# RISIS

## RESEARCH INFRASTRUCTURE FOR SCIENCE AND INNOVATION POLICY STUDIES

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# MODELLING THE FUNDING ENVIRONMENT OF EUROPEAN HEIs. SOME EMPIRICAL EVIDENCE

**Lugano, 19th of October, 2020**

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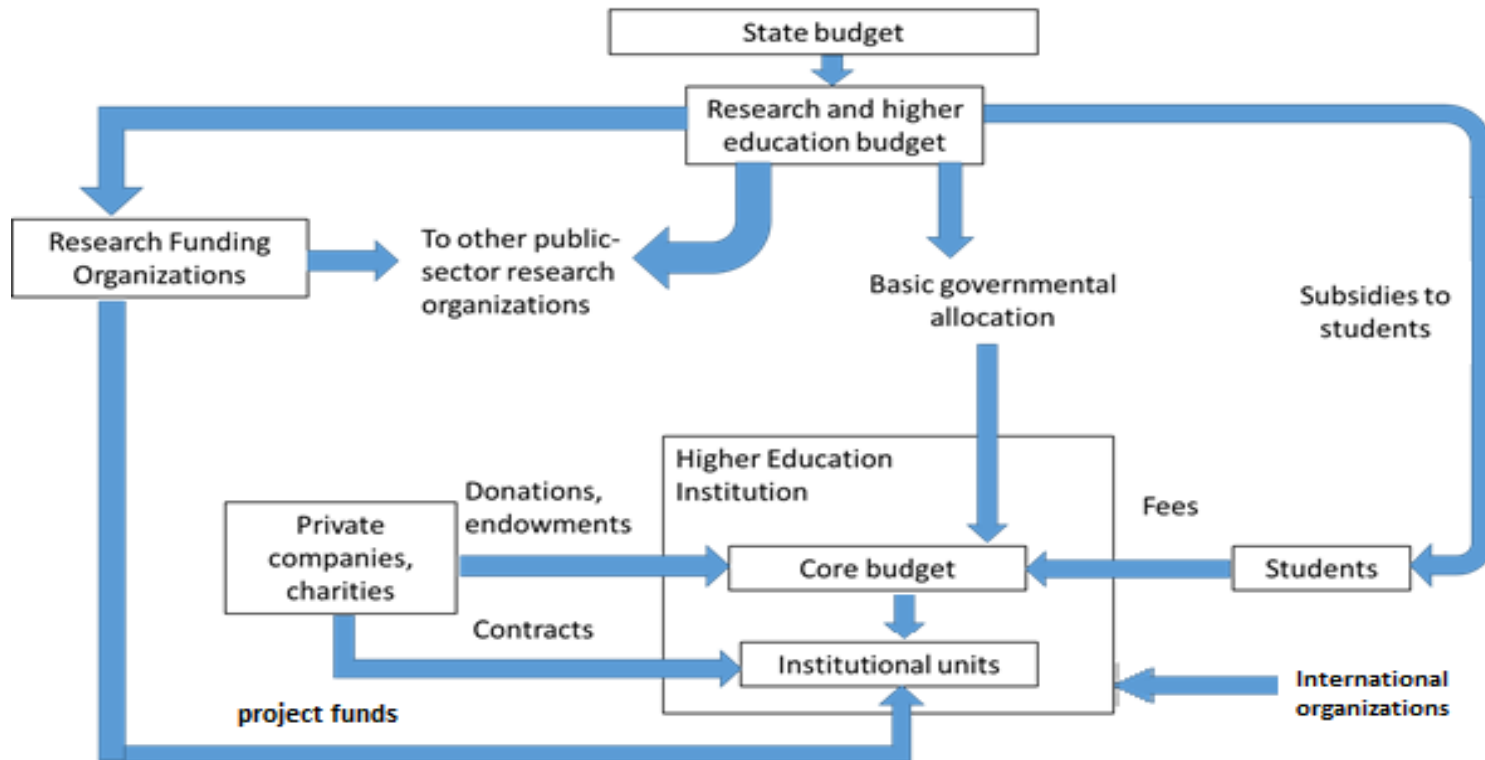
# Funding of higher education

- A core debate in higher education policy and higher education studies

- Changes in how funding is allocated with the emergence of New Public Management
  - Austerity/scarcity
  - Increase in the share of third-party funds
  - Changes in the allocation of core funding
- Evidence that changes are more gradual than revolutionary
  - But large differences between countries

# Hei funding allocation

- Basic governmental allocation
  - Usually as a lump sum from the state
  - Education & research
- Third-party funding
  - Public agencies
  - Private contracts
- Student fees
  - Students and families
  - Possibly a way to convey public funds to HEIs

# HEI funding structure

Jongbloed, Ben, and Benedetto Lepori. "The funding of research in higher education: Mixed models and mixed results." *The Palgrave international handbook of higher education policy and governance*. Palgrave Macmillan, London, 2015. 439-462.

# What we know (I)

- Funding levels (still) largely depends on the number of students

    - For the educational component, but also as 'research supplement'

- A share of funding is related to research (reputation)

    - Third-party funds

    - Performance-based state instalment

- Large differences between public and private

    - Due to eligibility to public funds

# What we know (II)

- Very large differences in the level of investment by country

- Differences in the composition of funds by country
  - Fees much more important in UK and IE
  - Large differences in the share of third-party funds for research

- Differences in how basic governmental allocation is attributed
  - Historical vs. performance based

# Goal of this presentation

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- Provide an empirical analysis of the funding structure of HEIs in Europe

  - Enriching previous analysis with more detailed evidence

- Analyze the interaction between

  - HEI characteristics (legal status, reputation, number of students)

  - Country characteristics (level of investment)

- Characterize the funding environment by country

  - Based on the observed data

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# Data

- An enriched version of the European Tertiary Education Register ([www.eter.project.com](www.eter.project.com))

  - Large coverage of European countries and HEIs (>3,000)

  - Including also data on scientific publications and EU-FP projects

- 1,312 HEIs in 19 countries with revenue data

  - Slightly less for breakdowns

  - Mostly public HEIs

  - Most large countries included (DE, FR, IT, UK)

# Variables

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- Country-level
  - Tertiary education public expenditure per inhabitant in euros PPPS
  - No reliable data on funding composition
- HEI level
  - Legal status
  - Research mandate (PhD awarding)
  - Number of undergraduate students
  - Research intensity (PhD, publications, projects normalized by students
- More variables can be added at later stage (subject mix, etc.)

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# Revenue variables by HEI

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- *Total current revenues in euros PPPs*
  - *Non-recurring revenues excluded.*
- *Revenues per undergraduate student*
- *Breakdown of total revenues by:*
  - Basic government allocation, i.e. resources acquired for the general functioning of HEI from the state.
  - Third-party funding, i.e. funds earmarked to specific activities and subunits from public research funding agencies and private companies.
  - Student fees, i.e. the amounts contributed by students.

# Analysis

- Descriptive analysis

  - Comparing groups of HEIs

  - Country vs. HEI level

- Multilevel model

  - Including country covariates and country random intercept

  - Distinct models by funding stream to look to differences in associations and country environment

# Summary of descriptives

- Very large differences in the volume of funding
  - Top-budgets: Oxford and Cambridge
- Huge differences in funding per student
  - Research institutes and graduate schools
  - Top-ranked international universities
  - Specialized universities in technical sciences, business or medicine
- Most HEIs funded mostly through core funding
  - Third-party funding complementary
- Fees play a core role for
  - Private HEIs
  - Public HEIs in the UK and IE

➔ large budgets (absolute and relative) associated with top-research

➔ Country and regulatory differences matter a lot

# Descriptives
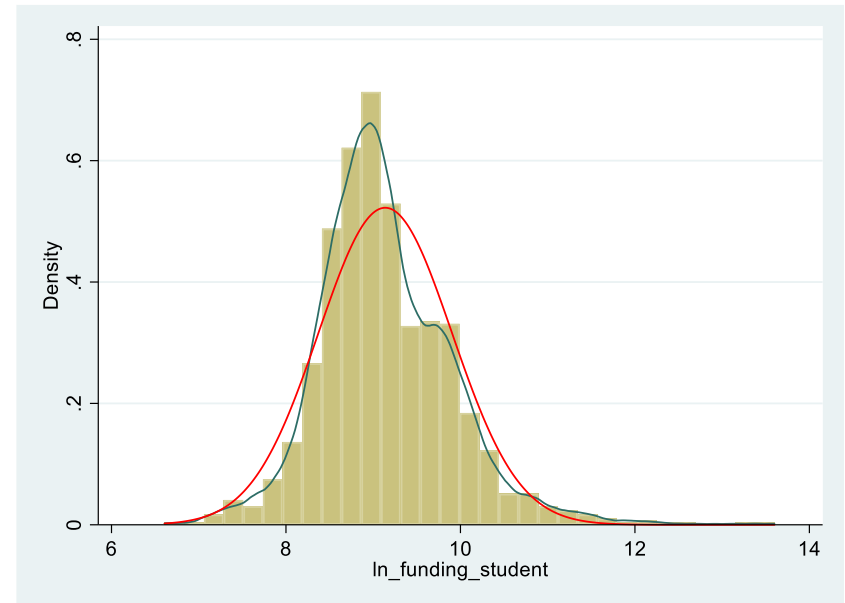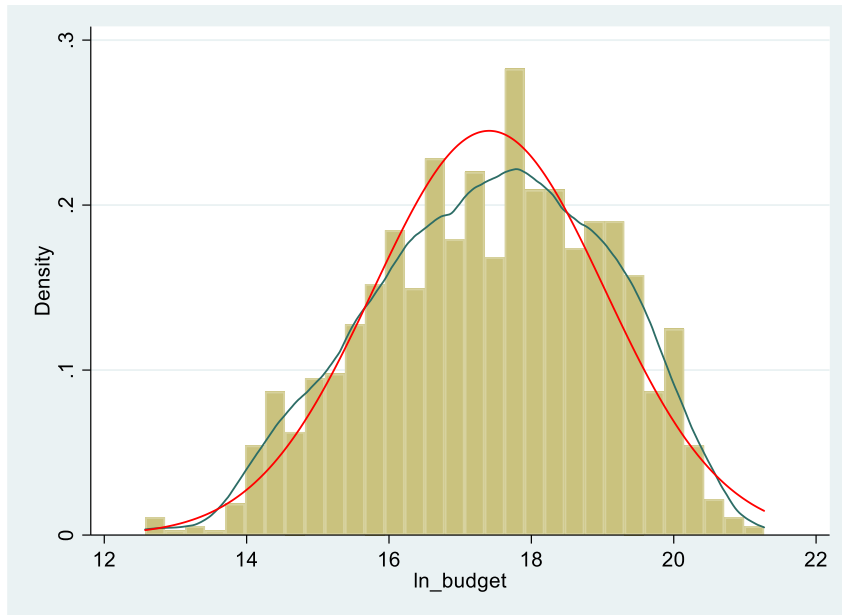
- ## Distribution of revenues nearly lognormal

- ## Distribution of revenues per students highly skewed

# Top revenues

| | englishinstitutionname | total~57 | newcur~p | fundin~t |
|---|---|---|---|---|
| 1. | The University of Cambridge | 14145 | 1.73e+09 | 122215.5 |
| 2. | The University of Oxford | 21315 | 1.51e+09 | 70762.91 |
| 3. | University College London | 29745 | 1.27e+09 | 42832.4 |
| 4. | The University of Manchester | 35035 | 1.07e+09 | 30411.19 |
| 5. | Imperial College of Science, Technology and Medicine | 12805 | 1.03e+09 | 80644.31 |
| 6. | Università Cattolica del Sacro Cuore | 39443 | 1.00e+09 | 25454.87 |
| 7. | Ludwig Maximilian University of Munich | 46308 | 9.51e+08 | 20537.3 |
| 8. | Aachen University | 37557 | 9.34e+08 | 24872.5 |
| 9. | Federal Institute of Technology Zurich | 14214 | 9.17e+08 | 64531.12 |
| 10. | The University of Edinburgh | 25770 | 8.87e+08 | 34426.43 |
| 11. | Technical University of Munich | 34821 | 8.69e+08 | 24945.38 |
| 12. | KU Leuven | 46076 | 8.60e+08 | 18656.23 |
| 13. | Sapienza University of Rome | 108318 | 8.05e+08 | 7433.003 |
| 14. | University of Zurich | 21556 | 7.90e+08 | 36654.68 |
| 15. | University of Cologne | 50427 | 7.40e+08 | 14676.86 |

- Medium-size research intensive universities have the largest budgets.
- Top ranked universities have large funding per student

# Top revenues per student

| englishinstitutionname | total~57 | newcur~p | fundin~t |
|---|---|---|---|
| The Institute of Cancer Research | 165 | 1.33e+08 | 805844.6 |
| National museum of natural history | 200 | 1.03e+08 | 516045.7 |
| Sant'Anna School for Advanced Studies | 177 | 5.64e+07 | 318579.3 |
| | 322 | 6.75e+07 | 209670.8 |
| London School of Hygiene and Tropical Medicine | 840 | 1.54e+08 | 183785.6 |
| Central European University (Budapest) | 473 | 8.41e+07 | 177770.5 |
| | 102 | 1.47e+07 | 144359.4 |
| Hannover Medical School | 2862 | 3.62e+08 | 126637.7 |
| The University of Cambridge | 14145 | 1.73e+09 | 122215.5 |
| European School of Management and Technology, Berlin | 191 | 2.20e+07 | 115168.6 |
| Protestant Theological University | 100 | 9722346 | 97223.46 |
| The General Jonas Zemaitis Military Academy of Lithuania | 348 | 3.26e+07 | 93771.22 |
| FH der Polizei Brandenburg (VerwFH) in Oranienburg | 356 | 3.31e+07 | 93016.76 |
| Charité – Universitätsmedizin Berlin | 6020 | 5.25e+08 | 87182 |
| Institute for Advanced Study – IUSS of Pavia | 60 | 5123624 | 85393.73 |

- Very specialized institutions (medical)
- Some top-ranked European universities

# Composition of funding
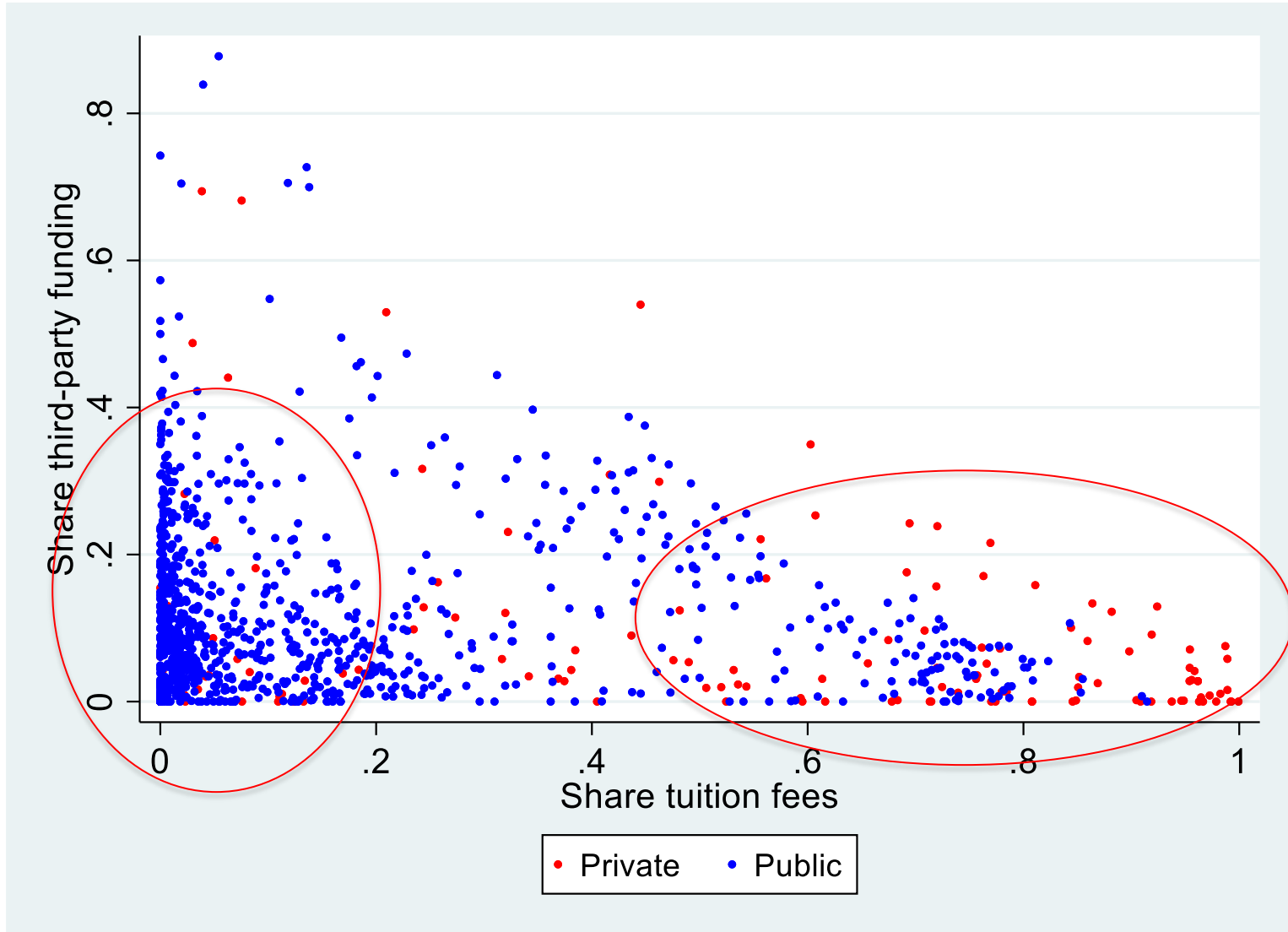
# Share tuition fees
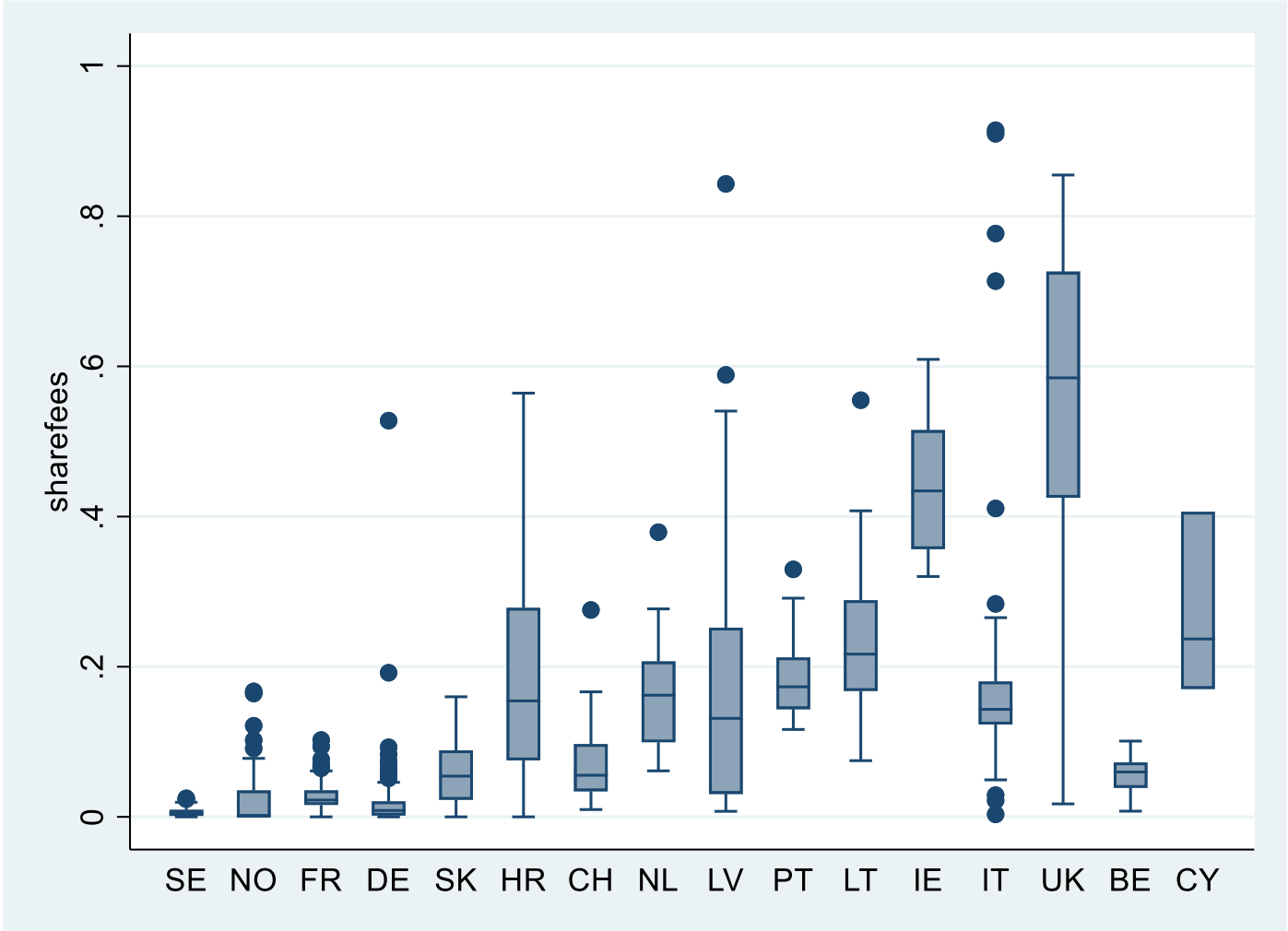
# Group differences

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| | Public | Private | p | No PhD | PhD | p |
|---|---|---|---|---|---|---|
| Total current revenues (PPP) | 53'038'916 | 5'721'094 | 0.000 | 13'383'953 | 96'208'328 | 0.000 |
| revenues_student | 8698.66 | 5948.86 | 0.000 | 6594.30 | 10246.73 | 0.000 |
| share_core | 0.77 | 0.11 | 0.000 | 0.77 | 0.72 | 0.000 |
| share_thirdparty | 0.08 | 0.03 | 0.000 | 0.05 | 0.10 | 0.000 |
| share_fees | 0.05 | 0.71 | 0.000 | 0.08 | 0.08 | 0.759 |
| N (total revenues) | 1113 | 196 | | 559 | 737 | |

- Private HEIs have much lower resources and are mostly funded by student fees
- PhD awarding HEIs have much higher revenues and slightly more third-party funding
- Significance is tested with non-parametric tests (Mann-Whitney)

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# Summary

- We have evidence of large differences between
  - Countries
  - HEIs by legal status
  - HEIs by research mandate
- But also different by variables
  - More differences for fees
  - Less for third-party funding
- Anova allows measuring the importance of group differences with respect to HEI variability:
  - Important to set-up the multilevel model

# Funding per student

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```
. anova ln_funding_student countrycodenr dummylegst dummyphd
```

|  | Number of obs = | 1,287 | R-squared | = | 0.3288 |
| --- | --- | --- | --- | --- | --- |
|  | Root MSE = | .630053 | Adj R-squared = | | 0.3182 |

| Source | Partial SS | df | MS | F | Prob>F |
| --- | --- | --- | --- | --- | --- |
| Model | 246.19464 | 20 | 12.309732 | 31.01 | 0.0000 |
| | | | | | |
| countryco~r | 161.05422 | 18 | 8.9474568 | 22.54 | 0.0000 |
| dummylegst | 3.9221984 | 1 | 3.9221984 | 9.88 | 0.0017 |
| dummyphd | 69.150896 | 1 | 69.150896 | 174.20 | 0.0000 |
| | | | | | |
| Residual | 502.5596 | 1,266 | .39696651 | | |
| | | | | | |
| Total | 748.75424 | 1,286 | .58223502 | | |

Group variables account only for 1/3 of differences in funding per student
- Even using log transformation to reduce the impact of outliers
- High variability within HEIs within the same group and country

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# Share of tuition fees

. anova sharefees countrycodenr dummylegst dummyphd

```
                    Number of obs =        1,062    R-squared     =   0.6777
                    Root MSE      =      .15628    Adj R-squared =   0.6724
```

| Source | Partial SS | df | MS | F | Prob>F |
|---|---|---|---|---|---|
| Model | 53.611853 | 17 | 3.1536384 | 129.12 | 0.0000 |
| countryco~r | 37.058149 | 15 | 2.4705433 | 101.16 | 0.0000 |
| dummylegst | 18.849454 | 1 | 18.849454 | 771.78 | 0.0000 |
| dummyphd | .80420271 | 1 | .80420271 | 32.93 | 0.0000 |
| Residual | 25.497959 | 1,044 | .02442333 | | |
| Total | 79.109813 | 1,061 | .07456156 | | |

Group variables account for 2/3 of differences in the share of fees

- Both country differences and legal status matter a lot

# Multilevel model (I)

- Measure the impact on funding of HEI characteristics

  - Number of students

  - Research intensity

  - Legal status and research mandate

- Baseline: funding proportional to students

  - Which is the prime research-oriented HEIs receive?

  - Differences in the composition of funding (for example third-party)

# Multilevel model (II)

- Impact of the national funding environment on HEI resourcing

  - Using a country covariate

- Characterize national funding environment

  - Difference in composition

  - Implications for different categories of HEIs

# Model

$$\ln(stream)_{ij} = \alpha + \beta \ (country)_j + (HEI)_{ij} + u_j + \varepsilon_{ij}$$

*National level of investment*

*Number of students research intensity*

*Non modelled country differences*

Legal status & research mandate

- The model is already multiplicative

- Random intercepts can estimated from the model

- You could also test random slopes, but data are maybe not enough

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```
. xtset countrycodenr
      panel variable:  countrycodenr (unbalanced)

. xtreg ln_budget tertiaryexpperinhab lnstudent resintensity i.dummylegst i.dummyphd, re


Random-effects GLS regression              Number of obs      =        1,287
Group variable: countrycod~r               Number of groups   =           19

R-sq:                                      Obs per group:
     within  = 0.8735                                    min =           18
     between = 0.8913                                    avg =         67.7
     overall = 0.8827                                    max =          382

                                           Wald chi2(5)       =      8871.13
corr(u_i, X)    = 0 (assumed)              Prob > chi2        =       0.0000
```

| ln_budget | Coef. | Std. Err. | z | P>\|z\| | [95% Conf. Interval] | |
|---|---|---|---|---|---|---|
| tertiaryexpperinhab | .0019626 | .000512 | 3.83 | 0.000 | .0009591 | .0029662 |
| lnstudent | .8354704 | .0121426 | 68.80 | 0.000 | .8116713 | .8592695 |
| resintensity | 23064.89 | 1202.168 | 19.19 | 0.000 | 20708.69 | 25421.1 |
| 1.dummylegst | -.403204 | .0473353 | -8.52 | 0.000 | -.4959795 | -.3104286 |
| 1.dummyphd | .558574 | .0365725 | 15.27 | 0.000 | .4868932 | .6302548 |
| _cons | 9.292671 | .235706 | 39.42 | 0.000 | 8.830696 | 9.754646 |

```
      sigma_u | .31554428  ◄──      SE of error terms
      sigma_e | .50958112
          rho | .27716258   (fraction of variance due to u_i)
```

# Overall results

| | ln_budget | | | ln_core_budget | | | ln_third-party | | | ln_student_fees | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Coef. | Std. Err. | P>z | Coef. | Std. Err. | P>z | Coef. | Std. Err. | P>z | Coef. | Std. Err. | P>z |
| tertiaryexpperinhab | 0.002 | 0.001 | 0.000 | 0.003 | 0.001 | 0.026 | 0.005 | 0.002 | 0.021 | -0.003 | 0.004 | 0.378 |
| Instudent | 0.835 | 0.012 | 0.000 | 0.802 | 0.022 | 0.000 | 1.277 | 0.058 | 0.000 | 1.003 | 0.053 | 0.000 |
| resintensity | 23064.890 | 1202.168 | 0.000 | 21776.480 | 2116.192 | 0.000 | 43309.240 | 5585.389 | 0.000 | 7042.980 | 5041.000 | 0.162 |
| 1.dummylegst | -0.403 | 0.047 | 0.000 | -1.887 | 0.095 | 0.000 | -1.373 | 0.225 | 0.000 | 3.070 | 0.208 | 0.000 |
| 1.dummyphd | 0.559 | 0.037 | 0.000 | 0.625 | 0.066 | 0.000 | 1.410 | 0.179 | 0.000 | 0.157 | 0.165 | 0.341 |
| _cons | 9.293 | 0.236 | 0.000 | 8.794 | 0.517 | 0.000 | 0.964 | 0.941 | 0.306 | 7.244 | 1.664 | 0.000 |
| Rsq within | 0.874 | | | 0.747 | | | 0.500 | | | 0.308 | | |
| Rsq between | 0.891 | | | 0.713 | | | 0.667 | | | 0.261 | | |
| Rsq overall | 0.884 | | | 0.712 | | | 0.533 | | | 0.253 | | |
| sigma_u | 0.316 | | | 0.733 | | | 1.126 | | | 2.056 | | |
| sigma_e | 0.510 | | | 0.888 | | | 2.365 | | | 2.107 | | |
| rho | 0.277 | | | 0.405 | | | 0.185 | | | 0.488 | | |
| Groups | 19 | | | 19 | | | 17 | | | 16 | | |
| Obervations | 1287 | | | 1204 | | | 1138 | | | 1082 | | |

- Compare explanatory power of the models
- Compare unexplained variance at the country level (fees!)
- Differences in coefficients depending on funding streams
  - Research intensity
  - Legal status

# Students

- Students coefficient is below 1
  - Less than proportional growth in funds
  - However effect relatively small since the coefficient is near to 1

- Third-party funds grow more rapidly with students
  - Capacity effect (more students, more staff)?
  - Correlation with research intensity

- Student fees are perfectly linear
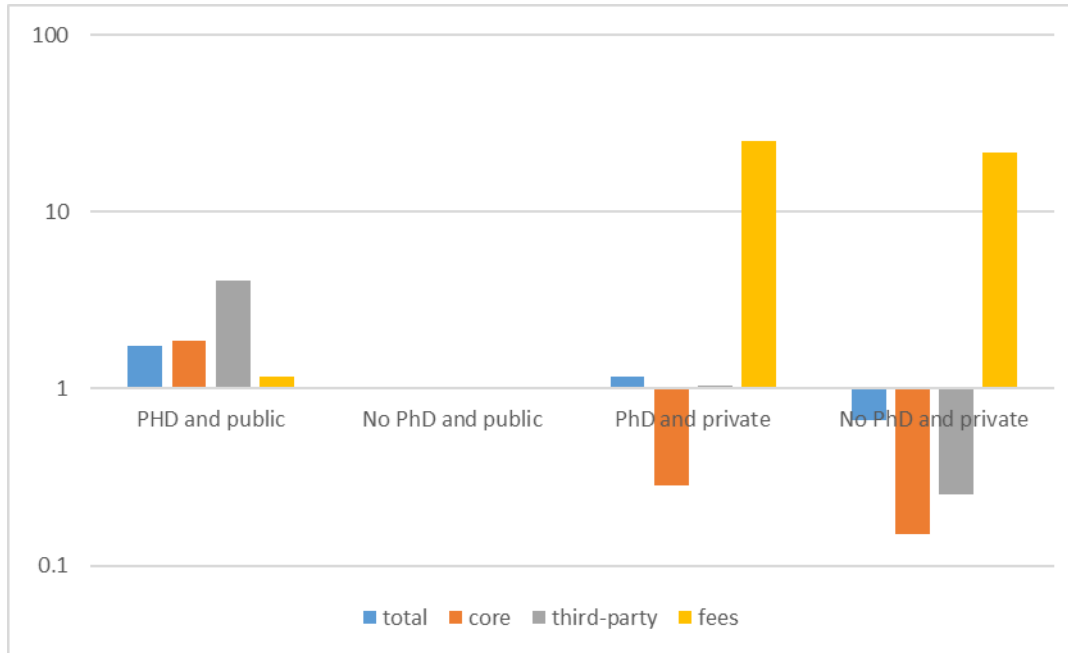  - As expected

# Research 'bonus'
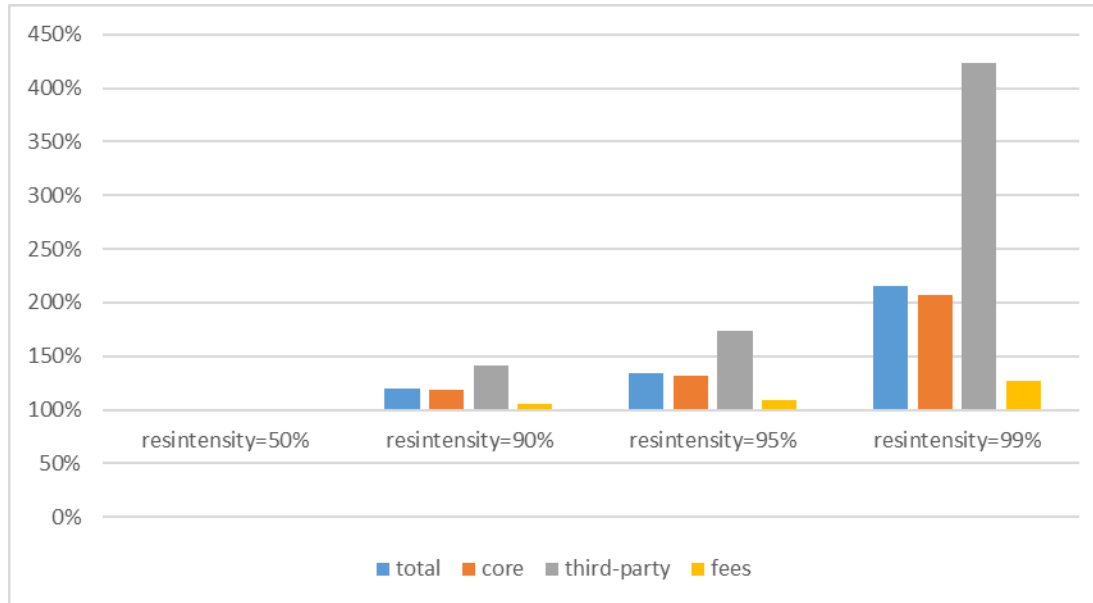


- Multiplicative factor of research intensity (same country and number of students)

- Very high research intensity must be sustained by very large amounts of resources!

- No bonus for fees

# Group differences



- Much larger amount of funding for PhD awarding HEIs
  - Particularly for third-party funding
- Lower funding for private
  - but much higher amount from fees

# Country analysis

- It is possible to compute the best estimate of the random intercept for each country individually

  - Best possible model estimate

- Use xtmixed (same results as xtreg)

  xtmixed ln_budget tertiaryexpperinhab lnstudent resintensity i.dummylegst i.dummyphd || countrycodenr:

  predict ebbudget,reffects

  etc.

- Then to compute whole 'country effects'

# Random intercept

| countrycode | ebbudget | ebcore | ebtpf | ebfees |
|---|---|---|---|---|
| DE | .1232893 | .4050663 | .1503896 | -2.19238 |
| FR | -.0643957 | -.0152139 | -.1895311 | -.6608966 |
| IT | .0641975 | .2575659 | -1.372377 | .0858932 |
| UK | .0956299 | -.9513156 | -.4479668 | 3.174163 |

$$\ln(stream)_{ij} = \alpha + \beta \ (country)_j + \gamma \ (HEI)_{ij} + u_j + \varepsilon_{ij}$$

$$(stream)_{ij} = \text{EXP} \ (\alpha + \gamma \ (HEI)_{ij} + \varepsilon_{ij}) * \text{EXP} \ (\beta \ (country)_j + u_j)$$

The expression in red is (the estimate of) a country (and stream) multiplicative factor given by a fixed effect given by tertiary education expenditures and of a random effect.

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# Country environments
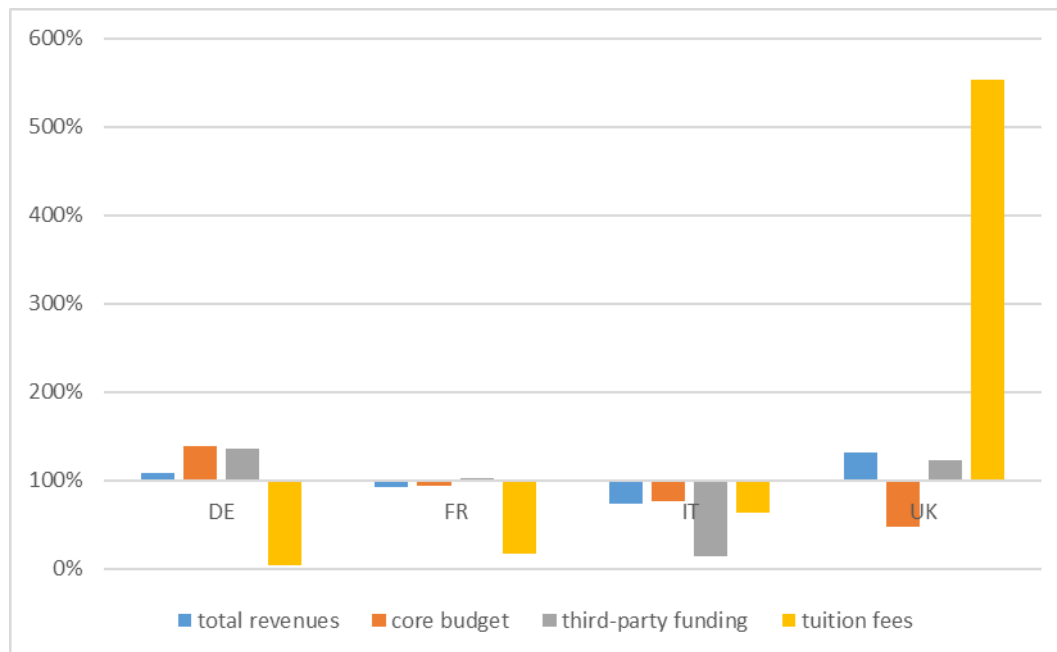


- Multiplicative factors of revenues of HEIs with the same characteristics
- Allows characterizing national funding environments from HEI-level data thanks to the ML model
- Fees make a huge difference in the UK

# Summary

- The largest difference in HEI funding environment by country is related to the national level of investment
  - This must be taken into account when comparing countries
  - There are more similarities in how resources are allocated

- Types of HEIs have different resourcing behaviour
  - By level *and* composition of resources
  - Funding reforms have a distributive effect (and, hence, a political dimension within the HEI system)

- Strong commonalities in the association of funding to activities
  - Mostly related to the number of students
  - Effect of research output limited except on the top of the pile

# Comment on the model

- ML model represents well the interaction between country and HEI effects

  - Allows characterizing countries' unobserved heterogeneity

- Key choices on the structure of the model

  - Pros and cons of the multiplicative structure

  - Could we have more flexible models?

  - At which price?