

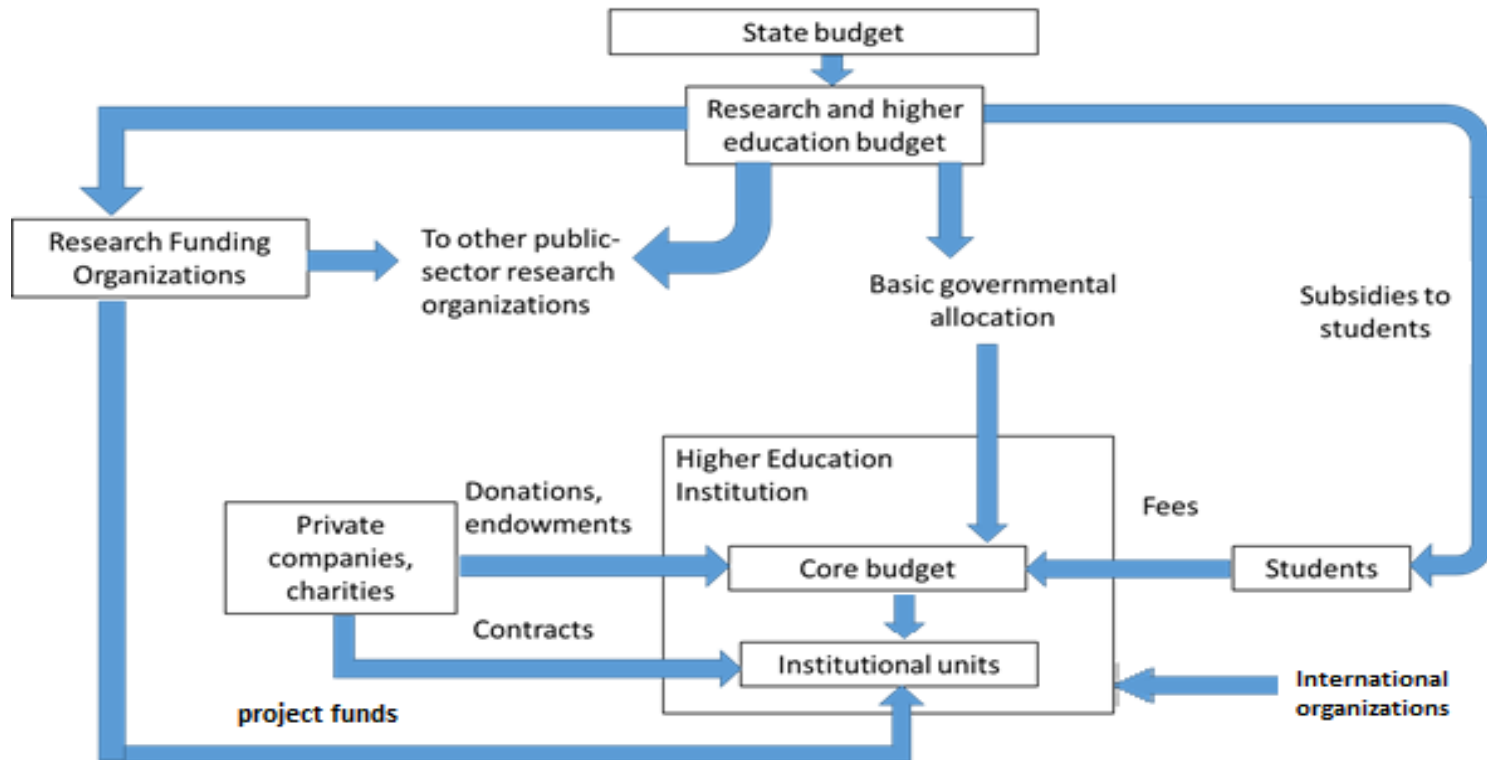


- A core debate in higher education policy and higher education studies
- Changes in how funding is allocated with the emergence of New Public Management
 - Austerity/scarcity
 - Increase in the share of third-party funds
 - Changes in the allocation of core funding
- Evidence that changes are more gradual 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



- An enriched version of the European Tertiary Education Register (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)

- 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.)

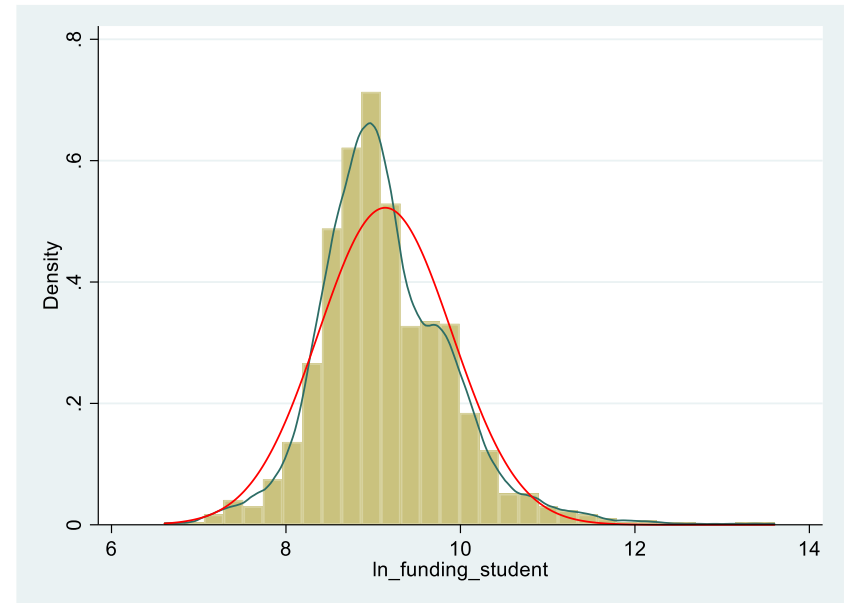
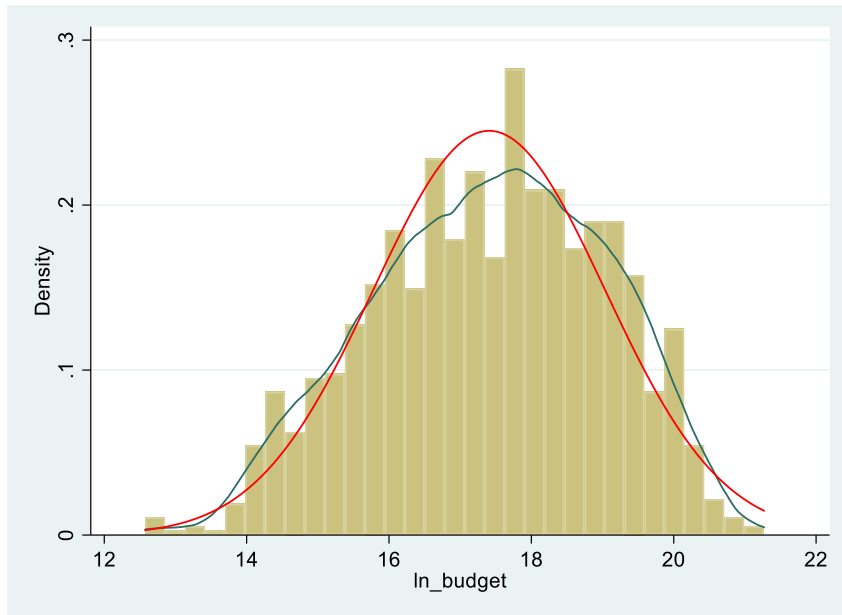


- *Total current revenues in euros PPPs*
 - *Non-recurring revenues excluded.*
- *Revenues per undergraduate student*
- *Breakdown of total revenues by:*
 - Basic government allocation, i.e. resources acquired for the general functioning of HEI from the state.
 - Third-party funding, i.e. funds earmarked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

- 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



- 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

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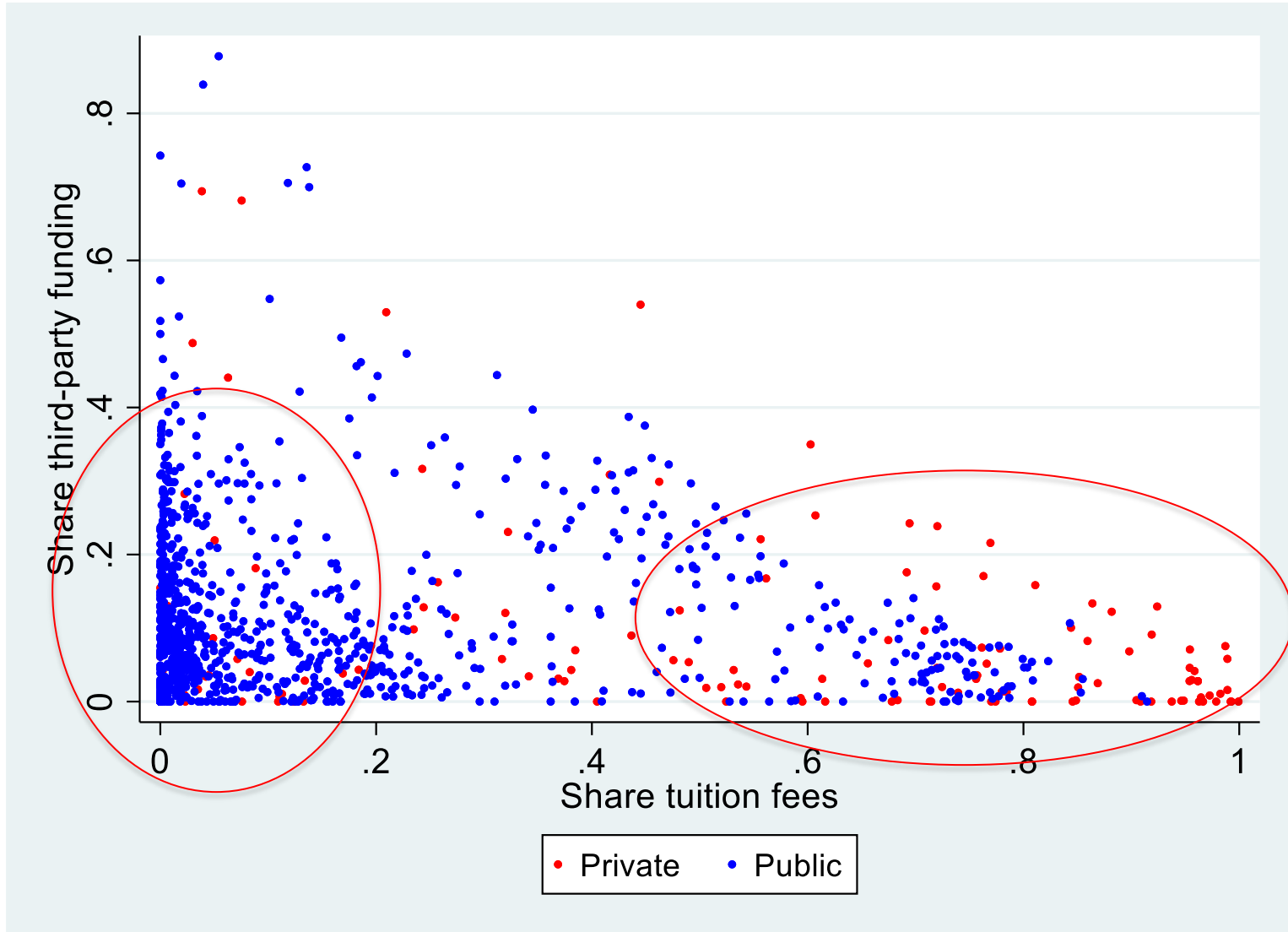


englishinstitutionname	total~57	newcur~p	fundin~t
The Institute of Cancer Research	165	1.33e+08	805844.6
National museum of natural history	200	1.03e+08	516045.7
Sant'Anna School for Advanced Studies	177	5.64e+07	318579.3
	322	6.75e+07	209670.8
London School of Hygiene and Tropical Medicine	840	1.54e+08	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

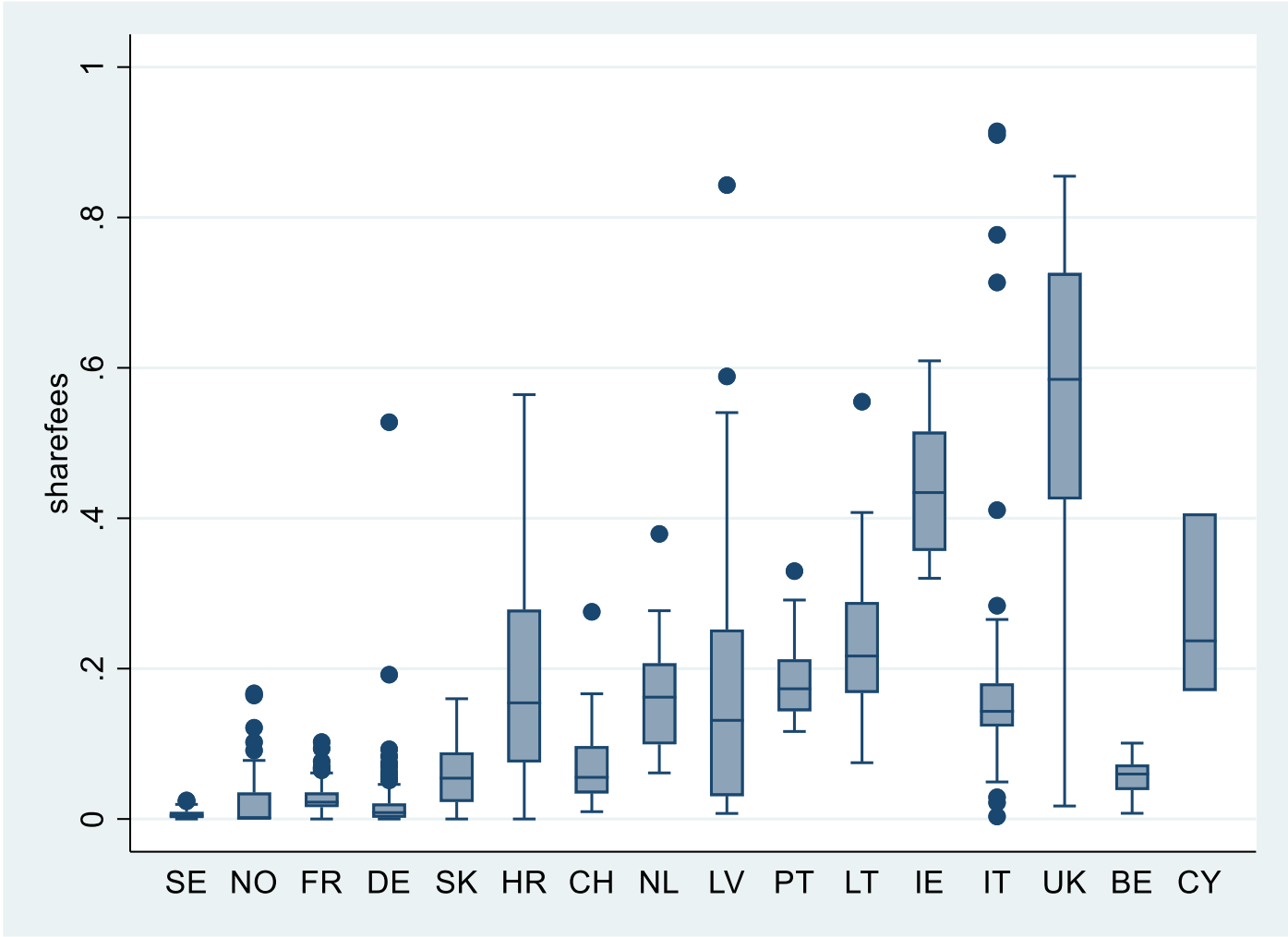
- Very specialized institutions (medical)
- Some top-ranked European universities

Composition of funding

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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)

- 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



```
. 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

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

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



*National level
of investment*



*Number of students
research intensity*

Legal status & research mandate

*Non modelled
country differences*

- The model is already multiplicative
- Random intercepts can be estimated from the model
- You could also test random slopes, but data are maybe not enough



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

```
. xtreg ln_budget tertiaryexpperinhab lnstudent resintensity i.dummyslegst i.dummyphd, re
```

```
Random-effects GLS regression
Group variable:  countrycodenr
```

```
Number of obs      =      1,287
Number of groups   =         19
```

R-sq:

```
within  = 0.8735
between = 0.8913
overall = 0.8827
```

```
Obs per group:
min =      18
avg  =     67.7
max  =     382
```

```
corr(u_i, X)      = 0 (assumed)
```

```
Wald chi2(5)      =     8871.13
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.dummyslegst	-.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					
sigma_e	.50958112					
rho	.27716258					

← SE of error terms

(fraction of variance due to u_i)

Overall results

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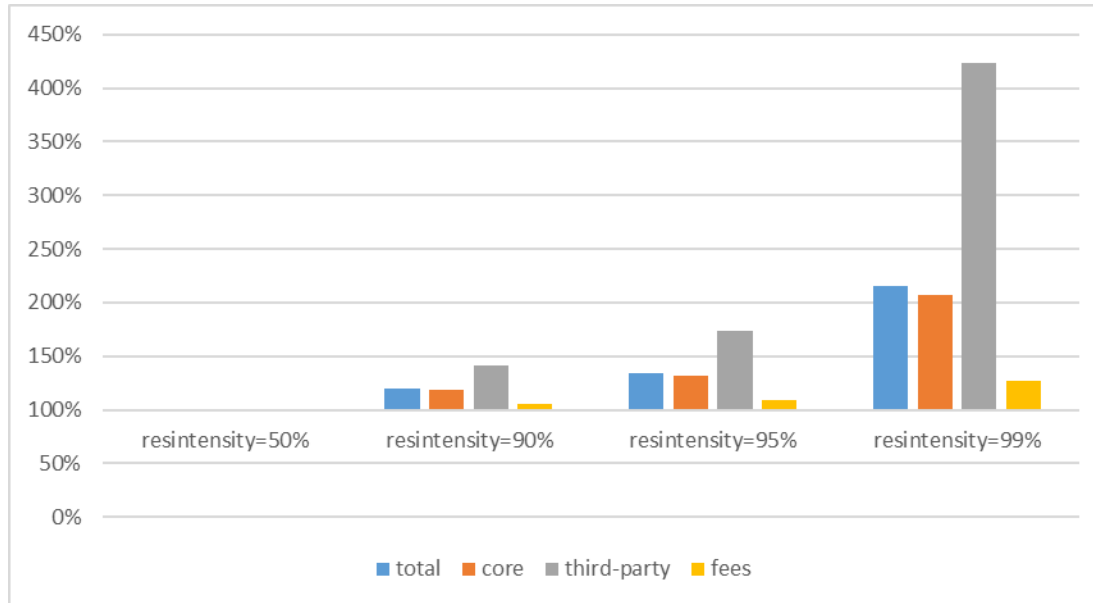


	In_budget			In_core_budget			In_third-party			In_student_fees		
	Coef.	Std. Err.	P>z	Coef.	Std. Err.	P>z	Coef.	Std. Err.	P>z	Coef.	Std. Err.	P>z
tertiaryexpperinhab	0.002	0.001	0.000	0.003	0.001	0.026	0.005	0.002	0.021	-0.003	0.004	0.378
lnstudent	0.835	0.012	0.000	0.802	0.022	0.000	1.277	0.058	0.000	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
Rsqr within	0.874			0.747			0.500			0.308		
Rsqr between	0.891			0.713			0.667			0.261		
Rsqr 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		
Observations	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

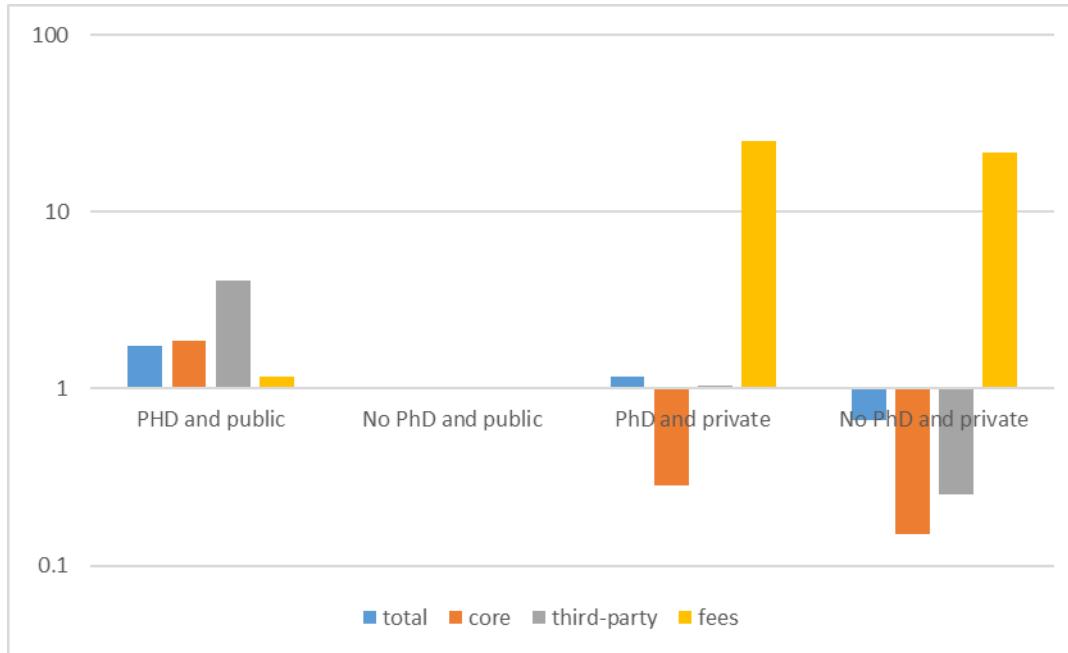
- Students coefficient is below 1
 - Less than proportional growth in funds
 - However effect relatively small since the coefficient is near to 1
- Third-party funds grow more rapidly with students
 - Capacity effect (more students, more staff)?
 - Correlation with research intensity
- Student fees are 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



- 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 Instudent
resintensity i.dummyslegst i.dummyphd | | countrycodenr:
predict ebbudget,reflects
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

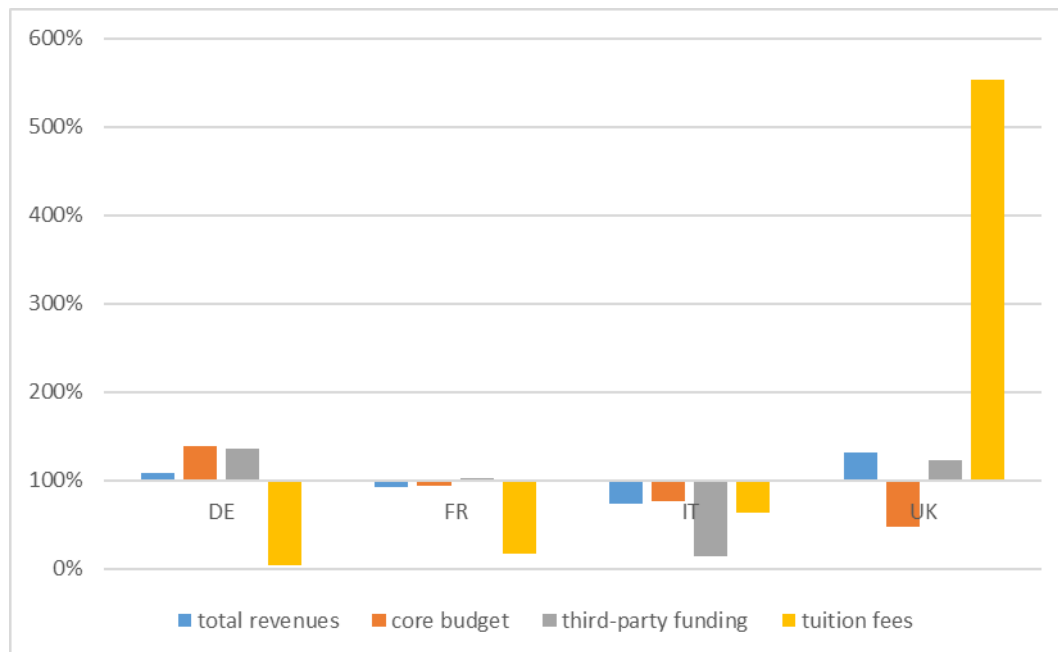
$$\ln(\text{stream})_{ij} = \alpha + \beta (\text{country})_j + \gamma (\text{HEI})_{ij} + u_j + \varepsilon_{ij}$$

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

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.

Country environments

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- 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

- 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

- 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?

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RESEARCH INFRASTRUCTURE FOR SCIENCE
AND INNOVATION POLICY STUDIES

THANK YOU!

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