**INTERNATIONAL WORKSHOP**
BBVA Foundation – Ivie

# KNOWLEDGE, INNOVATION AND REGIONAL DEVELOPMENT: NEW EVIDENCE

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Alice Bertoletti is a PhD candidate at Politecnico di Milano, Department of Management, Economics and Industrial Engineering. Her research interests are in the field of education economics, with particular attention to higher education. Her PhD thesis deals with the contribution of higher education to economic development of European regions. She also works on research projects in the Public Sector, collaborating mainly with universities and municipalities.


# Higher Education and Economic Development: a Longitudinal Study of European Regions

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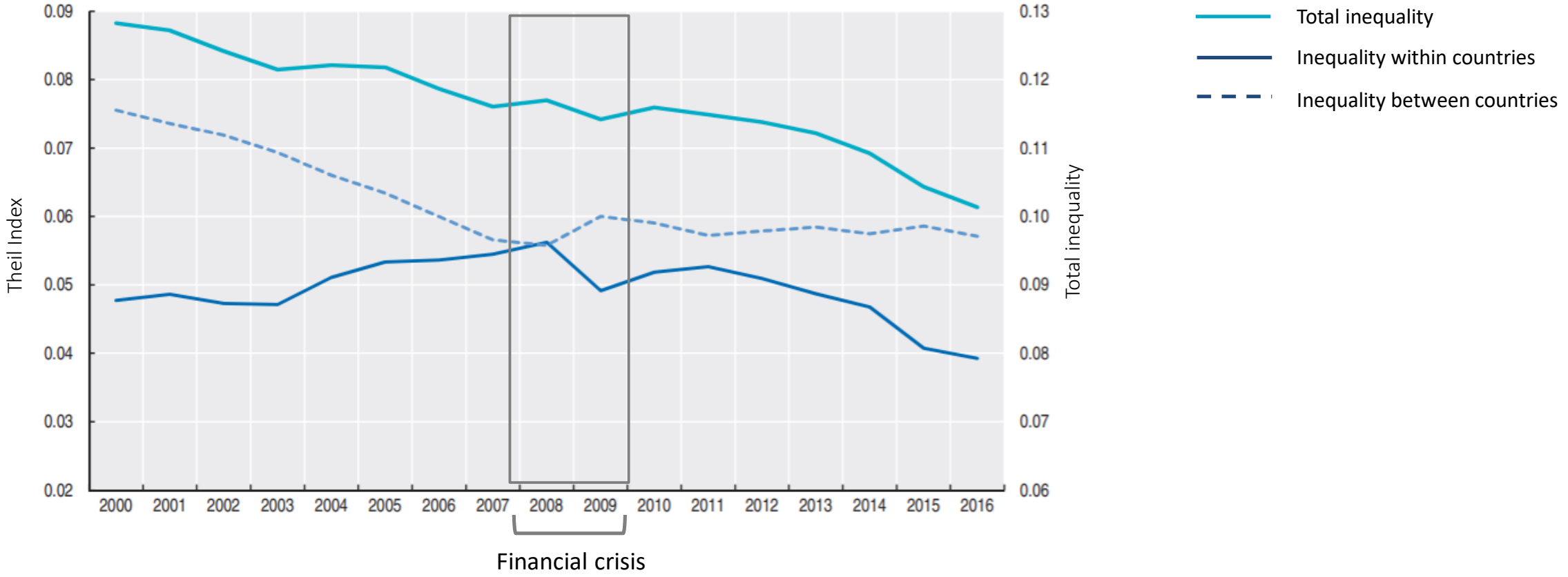
# Motivation (1/2)

Economic disparities between regions are drawing **attention of governments**, which aim at understanding the **causes** of an uneven distribution of economic development

Ezcurra and Rodríguez-Pose (2009)

GDP per capita disparities in OECD countries (Theil index)



# Motivations (2/2)

## Focus on Higher Education

- New Growth Economics Theory depicts **education as a crucial factor** for explaining the economic growth
- HE is potentially the **stage that most can contribute** to economic development (Sianesi and Van Reenen 2003)

## Focus on HE systems (HESs)

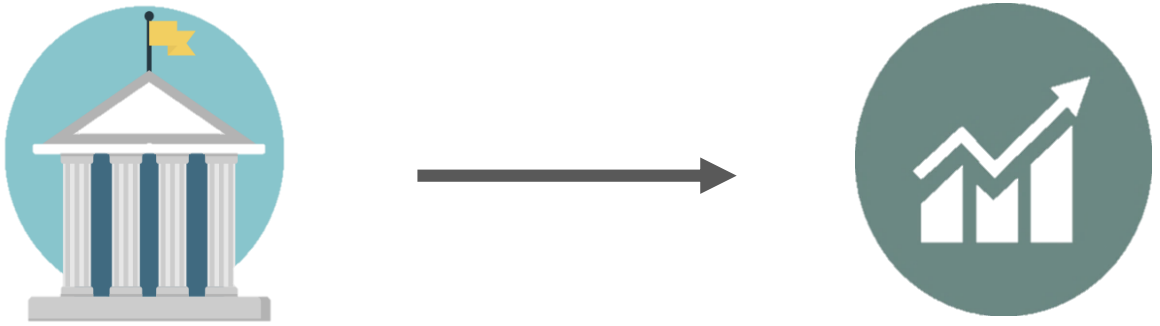
- **Lack of evidence** on the role of universities in fostering the economic growth (Valero and Van Reenen 2018)

Note: Regional HESs are defined as a group of universities or academic institutions that operate within a given region (see Filippakou et al. 2012)

# Research questions

[1] What is the impact of regional HESs on the economic growth of European regions?

[2] How has the financial crisis affected the relationship between HESs end regional economic growth?



# Literature: the link between universities and economic growth

**Few empirical contributions** on the effect of universities on regional economic development

- These papers are usually **focused on metropolitan areas** located in a **single country**

  Lendel (2010); Goldstein and Drucker (2006); Brenner and Schlump (2010); Schubert and Kroll (2014)

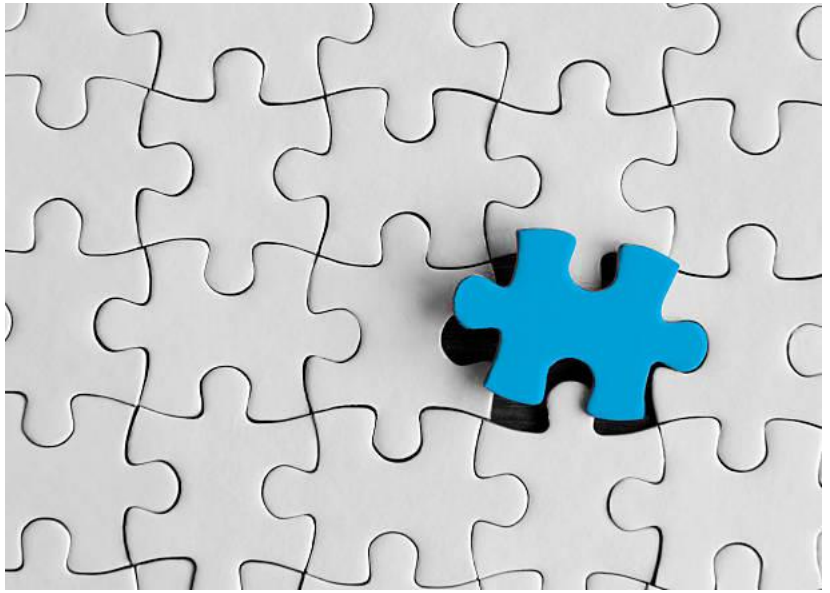
**Main contribution → Valero and Van Reenen (2019)**

- Regional economic growth in 78 countries (1950-2010)
- An increase of 10% in the number of universities is associated with around 0.4% higher GDP per capita
- Only the number of universities→ overlooking the overall contribution of HESs (i.e. their performance in key missions)

# Contributions

[1] Improving the measurement of HESs: considering the **heterogeneity of HE systems.**

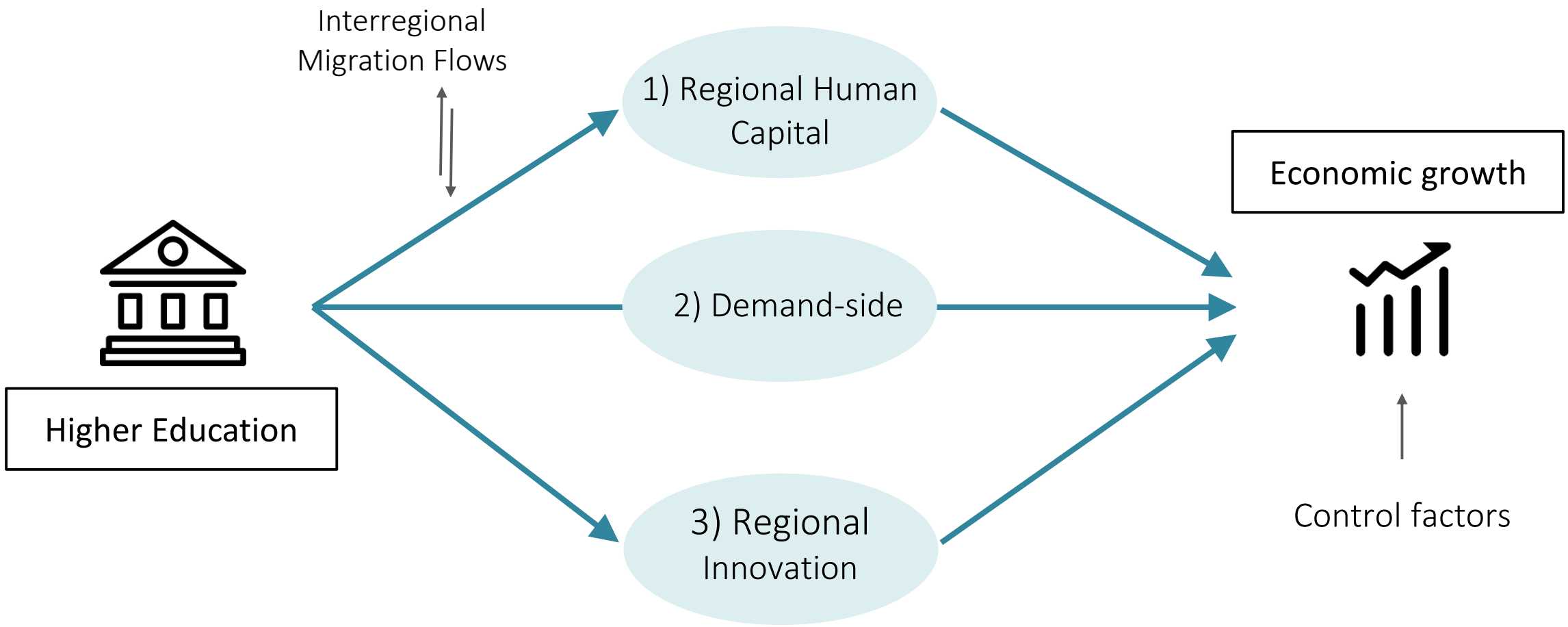
- Including indicators of HE systems' performance and dimension



[2] Investigating the **role of financial crisis** in affecting the relationship between HE systems and regional growth.

- Dataset including recent years (2000-2017).

# Theoretical framework



# Research context

- **285 regions (NUTS 2)** in **30 European countries**: the 28 EU members plus Norway and Switzerland
- **Time-span**: empirical analysis based on data from **2000 to 2017**
- **Integrated dataset…**
  (an interesting byproduct of this project, available for future research)

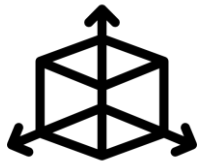



# Empirical Model (1/2): Measuring Higher Education performance

**Presence of universities:**

- Growth in # of Universities
- **WHED** (World Higher Education Database) - Based on Valero and Van Reenen 2019

**Size of universities:**

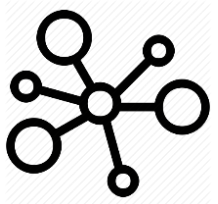


- Growth in # of divisions – proxy (no direct measure available)
- **WHED** Database

**Research performance:**

- Growth in the Publications in 10% top -measure of research quality
- **Incites Database**

**Third-mission performance:**



- Growth in %HE collaboration with industry - % of publications that have co-authors from industry
- **Incites Database**

# Empirical Model (2/2)

$$\Delta log(Y_{ic,t}) = \alpha_1 log(Y_{ic,t-1}) + \alpha_2 \Delta log(N\_uni_{ic,t-l}) + \alpha_3 \Delta log(Dimension_{ic,t-l}) + \alpha_4 \Delta log(Research_{ic,t-l}) + \alpha_5 \Delta Thirdmission_{ic,t-l} + \alpha_6 HumanCapital_{ic,t} + \alpha_7 \Delta HumanCapital_{ic,t-l} + \alpha_8 X'_{ic,t} + \gamma_c + \tau_t + \varepsilon_{ic,t}$$

Growth in regional GDP per capita

- Lagged level of GDP per capita (convergence rate)

- Interregional migration rate
- Level of population
- Population density
- Median age
- Capital in the region
- Financial crisis (dummy)

- Current level of HE attainment
- Growth in HE attainment (current and lagged)

- Growth in # of universities (lag 0/2)

- Growth in HE dimension (lag 0/2)

- Growth in # top publications (lag 0/2)

- Growth in %HE collaboration with industry (lag 0/2)

- Country fixed effects (Gennaioli et al. 2014)
- Time dummies

# Estimation strategy: System GMM

## Potential endogeneity

- **Simultaneity** of the effect
- **Dynamic panel model**: the model includes the lag of the dependent variable
- **Durbin–Wu–Hausman test** confirms the endogeneity of the main regressors

## System Generalized Method of Moments

(Arellano and Bover, 1995; Blundell and Bond, 1998)

- **First differencing:** for removing the potential source of endogeneity
- **Instrumenting** the predetermined variables with all their available lags in levels
- **System GMM** increases the number of instruments by including a system of the original equations in levels

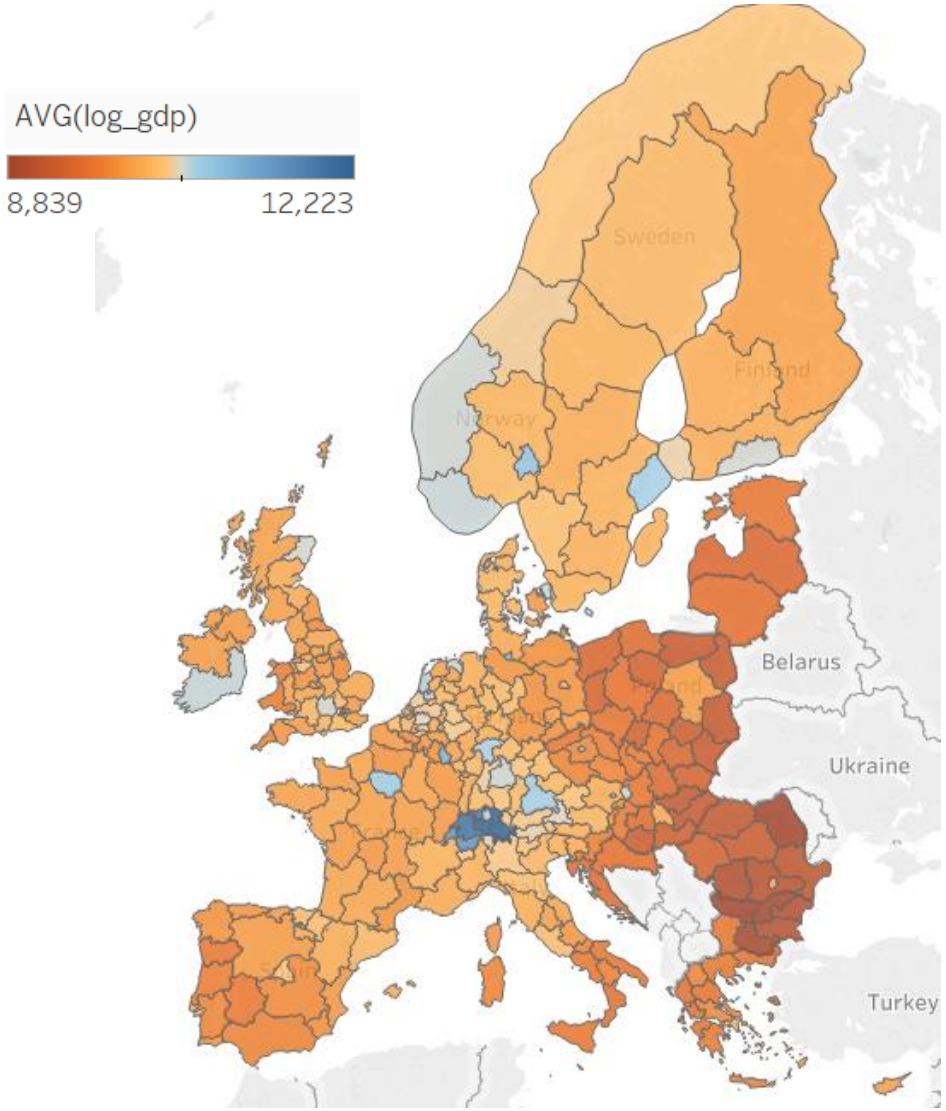
# Descriptive statistics

| Variable | Obs | Mean | Std.Dev. | Min | Max |
|---|---|---|---|---|---|
| Regional GDP per capita [PPS] | 4776 | 25807.91 | 18361.30 | 3600 | 270151 |
| Growth in regional GDP per capita [%] | 4519 | 2.72 | 4.28 | -0.16 | 24.53 |
| Level of HE attainment [%] | 4708 | 31.42 | 11.89 | 5.50 | 76.50 |
| Growth in HE attainment [%] | 4425 | 0.97 | 3.26 | -21.80 | 38.70 |
| Number of universities [#] | 4961 | 8.03 | 10.10 | 1 | 109 |
| Growth in # of universities [%] | 4957 | 1.37 | 7.49 | 0 | 100 |
| Level of HE dimension [#divisions] | 4961 | 242.85 | 278.08 | 0 | 2242 |
| Growth in HE dimension [%] | 4939 | 0.82 | 10.00 | 0.00 | 483.33 |
| Growth in HE research [%] | 4764 | 0.40 | 20.11 | -100.00 | 750.84 |
| Growth in Industry collaboration [%] | 4957 | 0.04 | 1.28 | -31.45 | 25.00 |
| Level of public expenditure [%GDP] | 4961 | 45.60 | 5.87 | 0.0 | 65.0 |
| Population growth [%] | 4927 | 0.30 | 1.64 | -10.81 | 30.00 |
| Population density [#/Km2] | 4775 | 429.6 | 1514.8 | 3.3 | 70808.6 |
| Median age | 4880 | 40.72 | 3.16 | 31.40 | 51.30 |
| Capital is in the region [%] | 4961 | 12.32 | 32.87 | 0 | 100 |

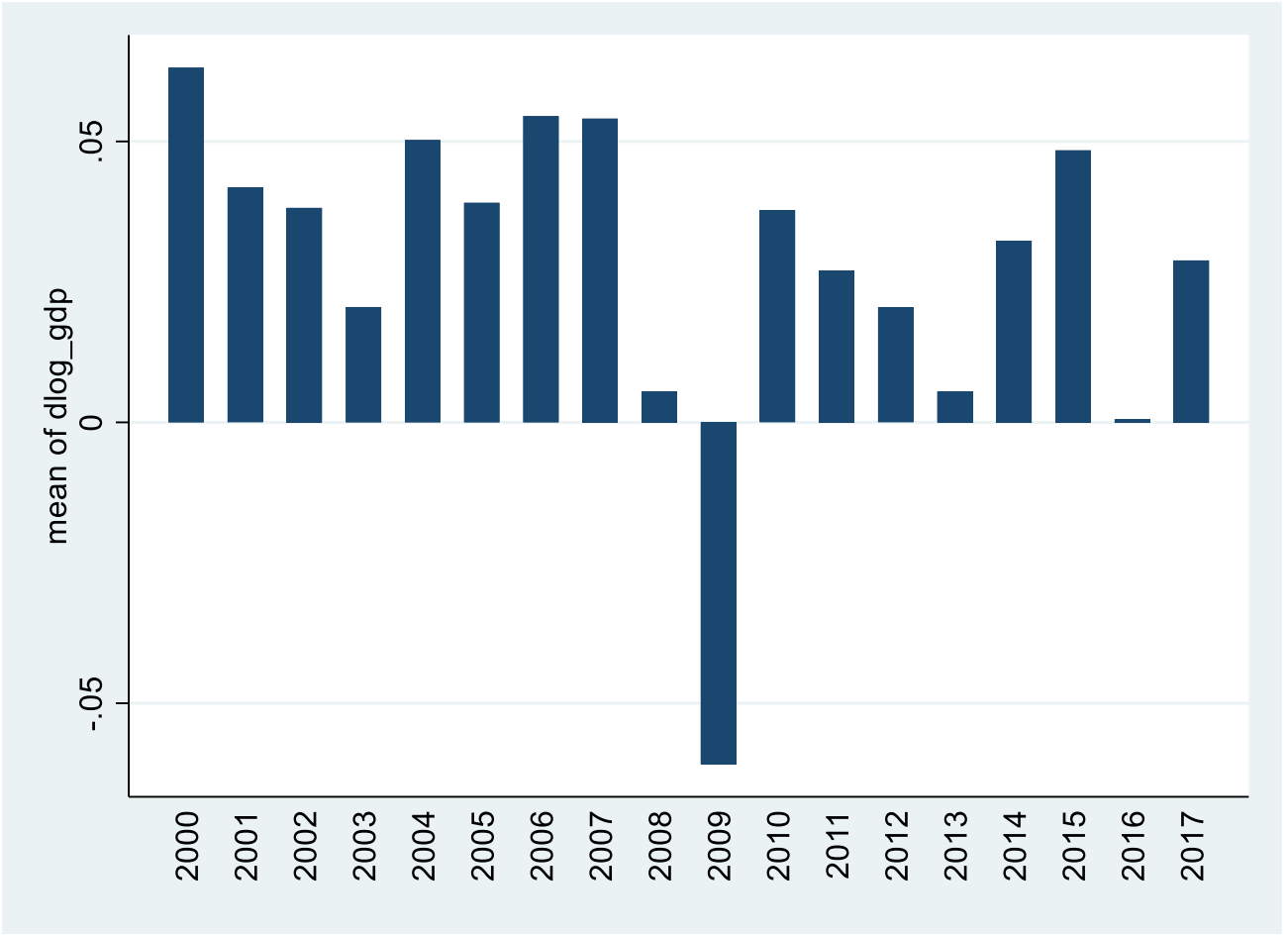
Note: the statistics refer to the time span 2000-2017

# Data Description: Regional GDP per capita

**Regional GDP per capita -** mean over years

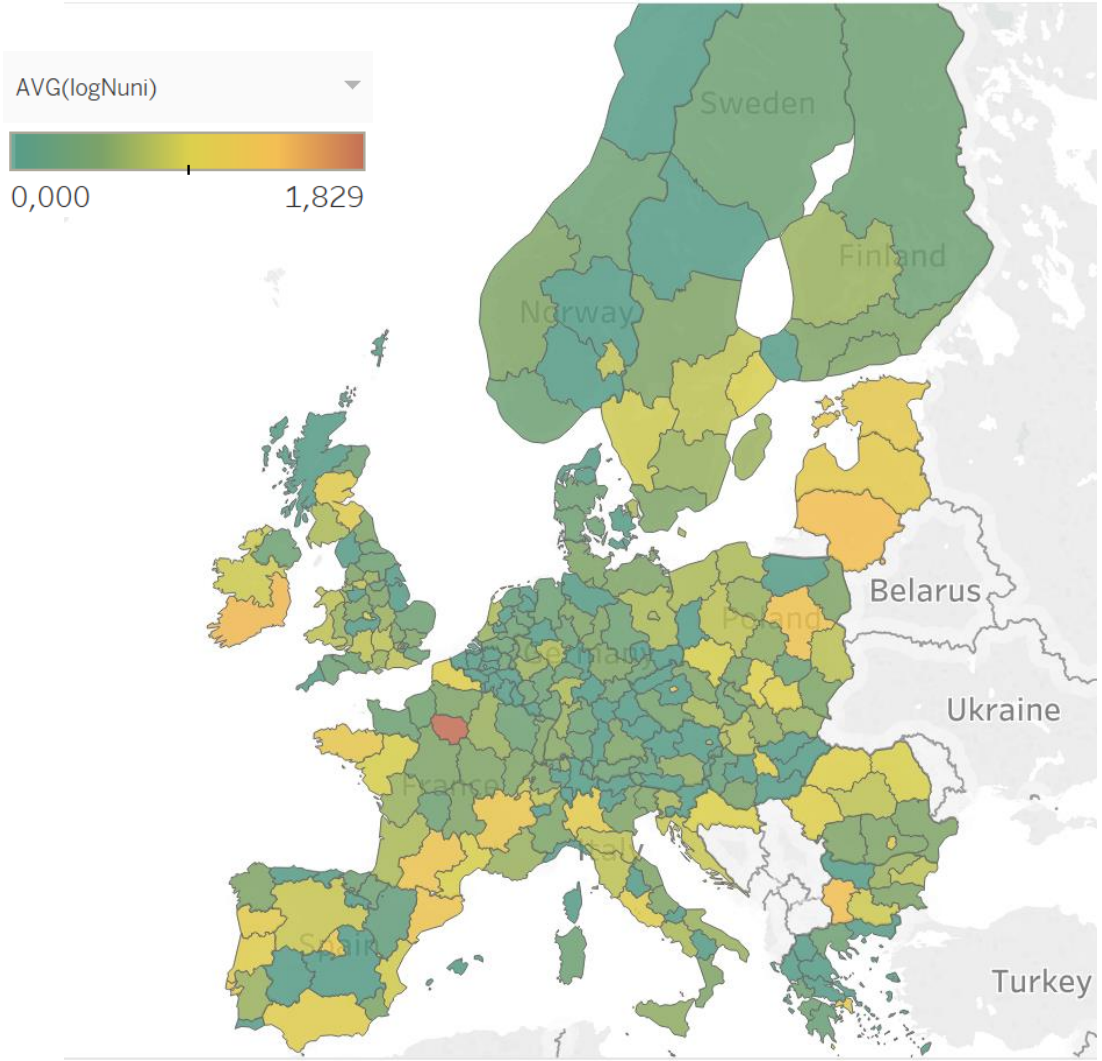



**Growth in GDP per capita-** mean over regions

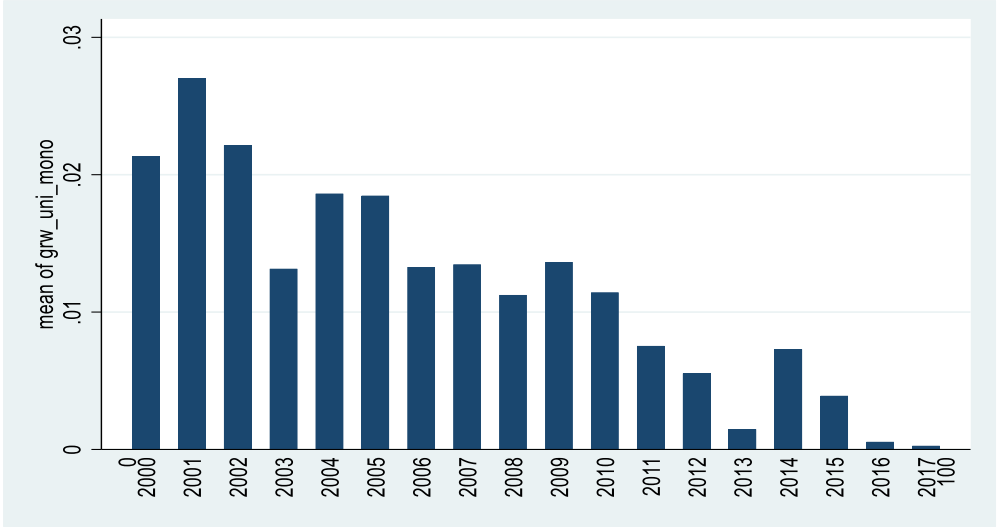


# Data Description: # of Universities

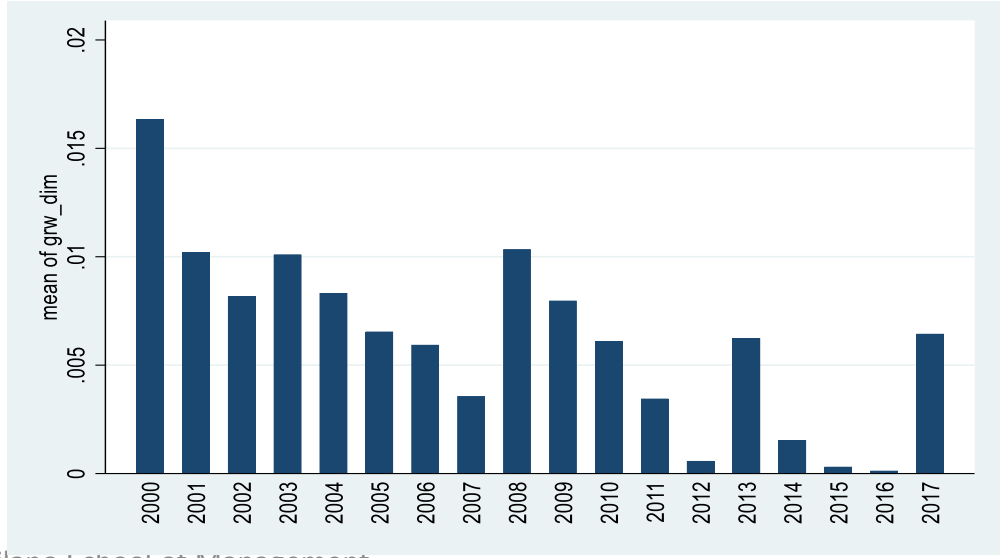
**Log(# Universities) -** mean over years



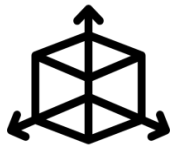

**Growth in # Universities** - mean over regions




Simple Indicator

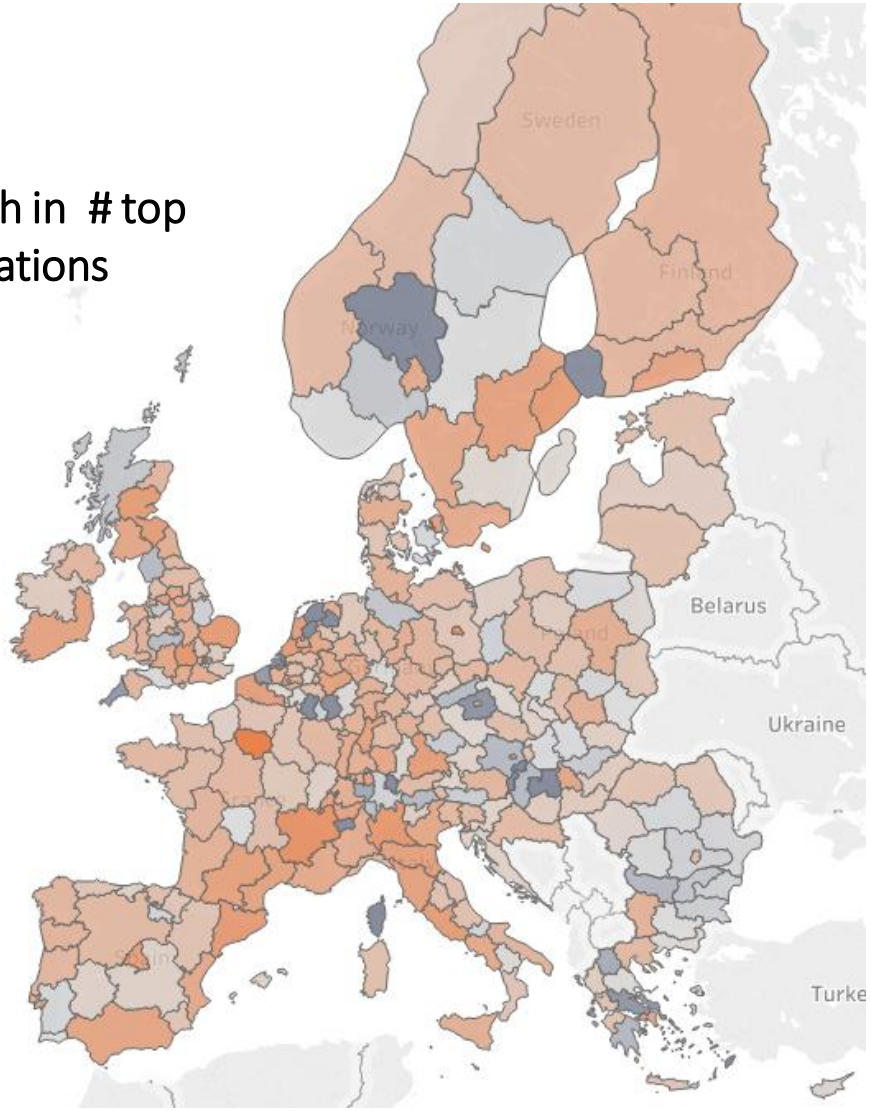



Size-weighted Indicator

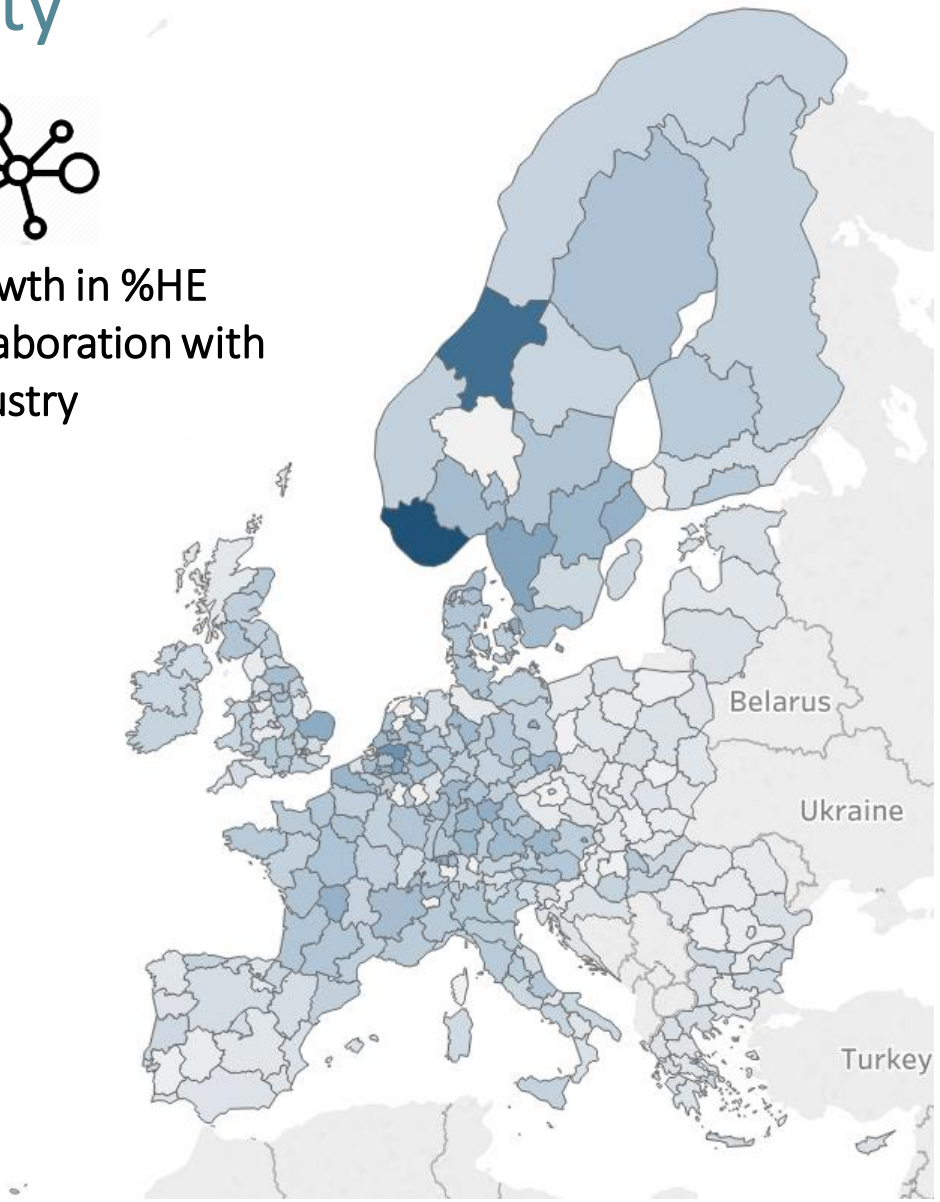


# Data Description: HESs' heterogeneity

Growth in # top publications




Growth in %HE collaboration with industry



# Preliminary Analysis

- **Endogeneity:** **Durbin–Wu–Hausman test** for detecting the endogenous regressor
  - Confirming the endogeneity problem for the main variables of interest.

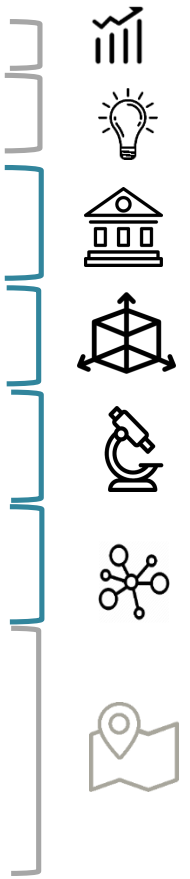
- **Cointegration:** **Kao test** for the cointegration in the specific case of panel data
  - **The null hypothesis is rejected → assuring the validity of the results / no spurious regressions**
  - The results for the baseline model:

| Kao test statistics | Statistic | p-value |
|---|---|---|
| Modified Dickey-Fuller t | -46.1597 | 0 |
| Dickey-Fuller t | -43.8189 | 0 |
| Augmented Dickey-Fuller t | -34.4121 | 0 |
| Unadjusted modified Dickey-Fuller t | -53.5431 | 0 |

# Empirical Results (1/3) – Generalized Method of Moments

| | (1) Growth in GPD per capita | (2) Growth in GPD per capita | (3) Growth in GPD per capita | (4) Growth in GPD per capita | (5) Growth in GPD per capita | (6) Growth in GPD per capita |
|---|---|---|---|---|---|---|
| Lagged level of ln(GDP per capita) | -0.0316*** | -0.0270*** | -0.0291*** | -0.0284*** | -0.0289*** | -0.0283*** |
| HE attainment | | 0.0003* | 0.0003* | 0.0003* | 0.0004** | 0.0003* |
| Growth in HE attainment | -0.0002 | | | | | |
| Lagged growth in HE attainment | 0 | | | | | |
| Growth in #universities | | | 0.0339 | | | |
| Lagged Growth in #universities (lag=1) | | | 0.0094 | | | |
| Lagged growth in #universities (lag=2) | | | 0.0151** | | | |
| Growth in HE dimension | | | | 0.0139 | 0.011 | 0.023 |
| Lagged Growth in HE dimension (lag=1) | | | | 0.0273*** | 0.0265*** | 0.0323*** |
| Lagged Growth in HE dimension (lag=2) | | | | 0.0128* | 0.0120* | 0.0123 |
| Growth in HE research | | | | | 0.004 | |
| Lagged Growth in HE research (lag=1) | | | | | 0.0052* | |
| Lagged Growth in HE research (lag=2) | | | | | -0.0001 | |
| Growth in HE third-mission | | | | | | -0.0037 |
| Lagged Growth inHE third-mission (lag=1) | | | | | | -0.0019 |
| Lagged Growth in HE third-mission (lag=2) | | | | | | -0.0004 |
| Growth in migration rate | 0.0008 | 0.0026** | 0.0021* | 0.0021* | 0.0021* | 0.0022* |
| Financial crisis | 1.9045*** | -0.1053*** | -0.0950*** | -0.0337*** | -0.0338*** | -0.0339*** |
| Capital in the region | 0.0159*** | 0.0108*** | 0.0102*** | 0.0113*** | 0.0111*** | 0.0109*** |
| Ln(population) | 0.0005 | 0.0003 | 0 | 0.0002 | 0.0003 | 0.0003 |
| Ln(population density) | 0.0007 | 0.0003 | 0.0001 | 0.0004 | 0.0004 | 0.0004 |
| Ln(public expenditure) | -0.4144*** | -0.0053 | -0.0905*** | -0.0906*** | -0.0886*** | -0.0942*** |
| Age | 0.0002 | 0.0007** | 0.0005* | 0.0005* | 0.0005* | 0.0005* |
| Constant | 0 | 0.3041 | 0.6686*** | 0.6561*** | 0.6501*** | 0.6697*** |
| Country fixed effects | yes | yes | yes | yes | yes | yes |
| Time dummies | yes | yes | yes | yes | yes | yes |
| Observations | 3,866 | 4,118 | 4,114 | 4,114 | 4,114 | 4,114 |
| Sys-GMM | yes | yes | yes | yes | yes | yes |
| Number of regions | 275 | 275 | 275 | 275 | 275 | 275 |
| Hansen test, p-value | 0.929 | 0.994 | 0.219 | 0.726 | 0.351 | 0.722 |

*** p<0.01, ** p<0.05, * p<0.1



# Empirical Results (2/3) – Summing up

- Confirmation of Barro's estimated "iron law": convergence rates around 2.83% per year

- Current level of HE attainment positively affects economic growth – however, the effect is small. Growth of qualified HC is not related with economic growth

- Growth in the # universities with two-year lag has a significant impact on the economic growth.
  - 10% increase in the number of universities is associated with **0.15 %** increase of GDP per capita in the region.

- # HE dimension (# divisions * # universities) influences positively the regional growth: the effect is statistically significant for the **one-year and two-year lags**.
  - Controlling for the size of universities: higher effects associated with the establishment of a new university in the region
  - A 10% increase in the research output is associated with about **0.3 %** rise in the GDP per capita.

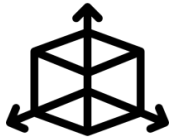
- Growth in the # of top publications has significant effect on regional economic growth (lag=1).
- Third-mission performance (external collaborations on publications) has not a statistically significant effect on regional economic growth

# Empirical Results (3/3) – The role of the financial crisis

**Crisis * Growth HE dimension (lag=1)**

| | |
|---|---|
| # Pre-crisis | 0.0491* |
| | (0.0291) |
| # crisis | 0.0071 |
| | (0.0051) |
| # Post-crisis | -0.0358 |
| | (0.0464) |

The effect of the **HE dimension is higher** before the financial crisis



The effect of the # of universities is **NOT statistically different** between pre-crisis and post-crisis

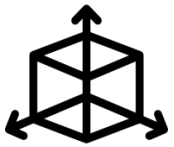
**Crisis * Growth HE Research (lag=1)**

| | |
|---|---|
| # Pre-crisis | 0.0055 |
| | (0.0033) |
| # Crisis | 0.0168*** |
| | (0.0061) |
| # Post-crisis | 0.0020 |
| | (0.0046) |

# Concluding remarks (preliminary)

- The results suggest the existence of a **positive effect** associated with the establishment of a new university in the region
  - The sys-GMM estimations confirm the findings of Valero and Van Reenen (2019)

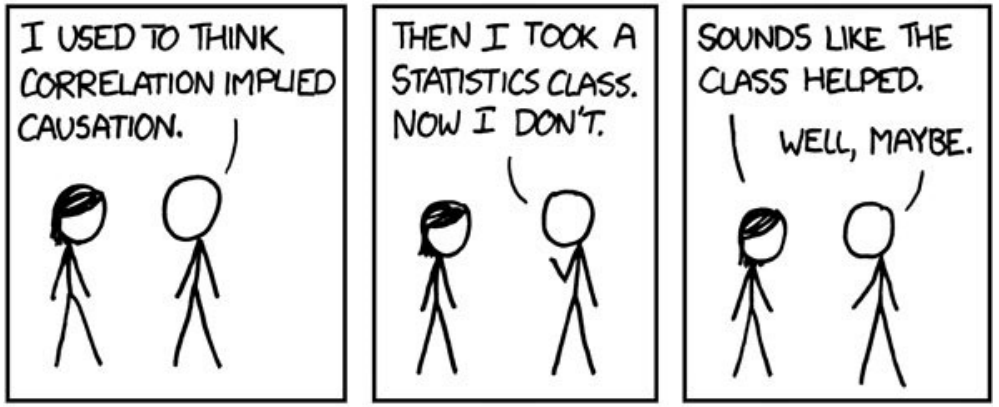
- Also the heterogeneity of universities matters:
  - **Positive effect** associated with the expansion in the **size of HE systems**
  - **Relevance of HE system's performance** – in particular, research quality has a positive effect on the regional growth



- The financial crisis seems to have affected the relationship between the dimension of HESs end regional economic growth:
  - Before the financial crisis → **higher effects** associated with the HE dimension
  - Possible explanation: universities need a longer time to generate a significant effect on economic performance.

# Limitations and next steps

- **Dealing with endogeneity:** Including external instruments in the sys-GMM




- **Improving data** and indicators of HESs
  - Data on teaching dimension (#students, #instructors)
  - Subject mix – area of specialization of universities

- Estimating the **spill-over effects** between regions

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Comments and suggestions are welcome

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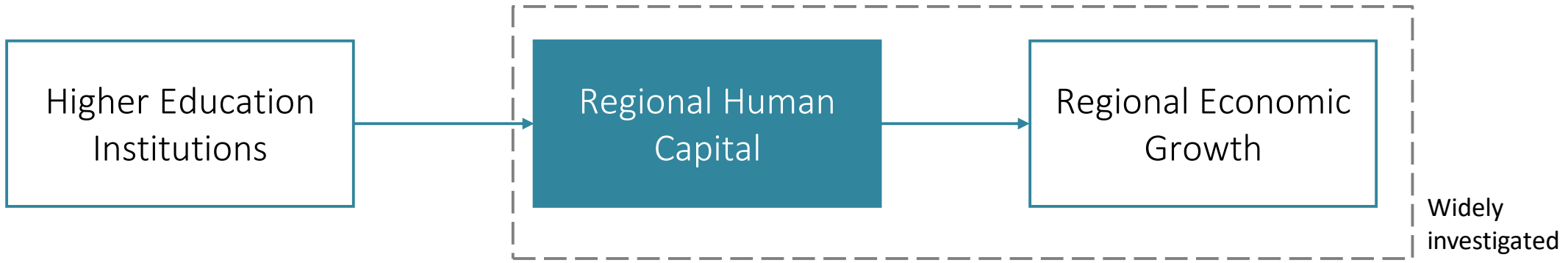
# Theoretical framework: Human capital channel




- Extensive literature on the relationship between HC and growth: Human Capital Theory (Schultz 1961, Becker 1964) and, in particular, New Growth Economics Theory (see Mankiw et al. 1992, Lucas 1988, Romer 1990)
  - **National level:** macroeconomic studies generally find a positive effect of human capital - typically expressed in years of schooling and economic growth (see among others de la Fuente and Domenech 2006).
  - **Regional level:** empirical analyses tend to confirm the importance of HC for increasing the regional GDP per capita (see Martin and Herranz 2004, Batabyal and Nijkamp 2013, Gennaioli 2013, Laskowska and Dańska-Borsiak 2016)
- Relationship between HEIs and HC is less investigated:
  - Abel and Deitz (2009) have found that degree production of universities has only a small positive relationship with local stocks of human capital, for the 283 US metropolitan areas studied.

# Theoretical framework: Innovation channel


- The 'innovation channel' captures the effects of the knowledge creation associated with research activity and the technological transfer of third-mission.
  - **Research activities** can contribute to the knowledge spillovers in different ways; for example:
    - Through **academic publications** (see for example Dębski et al., 2018).
    - The proximity to HEIs could be relevant to access to **research networks** (Audretsch and Lehmann, 2005).
  - **Third-mission** is associated with the production of patents and the development of business incubators and spin-offs (Shane, 2002).
- Regional development literature generally affirms the positive effect of innovation and R&D spillovers in promoting the economic growth of regions (Denti 2010).

# Theoretical framework: Demand-side channel


- The 'demand-side channel' captures the influence of HEIs on the local economy generated by the **expenditure** of HEIs and the respective **multiplier effects** (see Garrido-Yserte and Gallo-Rivera 2010):
  - Direct and indirect demand for local services and local goods.
  - Hiring academic staff and other employees.

- The 'direct' effect of universities is associated with a **short-term impact** on economic growth and it is considered less relevant than the other channels (Faggian and McCann 2009).

# Estimation strategy: System GMM (2/2)

$$y_{it} = \beta_1 X_{it} + \beta_2 W_{it} + u_{it} \qquad i = 1, \dots, N; t = 1, \dots, T$$

$$u_{it} = v_i + e_{it}$$

- $v_i$ are unobserved individual-level effects
- $e_{it}$ are the observation-specific errors
- $X_{it}$ is a vector of strictly exogenous covariates
- $W_{it}$ is a vector of predetermined regressors (that can include the lag of y) and endogenous regressors.

They may be correlated with $v_i$

1. First differencing: GMM approach removes $v_i$ and, therefore, the potential cause of endogeneity, by first-differencing regression.
2. Instrumenting: first-difference makes the predetermined variables endogenous (they are correlated with past errors):
   - Difference GMM instruments the differenced variables that are not strictly exogenous with all their available lags in levels
   - System GMM includes the original equation in levels to the model, to add additional instruments (lagged variables in first-difference can be used to instrument their own levels)

Lagged levels are usually poor instruments for first-differences

Better efficiency

# Preliminary Analysis (3/3): Endogeneity

- **Durbin–Wu–Hausman test** for detecting the endogenous regressors

1. **Regression**, where the independent variable that is suspected of endogeneity is **included as the dependent variable**, while other independent variables and control variables are still included as regressors
2. Estimating the **residuals** from the first regression and we included this estimate in the original model.
3. Estimating the **coefficient of the residuals** included in the second regression. If the **p-value** of this coefficient is statistically significant, the Durbin–Wu–Hausman test indicates that the variable is endogenous

All the variables that are suspected of endogeneity have been tested:

| | Growth in #universities | Growth in HE dimension | Growth in %top publications | Growth in industrial collaboration | HE attainment |
|---|---|---|---|---|---|
| p-value | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |

**The variables are endogenous** → instrumented in the sys-GMM

**INTERNATIONAL WORKSHOP**
BBVA Foundation – Ivie

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**18 October 2019 - Faculty of Economics**

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