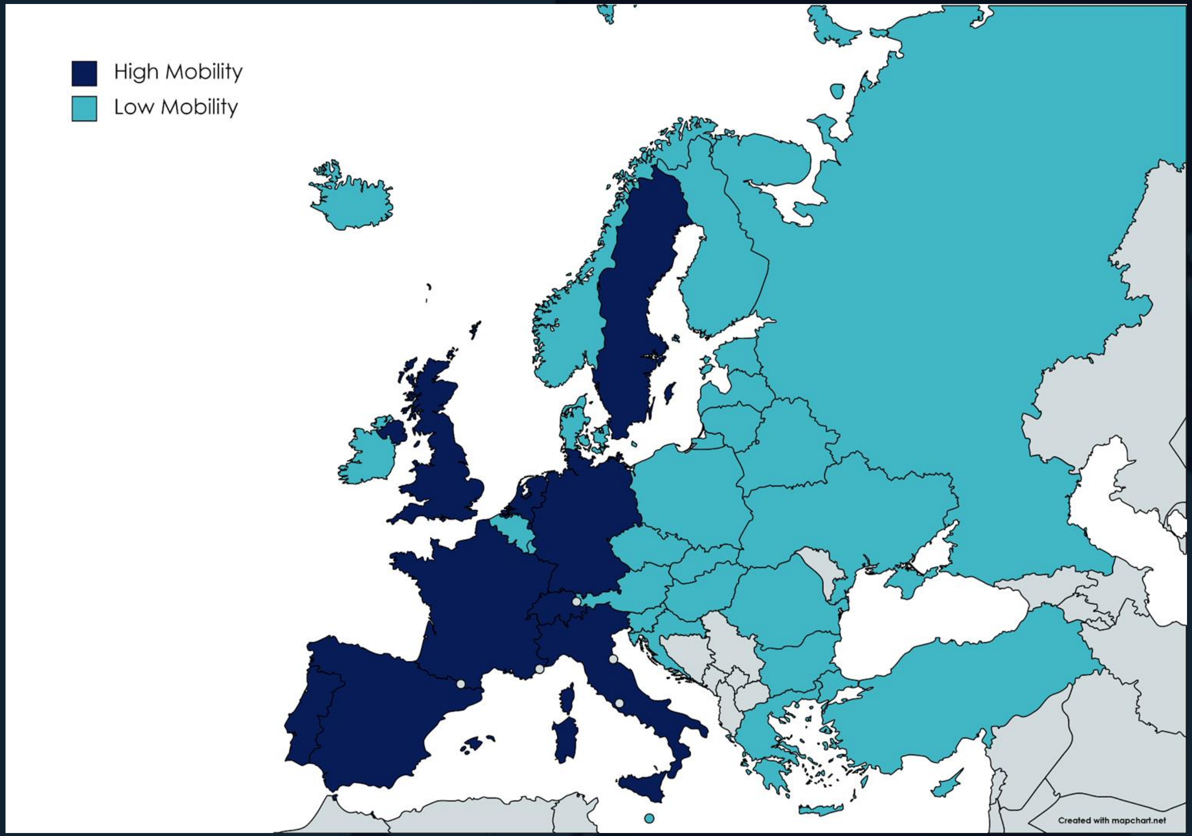
1. Determine the interactions and differences, if any, between groups of countries;

2. Highlight the principal determinants that influence flows in and out of a country, finding appropriate models;

3. Understand whether there is a temporal characterization or evolution.

Analysis of determinants by groups

Clustering divides Europe in **high mobility** and **low mobility** countries.



Problem: homoschedasticity assumption of ANOVA is **strongly violated**.

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Solution: Nonparametric Combinations based ANOVA

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Multi-aspect testing applying a p-value correction for the two tests via Nonparametric Combination.

Analysis of determinants by groups

We find a prototype of the general high mobility country.

Its features are:

1. Good universities
2. Good quality of life
3. Active entrepreneurial research
4. Investments

Surprisingly, no significant differences in terms of general wealth of a country (GDP per capita) or the general level of education of its population.

Regressor	p-value
University Score	0.000
Citations per document	0.100
University staff	0.011
Students per staff	0.945
GDP per capita	0.097
R&D over GDP	0.048
Education index	0.759
Local Purchasing Power Index	0.045
Global Gender Gap Index	0.042
Public Services	0.031
Security Apparatus	0.201
Patent Application	0.015

Determinants Analysis

Objective: find the determinants of the **flows** of researchers.

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First stage: covariate selection with both linear regression and GAMs.

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Second stage: tuning of parameters with AIC and stratified k-fold cross validation selection criteria.

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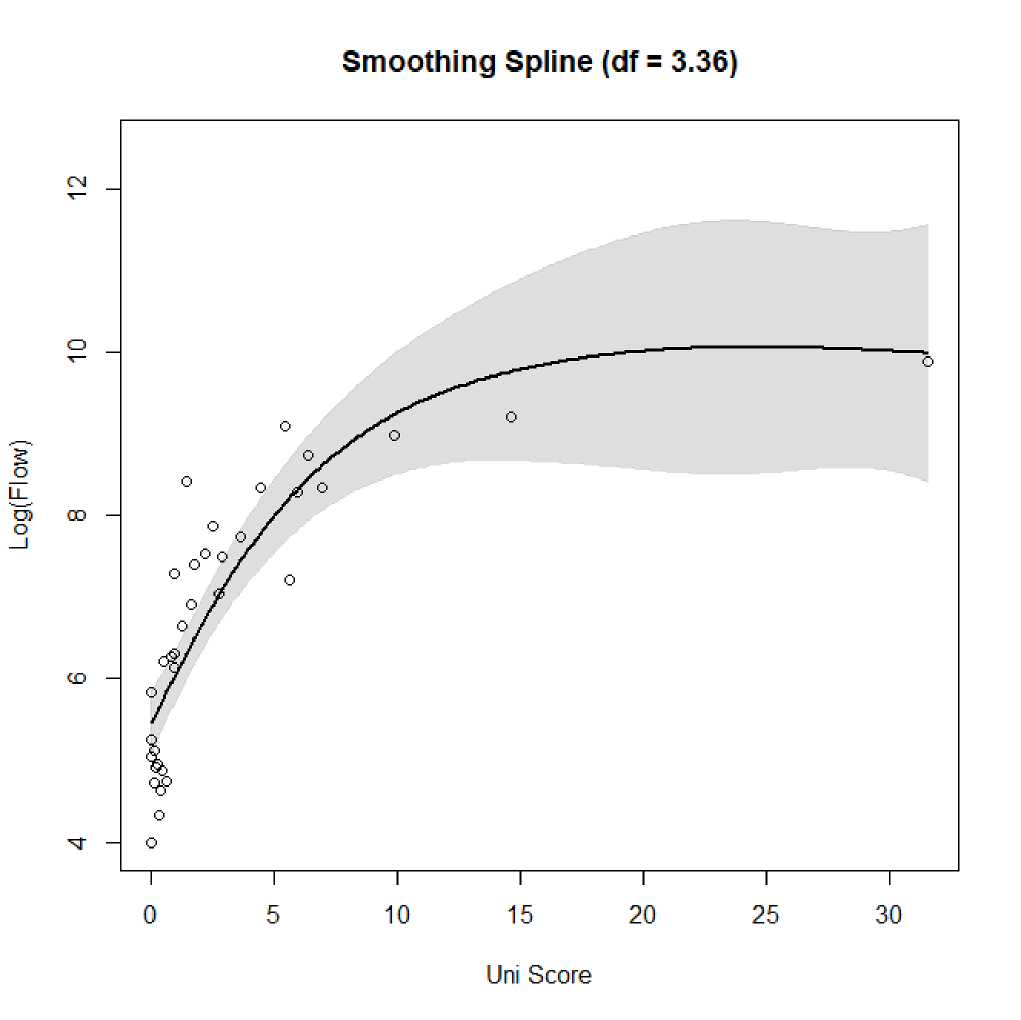
Multiple nonparametric regression models.

Selected Models

Model for total flow

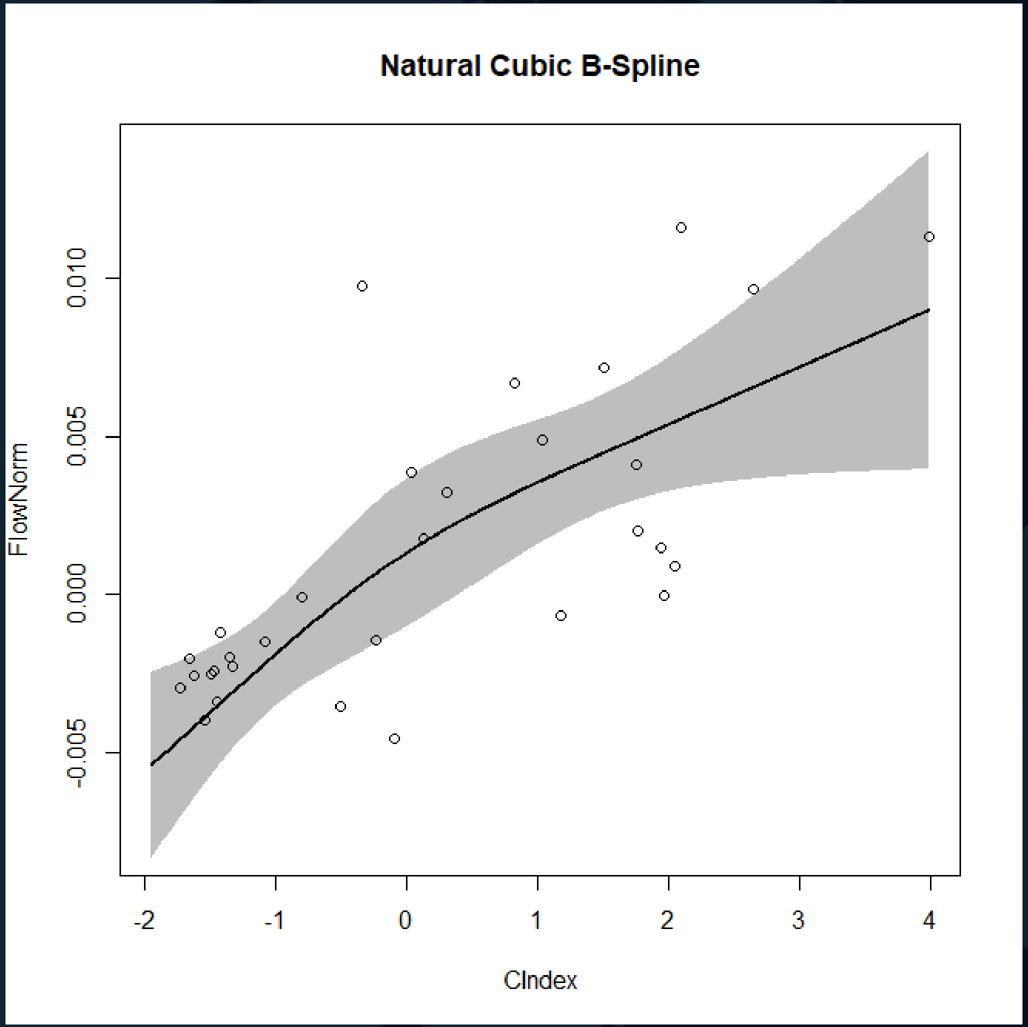


University score alone explains around 75% of the variability in total flow (using logarithmic scale).

The prestige of a country university is a fundamental driver for low mobility countries but reaches a plateau for the already active ones.

Selected Models

Model for Normalized Flow



Net flows (in - out) are normalized wrt the number of researchers of the country.

PCA built Composite Indicator of:

- Citations per Document
- Academic staff per student
- %GDP in R&D
- University Score

Almost linear dependence emerges even when using more sophisticated models.

Temporal Analysis – Repeated Measures

Objective: determining whether the phenomenon changes over time.

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Approach: repeated measures for each country along time.

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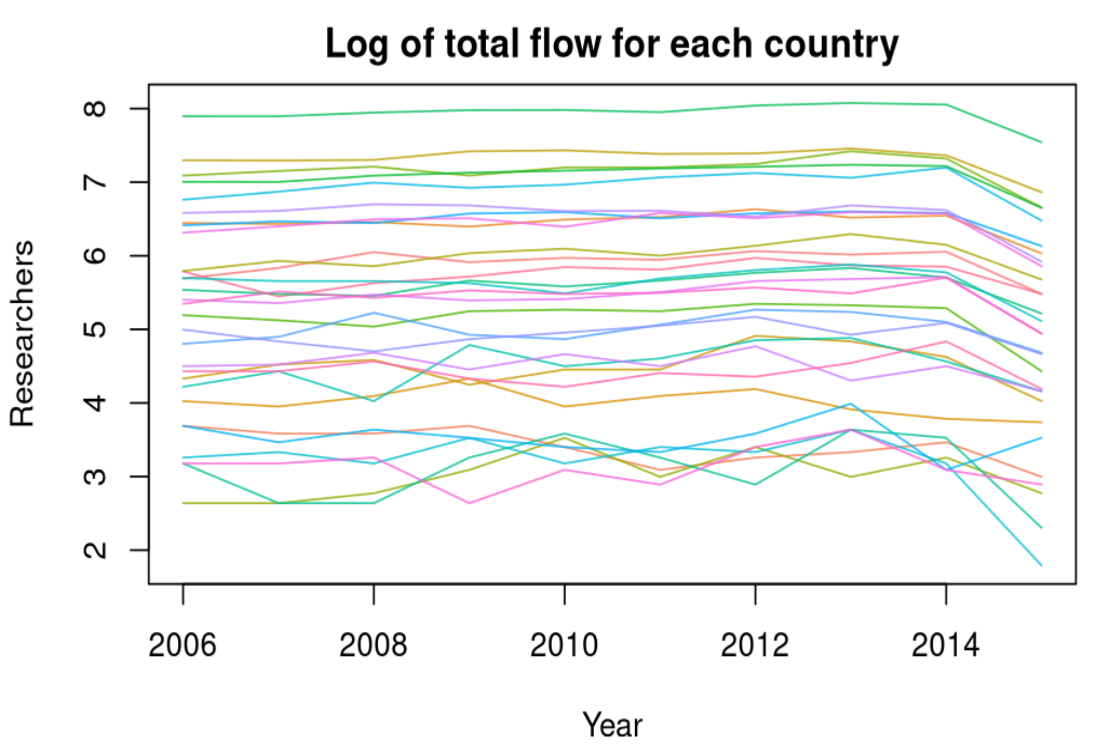
Robust Mixed effects model:

interaction of *UniScore* and time is tested, treating dependence between observations of the same country with a random term.



Temporal Analysis – Repeated Measures

We use the following model:

$$\boldsymbol{y}_i = X_i \boldsymbol{\beta} + Z_i \boldsymbol{b}_i + \boldsymbol{\varepsilon}_i \quad \forall i \in Country$$

$$\boldsymbol{b}_i \overset{ind}{\sim} N\left(\boldsymbol{0}, Z_i D_i Z_i^T\right) \quad \forall i \in Country$$

$$\boldsymbol{\varepsilon}_i \overset{iid}{\sim} F_\varepsilon$$

Robust approach: residuals are weighted with a smoothed Huber function (95% efficiency), same for their scale.

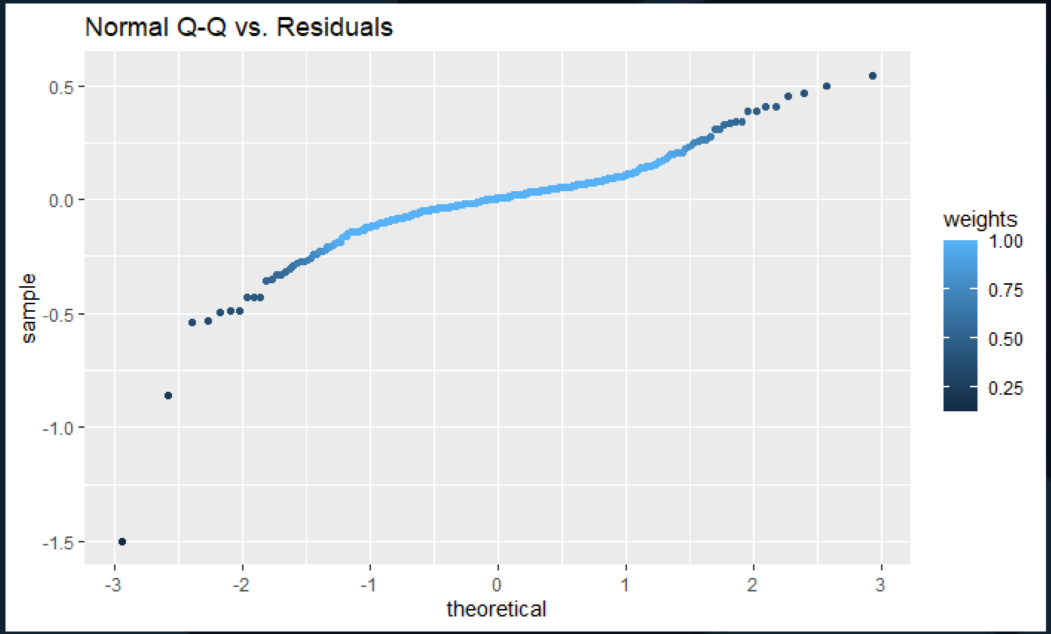
Permutation test:

$$H_0 : \log\left(TotFlow_{i,t}\right) = \beta_0 + f(UniScore_i) + \tilde{\varepsilon}_{i,t} \quad \forall t \in Year, \forall i \in Country$$

$$H_1 : \log\left(TotFlow_{i,t}\right) = \beta_0 + f_{\mathrm{t}}(UniScore_i) + \tilde{\varepsilon}_{i,t} \quad \forall t \in Year, \forall i \in Country$$

$f(x)$ *linear spline*

Temporal Analysis – Repeated Measures



QQ plot of the residuals with respective weights given by the smoothed Huber function.

P-value = 0

We reject the null hypothesis.

The effect of university score changes over time.

Temporal Analysis - FDA

Objective: Study the **concordance** of in & out flows of researchers across the years.

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Approach: Functional Data Analysis.

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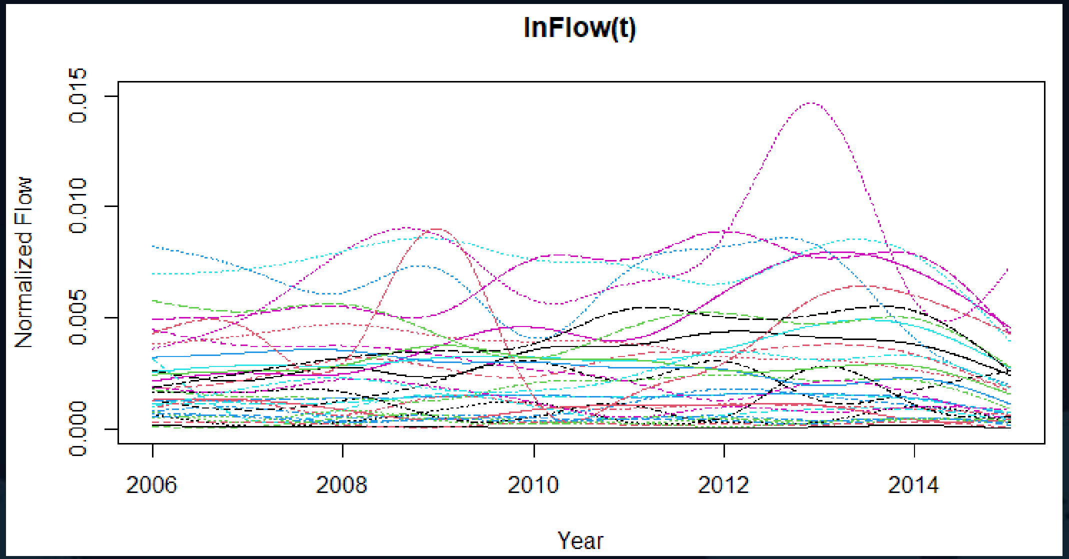
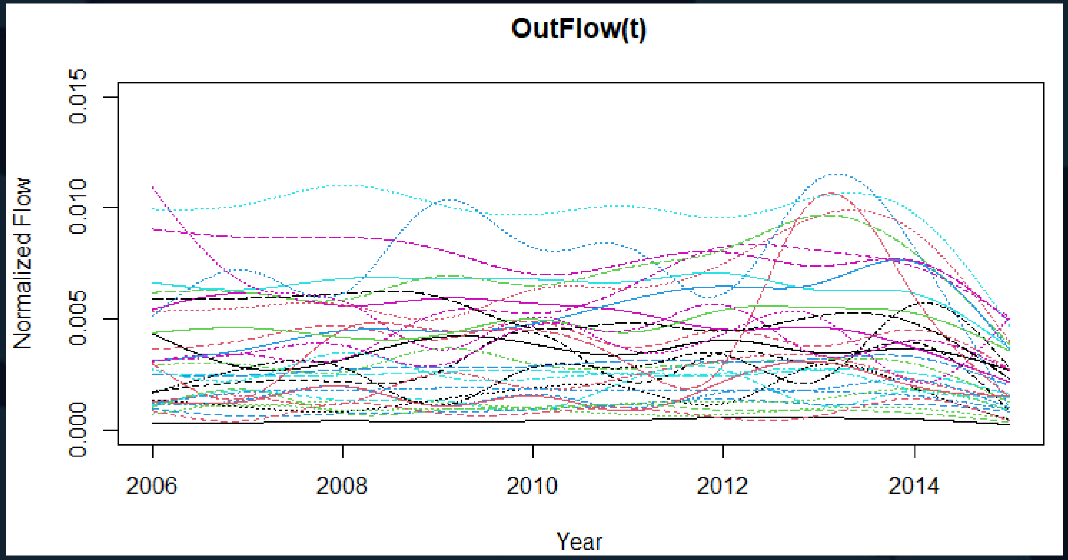
Normalized flows wrt the number of researches in the country (to address **scale variability** issues).





Temporal Analysis - FDA

Independence test of two functional populations:

- $X(t)$ normalized inflow
- $Y(t)$ normalized outflow

Permutation test on absolute value of Spearman Correlation index $\boldsymbol{\rho}(X(t), Y(t))$

$$H_0: \ | \boldsymbol{\rho}(X(t), Y(t)) | = 0$$

$$H_1: \ | \boldsymbol{\rho}(X(t), Y(t)) | \neq 0$$

P-value = 0

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Inflow and outflow are not uncorrelated.

$\boldsymbol{\rho}(X(t), Y(t)) = 0.942$

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They behave in a positive concordant way.

Policy proposals

Low Mobility Countries

- Lack of prestige of universities is detrimental for the researchers mobility.
- Already existing EU funds for R&D should be targeted at improving local universities.

High Mobility Countries

- Further improvements of already prestigious institutions are not that efficient by themselves.
- Generalized investments on activity and personnel expansions can increment the attractivity.

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