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Appendix

Annex for the paper

A1. Details of the weighted procedure for the variable RESEARCH

As for RESEARCH, we use a measure of the number of total works published by the faculty members of each institution and, in so doing, we move away from most works generally employing a financial measure, like the amount of grants received by an institution. In particular, our data differentiate documents according to a national categorization of the disciplinary areas of the authors realized by ANVUR. Two classes are identified, bibliometric areas (mathematics, physics, chemistry, earth sciences, biology, medicine, agriculture, engineering) and non-bibliometric areas (architecture, humanities, economics and statistics, law, political and social sciences), and for each area documents are differentiated by category of publication. For the bibliometric areas we consider a weighted sum of the documents of each institution, according to the following weights: articles in Scopus (1), articles not in Scopus (0.5), other documents such as book chapters, conference papers, conference reviews, editorials, articles in press, etc. (0.3). Similarly, for the non-bibliometric areas we compute a weighted sum of the documents of each institution, according to the following weights: articles and monographs (1), book chapters (0.7), abstracts, bibliography, datasets, posters, prefaces, etc. (0.3). The overall research output of each institution is, therefore, the sum of the weighted number of bibliometric and non-bibliometric documents.

A2. Economies of scale and scope - Regression model

In this section, we report the estimates of the economies of scales and scope referred to the regression analysis, together with the details on the marginal costs and the average incremental costs. In particular, for the subsequent analyses, we focus on model R6 of Table II (with all the variables but without the constant). As shown in Table A.I, A.II, A.III and A.IV, the results are very similar to the ones found for the SFM, described in the main body of the paper.

Table A.I. Marginal costs estimate

% of output mean	MC(Students)	MC(PhD)	MC(Research)
25%	3.132***	59.88***	30.45***
	(0.213)	(4.962)	(1.327)
50%	3.104***	61.47***	29.25***
	(0.183)	(4.368)	(1.163)
75%	3.075***	63.05***	28.05***
	(0.162)	(3.969)	(1.053)
100%	3.047***	64.64***	26.85***
	(0.155)	(3.826)	(1.014)
125%	3.019***	66.23***	25.65***
	(0.162)	(3.969)	(1.053)
150%	2.990***	67.81***	24.45***
	(0.183)	(4.368)	(1.163)
175%	2.962***	69.40***	23.25***
	(0.213)	(4.962)	(1.327)
200%	2.933***	70.99***	22.05***
	(0.249)	(5.690)	(1.526)
225%	2.905***	72.58***	20.86***
	(0.249)	(5.690)	(1.526)
250%	2.877***	74.16***	19.66***
	(0.330)	(7.386)	(1.989)
275%	2.848***	75.75***	18.46***
	(0.374)	(8.305)	(2.239)
300%	2.820***	77.34***	17.26***
	(0.419)	(9.252)	(2.497)

Note: *** indicates significance at the 1% level, ** at the 5% level and * at the 10% level. Standard errors are reported in parentheses. Values in ,000€. Authors' elaboration using Stata 14.

Table A.II. Average incremental costs estimate

% of output mean	AIC(students)	AIC(PhD)	AIC(Research)
25%	3.833***	227.7***	35.62***
	(0.213)	(46.81)	(1.327)
50%	4.506***	271.7***	39.59***
	(0.183)	(41.21)	(1.163)
75%	5.179***	315.7***	43.56***
	(0.162)	(37.44)	(1.053)
100%	5.852***	359.7***	47.53***
	(0.155)	(36.10)	(1.014)
125%	6.524***	403.7***	51.50***
	(0.162)	(37.44)	(1.053)
150%	7.197***	447.6***	55.47***
	(0.183)	(41.21)	(1.163)
175%	7.870***	491.6***	59.44***
	(0.213)	(46.81)	(1.327)
200%	8.542***	535.6***	63.40***
	(0.249)	(53.69)	(1.526)
225%	9.215***	579.6***	67.37***
	(0.249)	(53.69)	(1.526)
250%	9.888***	623.6***	71.34***
	(0.330)	(69.69)	(1.989)
275%	10.56***	667.6***	75.31***
	(0.374)	(78.35)	(2.239)
300%	11.23***	711.6***	79.28***
	(0.419)	(87.29)	(2.497)

Note: *** indicates significance at the 1% level, ** at the 5% level and * at the 10% level. Standard errors are reported in parentheses. Values in ‚000€. Authors' elaboration using Stata 14.

Table A.III. Product specific and ray economies of scale

% of output mean	E (students)	E (PhD)	E (Research)	E (Ray)
25%	1.078**	3.858***	2.658***	1.051***
	(0.494)	(0.492)	(0.648)	(0.008)
50%	1.578***	4.130***	2.101***	1.051***
	(0.425)	(0.433)	(0.568)	(0.007)
75%	2.078***	4.402***	1.543***	1.051***
	(0.378)	(0.393)	(0.514)	(0.006)
100%	2.578***	4.673***	0.986*	1.052***
	(0.360)	(0.379)	(0.495)	(0.006)
125%	3.078***	4.945***	0.428	1.052***
	(0.377)	(0.393)	(0.514)	(0.006)
150%	3.578***	5.216***	-0.12	1.053***
	(0.425)	(0.433)	(0.568)	(0.007)
175%	4.079***	5.488***	-0.68	1.053***
	(0.494)	(0.492)	(0.647)	(0.008)
200%	4.579***	5.759***	-1.24	1.054***
	(0.577)	(0.564)	(0.745)	(0.010)
225%	5.079***	6.031***	-1.80**	1.054***
	(0.577)	(0.564)	(0.745)	(0.010)
250%	5.579***	6.302***	-2.35**	1.054***
	(0.767)	(0.732)	(0.971)	(0.013)
275%	6.079***	6.574***	-2.91**	1.055***
	(0.868)	(0.824)	(1.093)	(0.015)
300%	6.579***	6.845***	-3.47***	1.055***
	(0.971)	(0.918)	(1.219)	(0.016)

Note: *** indicates significance at the 1% level, ** at the 5% level and * at the 10% level. Standard errors are reported in parentheses. *E(Students), E(PhD) and E(Research)* are the product specific economies of scale, while E Ray represents the Ray economies of scale. Authors' elaboration using Stata 14.

Table A.IV. Product specific and global economies of scope

% of output mean	PES(students)	PES(PhD)	PES(Research)	ESG
25%	-0.081***	-0.277***	-0.166***	-0.071***
	(0.013)	(0.064)	(0.015)	(0.017)
50%	-0.256***	-0.429***	-0.346***	-0.270***
	(0.011)	(0.056)	(0.013)	(0.015)
75%	-0.432***	-0.580***	-0.527***	-0.470***
	(0.010)	(0.051)	(0.012)	(0.013)
100%	-0.607***	-0.731***	-0.707***	-0.669***
	(0.010)	(0.049)	(0.012)	(0.013)
125%	-0.782***	-0.883***	-0.887***	-0.869***
	(0.010)	(0.051)	(0.012)	(0.013)
150%	-0.958***	-1.034***	-1.068***	-1.068***
	(0.011)	(0.056)	(0.013)	(0.014)
175%	-1.133***	-1.186***	-1.248***	-1.268***
	(0.013)	(0.064)	(0.015)	(0.017)
200%	-1.308***	-1.337***	-1.429***	-1.467***
	(0.016)	(0.073)	(0.018)	(0.019)
225%	-1.484***	-1.489***	-1.609***	-1.667***
	(0.016)	(0.073)	(0.018)	(0.019)
250%	-1.659***	-1.640***	-1.790***	-1.866***
	(0.021)	(0.096)	(0.023)	(0.026)
275%	-1.834***	-1.791***	-1.970***	-2.066***
	(0.024)	(0.107)	(0.026)	(0.029)
300%	-2.009***	-1.943***	-2.151***	-2.265***
	(0.026)	(0.120)	(0.029)	(0.032)

Note: *** indicates significance at the 1% level, ** at the 5% level and * at the 10% level. Standard errors are reported in parentheses. *PES(students), PES(PhD)* and *PES(Research)* are the product specific economies of scope, while *ESG* represents the global economies of scope. Authors' elaboration using Stata 14.