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Social Stratification in Higher Education: What It Means at the Micro-Level of Individual Academic Scientists

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Abstract

The academic profession is as heavily internally divided as never before. In this cross-national comparative study, a sample of European academic scientists (N=8,466) from universities in 11 countries is used to analyze three stratification types in higher education. They are termed 'academic performance stratification', 'academic salary stratification', and 'international research stratification'. This emergent stratification of the global scientific community is predominantly research-based, and internationalization in research is at its center. This study views research as purely prestige-driven, internationally competitive, at the heart of academic recognition systems – and as the single most stratifying factor at the level of individual scientists in the higher education enterprise today. The stratification processes are pulling different segments of the academic profession in different directions; specifically, the study analyzes highly productive academics ("research top performers"), highly paid academics ("academic top earners"), and highly internationalized academics (”internationalists” in research). Implications at the micro-level of individual scientists, meaning what to do and what not to do and why, are explored.

Introduction

Social stratification in higher education has been a recurring theme in higher education research for more than half a century. To explore this phenomenon with new cross-national evidence, we have drawn on large-scale comparative quantitative data from across Europe (11 countries, N=8,466 returned surveys, the university sector only) to test the assumption that the increasing tensions in higher education attributed to changes in governance and funding regimes extend to the micro-level of the individual academic. The individuals who collectively constitute the academic profession find themselves at the center of these changes and the tensions that ensue (Fumasoli et al. 2015; Altbach 2015; Marginson 2009). In both elite research-focused institutions and their less prestigious teaching-focused counterparts, systemic and institutional changes filter down into the work and life of academic scientists (Carvalho 2017). The increasing stratification of institutions and individuals mirrors the ongoing evolution of governance and funding regimes and resultant academic job requirements. These issues are routinely analyzed at the meso-level of university organization (Lewis 2013). However, they have far-reaching implications for the academic profession and can be analyzed using micro-level data.

Three types of social stratification in higher education are discussed in this paper, with research as the core university-sector activity figuring prominently in all of them:

- *Academic performance stratification* (individual research performance differentials across Europe, with top research performers contrasted with their lower-performing colleagues);
- *Academic salary stratification* (income differentials vs. research performance differentials across Europe, with academic top earners contrasted with their lower-earning colleagues); and
- *International research stratification* (research productivity differentials vs. international collaboration differentials, with ‘internationalists’ in research contrasted with ‘locals’ in research).

However, there are other stratification types: the academic profession is heavily divided along other fundamental dimensions too. In academic power stratification, scientists are divided by academic positions; in academic age stratification, they are divided by age cohorts; in academic role stratification, they are divided by teaching and research roles assumed; in research funding stratification, scientists are divided by funding opportunities, and in academic journal stratification – they are divided by journals in which they publish. And on top of these, there is strong gender stratification, cross-cutting the above stratification types. The scientific community is thus heavily divided by research achievement, income, academic position, gender, age cohort, distribution of teaching and research time, research funding opportunities, and space in prestigious journals. Overall, this stratification of the global scientific community is predominantly research-based, and internationalization in research is at its center. The notion of social stratification in science refers directly to scientists and their work and lives and it is *internal* rather than *external* to the academic profession. The research issue of the paper is as follows: is it analytically useful to study the changes in the European academic profession through the notion of social stratification in science, and specifically, through its three types closely linked to research productivity? Assuming that the profession is heavily divided, how does the notion work in understanding the divisions and individual-level implications they ensue?

Research (combined with its increasingly competitive funding modes) is the single most stratifying factor at the micro-level of individual scientists in the higher education enterprise today. Prestige, success, and recognition in science are all inseparable from significant, consequential, high-quality publications. Research is thus in the center of this paper, and in the center of the three types of stratification in higher education analyzed below, even though it is not in the center of the majority of higher education systems and institutions, in Europe and beyond. Research is viewed here as a powerful academic game: it is not inclusive, not democratic, and not egalitarian – and unrelated to the community engagement agenda and the teaching mission of universities. Research is prestige-driven, ruthlessly, internationally competitive – and at the heart of academic recognition and reward systems.

At an individual level, social stratification in higher education means that the scientific community is not a 'company of equals': 'individuals, groups, laboratories, institutes, universities, journals, fields and specialties, theories, and methods are incessantly ranked and sharply graded in prestige' (Zuckerman 1988: 526). Academic recognition translates into resources for further research, and the distribution of academic rewards—including research funding—is sharply graded. While the intense research-related stratification of the academic profession is not easily seen from the outside, it is enormously powerful inside. Prestige allocation in science makes some scientists work much harder while, on some, it exerts no pressure at all. This traditional elitist, exclusive, and hierarchical function of research in universities—differentiating and rank-ordering the academic profession (Marginson 2014)—has been strengthened in the era of New Public Management.

This paper is structured as follows: its tripartite focus leads to the Theoretical background section to be divided into three subsections, separately discussing the three stratification types. The data section is followed by the Findings section which is also divided into three parts, referring to the three stratification types. Finally, the Discussion is followed by a section on implications at the level of individual scientists – and then Conclusions are presented.

Theoretical background

Theoretical background will be discussed briefly separately for each of the three stratification types analyzed in the Findings section: academic performance stratification, academic salary stratification, and international research stratification.

Academic performance stratification: research productivity and inequality in the knowledge production

The world of science has always been utterly unequal (Ruiz-Castillo and Costas 2014; Stephan 2012): the intrinsic property of science has been what Derek J. de Solla Price (1963) termed 'essential, built-in undemocracy' (59). Individual performance in science tends not to follow a Gaussian (normal) distribution. Instead, it follows a Paretian (power law) distribution (O'Boyle and Aguinis 2012). Distributions of different social phenomena—such as income, wealth, and prices—show 'strong skewness with long tail on the right, implying inequality' (Abramo et al.2017: 324). Academic knowledge production is not an exception.

Highly productive academic scientists as a separate segment of the academic profession are a rare scholarly theme. Scientific productivity is skewed, and its skewness has been widely studied in terms of two standard measures of individual performance: publication numbers and citations of publications (Albarrán et al. 2011; Carrasco and Ruiz-Castillo 2014). For instance, in a study of 17.2 million authors and 48.2 million publications in Web of Science, Ruiz-Castillo and Costas (2014) show that 5.9 percent of authors accounted for about 35 percent of all publications.

Scholarly interest in the skewness of science and high individual research performance has been growing exponentially in the last few years. Highly productive academic scientists have been studied mostly intra-nationally and in single fields of knowledge (particularly in economics and psychology). Recent studies on high research performers include research on star scientists (Abramo et al. 2009; Yair et al. 2017), star performers (Aguinis and O'Boyle 2014) and superstars (Agrawal et al. 2017; Serenko et al. 2011).

The 'superstar effect' refers to markets ('relatively small numbers of people earn enormous amounts of money and dominate the activities in which they engage' Rosen 1981: 845), and the 'Matthew effect' (Cole and Cole 1973; Merton 1968) refers to the science system: a small number of scholars produce most of the works, attract huge numbers of citations, hold prestigious academic positions, and form the disciplines' identity (Cortés et al. 2016; Serenko et al. 2011). For Robert K. Merton and Sherwin Rosen, performance determines rewards. In Rosen's 'economics of superstars,' small differences in talent translate into a disproportionate level of success. However, Rosen emphasizes innate talent, and Merton emphasizes external resources (DiPrete and Eirich 2006). Resources and the motivation to publish flow to scientists with high esteem in the scientific community, and that esteem 'flows to those who are highly productive' (Allison and Stewart 1974: 604). Consequently, Merton's Matthew effect in the system of science inevitably leads to inequalities in resources, research outcomes, and monetary or non-monetary rewards (Xie 2014).

High research productivity has been an important scholarly topic for a long time (for some original formulations, see Crane 1963; Price 1963; Merton 1968; and Cole and Cole 1973). The literature has identified a number of individual and institutional factors that influence high research productivity, including the size of the department, disciplinary norms, reward and prestige systems, and individual-level psychological constructs such as a desire for the intrinsic rewards of puzzle solving (see Leišyte and Dee 2012; Hermanowicz 2012; Stephan and Levin 1992). Faculty orientation towards research is generally believed to predict higher research productivity; as are the time spent on research, being a male academic, faculty collaboration, faculty academic training, years passed since PhD, as well as a cooperative climate and support at the institutional level (Smeby and Try 2005; Lee and Bozeman 2005; Fox 2015). The extreme differences in individual research productivity can be explained by a number of theories: specifically, the 'sacred spark' theory, the 'cumulative advantage' theory, and 'the utility maximizing theory'.

The 'sacred spark' theory presented by Cole and Cole (1973) simply says that 'there are substantial, predetermined differences among scientists in their ability and motivation to do creative scientific research' (Allison and Stewart 1974: 596). Highly productive scholars are 'motivated by an inner drive to do science and by a sheer love of the work' (Cole and Cole 1973: 62). The 'accumulative advantage' theory developed by Merton (1968) holds that productive scientists are likely to be even more productive in the future, while the productivity of those with low performance will be even lower. In its simplest formulation it states that 'scientists who are rewarded are productive, and scientists who are not rewarded become less productive' (Cole and Cole 1973: 114). Finally, according to the 'utility maximizing theory', researchers choose to reduce their research efforts over time because they think other tasks may be more advantageous. As Kyvik (1990: 40) comments, 'eminent researchers may have few incentives to write a new article or book, as that will not really improve the high professional reputation that they already have'. These three major theories of research productivity are complementary rather than competing. In the first subsection of Findings, we explore briefly highly productive academics contrasted with the rest of academics.

Academic salary stratification: research productivity and income

As in every other sector of economy, the number of highly paid academic positions in higher education is limited. Most academics globally, perhaps except for full-professors across major European systems, cannot live a middle-class lifestyle with their academic salary alone (Altbach 2015: 7). A traditional view is that academic scientists tend to trade-off 'pecuniary' and 'non-pecuniary' elements of their work (or tend to assess 'non-pecuniary advantages' of academic work higher than its 'pecuniary disadvantages', Ward and Sloane 2000). Academic positions, like other jobs, provide both extrinsic rewards (salaries and other material benefits) and intrinsic rewards (derived from academic work) (Blau 1994: 80) and academic scientists as 'calculating individuals' make individual career choices with these two reward types in mind.

A major issue for European universities is the lure of corporate and industry work in some areas, and its lack in other areas, leading to cross-disciplinary tensions over salary levels. The academe-industry gap refers in different degrees to different areas and there is a tension between more curiosity-driven research in lower-paid academia and more applied research in higher-paid industry. Currently, freedom to pursue one's own research project still 'compensates for much lower monetary rewards in academe' (Balsmeier and Pellens 2016: 25).

Institutions with more open salary systems, notably in the US, are more able to attract top-quality researchers from institutions with less open salary systems, notably those in Continental Europe. Academic scientists across large parts of Continental Europe are still typically civil servants paid largely based on a single well-defined fixed-salary system (Altbach et al. 2012). While unstructured, merit-based systems attempt to reward performance, in structured systems academics are paid largely based on a single, well-defined fixed-salary schedule. There are inevitable implications for academic work in European-type structured systems: indifference to differences in performance from the perspective of salaries (Hansen 1992: 1478).

Between two ideal type systems there is a continuum that blends elements of both. Most European systems tend to introduce various forms of merit pay, moving slowly away from the extreme of a pure structured salary system (see selected European country chapters in Enders and de Weert 2004 and in Altbach et al. 2012). However, the challenge in trying to reward individual merit hinges on the definition of merit

(Hansen 1992: 1481): ‘internally determined merit’ (assessment of contribution to one’s own institution) is in sharp contrast to ‘externally determined merit’ (assessment by other institutions or based on publication record). In increasingly stratified European systems, ‘externally determined merit’ based on research achievements tends to matter more in upper echelons of institutions, and ‘internally determined merit’ in lower echelons of institutions, more focused on teaching and service missions.

Scientists’ engagement in research can be either investment-motivated (seeking future financial rewards), consumption-motivated (solving research puzzles) or both (Thursby et al., 2007). While the investment motive implies a decline in research productivity over one’s career, the consumption motive does not imply such a decline. A ‘taste for science’ (see Roach and Sauermann 2010) causes scientists to choose academia over industry. Academics with different abilities and tastes in terms of nonpecuniary returns choose different careers: basic or applied research – in academia or industry (Agarwal and Ohyama 2013).

In testing the high research productivity-high prestige-high salary link below, we go beyond the traditional account in which scientists are rewarded for their research performance almost exclusively by their peers and see whether high research performance, apart from the traditional academic recognition, is complemented by higher salaries. Universities – as well as individual academics – are viewed here as competing in prestige markets. In particular, there is a strong link between individual and institutional prestige, as the ‘prestige maximization theory’ suggests: ‘In maximizing their individual prestige, faculty members simultaneously maximize the prestige of their departments and institutions’ (Melguizo and Strober 2007: 635). The maximization of prestige, in this theoretical framework, is strongly correlated with faculty salaries. Academics who help their institution to become more prestigious are rewarded by the institution with higher salaries: more articles and books published in prestigious outlets, more prestigious research grants, etc. lead to higher institutional prestige, which consequently, albeit not directly, leads to higher individual salaries.

Following the logic of this salary model, highly productive academics should be disproportionately over-represented among highly paid academics. Because more time spent on teaching means less time spent on research and vice versa, academics spending, on average, more time on research should be receiving higher average salaries. Spending more time on teaching, in turn, should have a negative or, at best, neutral effect on one’s salary (Fairweather 1993).

International research stratification: research productivity and international research collaboration

International research collaboration (IRC) is highly discipline-sensitive and previous research suggests that the ‘collaborative imperative’ dominates in academic science (Lewis 2013), especially in hard disciplines where internationally co-authored publications lead to academic recognition and, increasingly, to access to national and international competitive research funding (Jeong et al. 2014). ‘Internationalists’ (defined here as academic scientists involved in IRC) increasingly compete with ‘locals’ (or academic scientists not involved in IRC) in university hierarchies of prestige across Europe. In this theoretical framework, internationalists tend to compete for international academic recognition – and locals tend to do research and publish for national research markets. However, the level of international orientation in research depends on the researchers themselves (Wagner and Leydesdorff 2005): it is disproportionately shaped by individual predilections.

Impediments to IRC are related to macro-level factors (geopolitics, history, language, cultural traditions, country size, country wealth, and geographical distance), institutional-level factors (reputation and resources), and individual-level factors (Georghiou 1998). IRC has its benefits and its costs (Katz and Martin 1997). Specifically, transaction costs (Georghiou 1998) and coordination costs (Cummings and Kiesler 2007) are higher in international than in national research collaboration. In collaborative research, there is always a trade-off between additional publications and research funds and higher transaction and coordination costs (Landry and Amara 1998).

In the context of changing incentive and reward systems in increasingly output-oriented European science (Kyvik and Aksnes 2015), it is ever more important for individual academic scientists to cooperate internationally: the broad awareness of international research-based university rankings makes scholarly publishing more than an individual matter. Publishing is closely linked to institutional prestige – and funding.

However, in highly competitive global science systems, IRC is primarily motivated by academic reward structures and by benefits it brings to individual scientists. Scientists collaborate because it is beneficial to them. As Wagner and Leydesdorff (2005: 1616) argue, ‘highly visible and productive researchers, able to choose, work with those who are more likely to enhance their productivity and credibility.’ The interrelations between scientists and their institutions can be explained by the already mentioned ‘prestige maximization theory” in which highly cited internationally-coauthored publications (and international research funding) lead to higher prestige of scientists and their higher salaries, non-profit higher education institutions acting largely as ‘prestige maximizers’ (Melguizo and Strober 2007: 635). Research collaboration at an individual level is reported to be ruled by researchers’ ‘pragmatism’ (‘when there is something to gain, then a particular collaboration will occur; otherwise, it will not’) and by their ‘self-organization’ (individual rather than institutional determination of ‘with whom to cooperate and under which forms’) (Melin 2000: 39). What matters in bottom-up collaborations is the individual interests of researchers seeking resources and reputation rather than anything else (Wagner and Leydesdorff 2005: 1616).

A brief note on data

The data used in this paper come from the 'European Academic Profession: Responses to Societal Challenges' (EUROAC) project, a sister project to the global 'Changing Academic Profession' (CAP) project (see Carvalho 2017 for a recent overview of the CAP/EUROAC family of studies). The data come from the eleven countries involved in both the CAP and EUROAC projects, with national datasets subsequently cleaned, weighted and merged into a single European dataset. We worked on the final data set dated June 17, 2011 created by René Kooij and Florian Löwenstein from the International Centre of Higher Education and Research – INCHER-Kassel. The survey questionnaire was sent out to the CAP countries in 2007 and to the EUROAC countries in most cases in 2010. The total number of returned surveys was 17,211 and included between 1,000 and 1,700 returned surveys from all countries studied except for Poland where it was higher. Overall, the response rate differed from over 30 percent (in Norway, Italy, and Germany), to 20-30 percent (in the Netherlands, Finland, and Ireland), to about 15 percent in the United Kingdom, 11 percent in Poland and 10 percent or less in Austria, Switzerland and Portugal.

Both simple random sampling, systematic sampling, and stratified random sampling methods were used, depending on the country. However, in most countries, stratified random sampling was used to allow the resulting sample to be distributed in the same way as the population (Hibberts et al. 2012: 61-62; Bryman 2012: 192-193). Stratified sampling frames were created and several stratifying criteria were used (for instance, gender and academic position). The stratification of the sample mirrored the population stratification on the stratifying criteria, and mirrored simple random sample in every other way. Random sampling was used to obtain the elements from each stratum. No groups of scientists were systematically excluded from the sampling frame (so 'sampling bias' did not occur: no members of the sampling frame had no or limited chances for inclusion in the sample, Bryman 2012: 187). However, it is not possible to state to what extent the pool of respondents differs from the pool of non-respondents, and consequently, to state whether 'non-response bias' occurs. 'Non-response bias' can occur when certain groups of respondents fail to respond or are less likely than others to participate in the survey or answer certain survey questions (Hibberts et al 2012: 72) or when survey participation is correlated with survey variables (Groves 2006).

Only the sub-sample of European academic scientists was used (N = 8,466 individual scientists): those involved in both teaching and research and employed full-time in the university sector as defined in each of the 11 countries studied. The characteristics of the three internationally under-researched classes of academics were analyzed: highly productive academics (or "research top performers", the upper 10 percent in terms of productivity), highly paid academics (or "academic top earners", the upper 20 percent in terms of gross academic income), in both cases selected separately in each country and in each of the major clusters of academic fields; and highly internationalized academics (or "internationalists" in research defined as scientists involved in international research collaboration).

Findings

Academic performance stratification

Academic scientists are heavily stratified by their research output. Academic performance stratification results from systematic inequalities in individual academic knowledge production. Our results show that the distribution of research productivity is strongly skewed, with a long tail to the right indicating inequality (Figure 1). As a universal academic species across Europe, the tiny ten percent minority of scientists – termed top performers here – accounts for roughly half of all peer-reviewed academic publications in the three-year reference period analyzed. Top performers produce on average 53.4 percent of peer-reviewed articles and books chapters, 45.6 percent of publications in English, and 50.2 percent of internationally co-authored publications, with small national variations (DELETED). Across the major academic clusters (Figure 2), the mean research productivity of top performers is on average 8.56 times higher than that of other research-active scientists (or the remaining ninety percent of them). For instance, top performers in life sciences are on average 6.77 times more productive and in engineering and professions more than ten times. The stunning difference between average productivity of top performers measured by peer-reviewed articles (PRA) and by peer-reviewed article equivalents (PRAE) in the case of humanities and social sciences and professions can be explained by the substantial role of authored and edited books counted in the PRAE measure.

Research productivity differentials between top performers and the rest of scientists measured by peer-reviewed articles and internationally co-authored peer-reviewed article equivalents (IC-PRAE) published in the three-year reference period by clusters of academic fields is shown in Tables 1 and 2, respectively. For instance, in life sciences, mean research productivity for PRA is 22.5 for top performers and 3.3 for the rest of scientists, and for IC-PRAE (that is, including articles, authored and edited books), it is 8.1 for top performers and 0.9 for the rest of scientists).

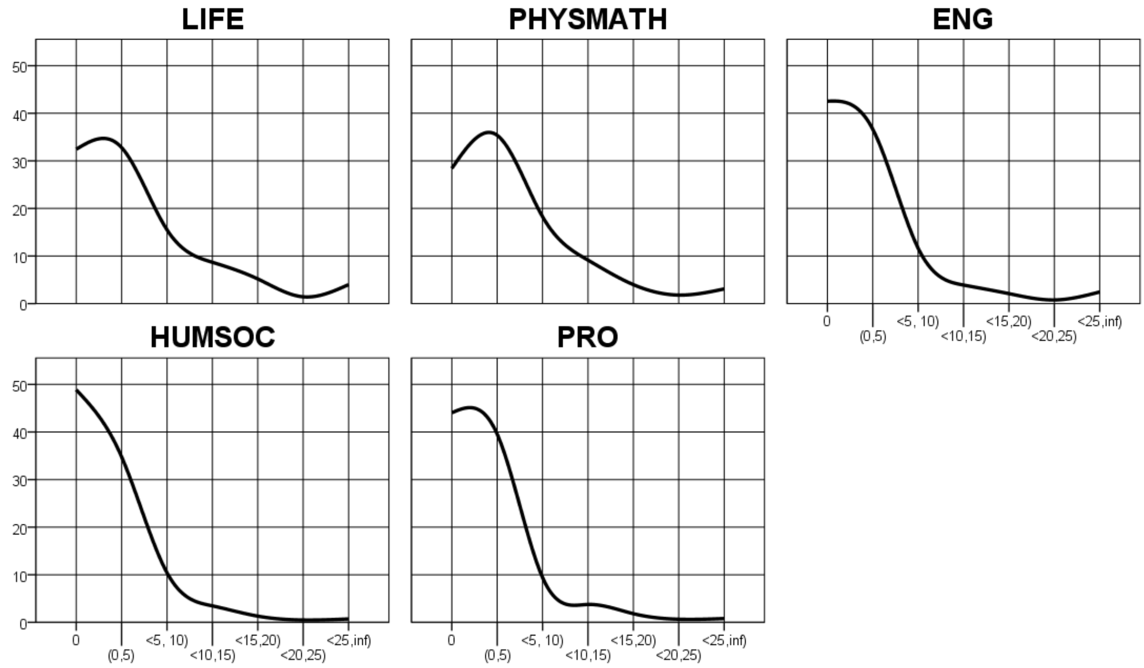


Figure 1. The distribution of peer-reviewed article equivalents (PRAE) published during the three-year reference period, by cluster of academic disciplines and publication number groups (in percentage). Vertically: percentage of authors, horizontally: number of papers published. All 11 European countries combined (in %).

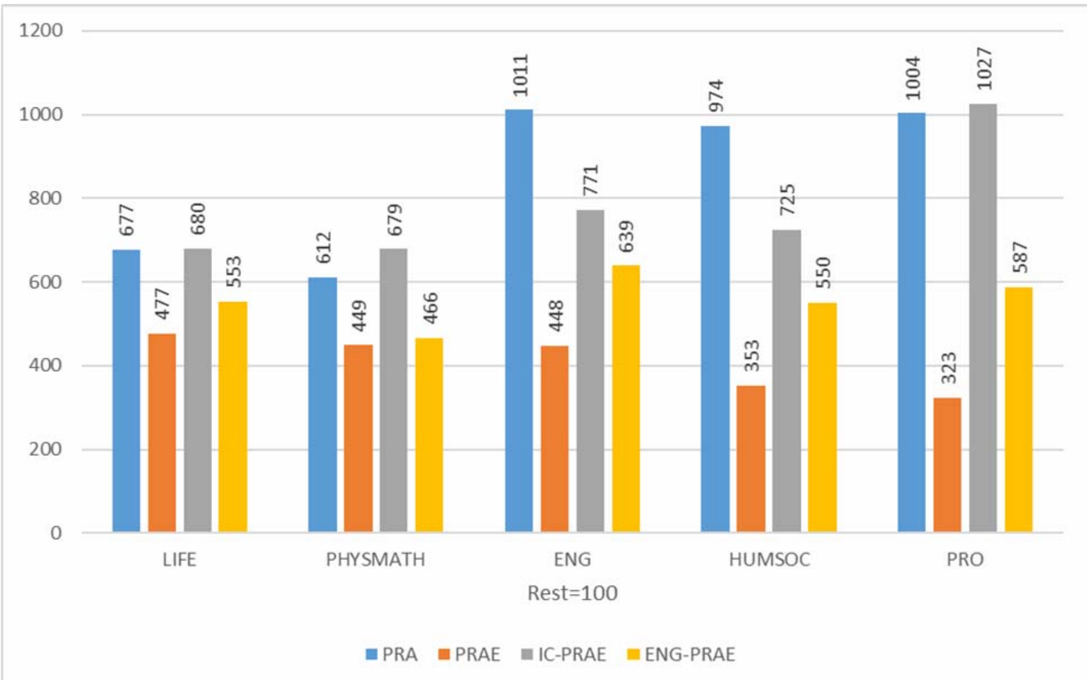


Figure 2. Research productivity by cluster of academic disciplines: top performers vs. other scientists (productivity of top performers as percentage of productivity of other scientists: the Rest = 100%). The average number of peer-reviewed articles (PRA), peer-reviewed article equivalents (PRAE), internationally co-authored peer-reviewed article equivalents (IC-PRAE), and English language peer-reviewed article equivalents (ENG-PRAE) published in a three-year reference period. For all clusters, the results are statistically significant. All 11 European countries combined (in %).

International *comparative* studies of higher education have not generally explored this unique class of academics. To identify these top performing scientists and the factors that increase their chances of entry to this echelon, we investigated whether they share the same patterns of working time distribution (Table 3) and academic role orientation (Table 4), both of which are traditionally linked to research productivity. Our analysis identified several common features of top performers across the 11 countries studied. They tend to be male, middle-aged (mean age 47), and predominantly full professors. Top performers' research tends to be international in scope or orientation; they collaborate more often both nationally and internationally and publish abroad more often than other scientists. They work longer total hours and longer research hours, and they are substantially more research-oriented, with a tendency to focus on basic and theoretical rather than applied research. They sit on national and international committees and boards and are more likely than their lower-performing colleagues to participate in peer review.

Table 1. Research productivity: peer-reviewed articles (PRA) published in the three-year reference period, research top performers (10%) vs. the rest (90%). All 11 European countries combined, by cluster of academic field.

	Top performers (upper 10%)						Rest (90%)					
	Mean PRA	95% confidence interval, lower band	95% confidence interval, upper band	Median	Standard Deviation	N	Mean PRA	95% confidence interval, lower band	95% confidence interval, upper band	Median	Standard Deviation	N
LIFE	22.5	21.2	23.8	20.0	11.9	316	3.3	3.1	3.5	2.0	4.1	2036
PHYSMATH	21.8	19.6	24.1	20.0	13.8	149	3.6	3.3	3.8	2.0	4.0	1037
ENGITECH	17.2	14.4	20.1	13.6	14.7	107	1.7	1.5	1.9	0.3	2.6	716
HUMSOC	11.8	10.8	12.9	10.0	8.9	262	1.2	1.1	1.3	0.0	1.9	1708
PRO	12.3	11.0	13.6	10.0	7.7	133	1.2	1.1	1.4	0.0	1.9	800

Table 2. Research productivity: internationally co-authored peer-reviewed articles (IC-PRA) published in the three-year reference period, research top performers (10%) vs. the rest (90%). All 11 European countries combined, by cluster of academic field.

	Top performers (upper 10%)						Rest (90%)					
	Mean IC-PRA	95% confidence interval, lower band	95% confidence interval, upper band	Median	Standard Deviation	N	Mean IC-PRA	95% confidence interval, lower band	95% confidence interval, upper band	Median	Standard Deviation	N
LIFE	8.1	7.2	9.0	5.7	8.3	316	0.9	0.8	1.0	0.0	2.0	2036
PHYSMATH	11.2	9.0	13.4	8.0	13.7	149	1.3	1.2	1.5	0.0	2.4	1037
ENGITECH	5.4	4.1	6.7	2.6	6.8	107	0.3	0.3	0.4	0.0	1.1	716
HUMSOC	2.5	2.0	3.1	0.4	4.6	262	0.2	0.1	0.2	0.0	0.6	1708
PRO	3.3	2.4	4.1	1.3	4.9	133	0.2	0.1	0.2	0.0	0.6	800

Working time distribution differs substantially between top performers and other scientists in each country studied. The differential in annualized (calculated as 60 percent teaching-time and 40 percent non-teaching time in a year) mean weekly working time is 5.7 hours, ranging from 3.7 hours in Italy to 7.4 hours in Germany and 8.0 hours in Norway. For example, German top performers work an additional 42.6 days per year when compared with other research-oriented German scientists. In Norway, top performers work an additional 46.0 days. In addition, and in contrast to the expected teaching-research productivity trade-off (Fox 1992; Katz 1973; Dillon and Marsh 1981), top research performers in most countries studied spend more time than their lower-performing colleagues on teaching, service, and administration. For each pair with a mean difference significantly different from zero, the symbol of the larger category ('Top' for top performers or 'Rest' for the rest of scientists) appears in the column; tests are adjusted for all pairwise comparisons within a row for each innermost sub-table using the Bonferroni correction (Table 3).

The most instructive example comes from life sciences (with 2,352 cases and the highest number of statistically significant differences between the two subpopulations among several academic activities studied). The top performers in life sciences, on average, seem to follow all traditional accounts of productive academic scientists in the sociology of science. On average, they work many more hours per week, and specifically, they have the traditional working time distribution attributed to high publishers (Fox 1983) according to which research-time allocations compete directly with teaching-time allocations (Fox 1992; Kyvik 1990; Ramsden 1994), or the only relevant difference is in general between research time and non-research time (Stephan 2012). Their average weekly teaching time is much shorter, and their research time is much longer; in addition, they spend more hours on administration (presumably more research involves more research grants which require more administrative work; alternatively, these academic scientists are more often heads of research groups or medium-level administrators, such as directors and deans).

Across all the systems studied, top performers are also more research-oriented than others. Bluntly put, identifying teaching as one's primary interest all but excludes one from the class of research top performers; in Ireland, for example, the maximum level of entry is 1.1 percent. Again, being interested in both but leaning toward teaching all but excludes one from the class of top research performers, with figures ranging from three to eight percent in Finland, Ireland, Italy, the Netherlands, Norway, and the UK. In short, research role orientation is a powerful indicator of top performer status in European countries while teaching orientation virtually excludes one from this class; as before, for each pair with a fraction difference significantly different from zero, the symbol for the larger category appears in the column (Table 4). These findings confirm that academic knowledge production in Europe hinges on top performers, who are highly homogeneous in terms of working pattern and role orientation. They are similar cross-nationally and differ substantially from other scientists intra-nationally.

Table 3: Results of t-tests for the equality of means, top performers (Top) vs. the rest of scientists (Rest), all 11 European countries, all clusters of academic fields combined. Question B1: 'Considering all your professional work, how many hours do you spend in a typical week on each of the following activities? (when 'classes are in session' and when 'classes are not in session'), only full-time scientists in universities involved in both teaching and research.

	AT	FI	DE	IE	IT	NL	NO	PL	PT	CH	UK
Teaching				Rest	Rest		Top	Rest		Top	
Research			Top	Top	Top			Top	Top		Top
Service					Top		Top				
Administration	Top	Top	Top		Top	Top	Top	Top		Top	
Other	Top		Top	Top			Top				
Total	Top	Top	Top	Top	Top	Top	Top	Top	Top	Top	Top

Table 4: Results of z tests for the equality of fractions, all countries. Preferences for teaching/ research (Question B2: 'Regarding your own preferences, do your interests lie primarily in teaching or in research?'), research top performers (Top) vs. the rest of scientists (Rest), all 11 European countries, all clusters of academic fields combined.

	AT	FI	DE	IE	IT	NL	NO	PL	PT	CH	UK
Primarily in teaching		Rest	Rest	Rest	.a	.a	.a	Rest	Rest		.a
In both, but leaning towards teaching		Rest		Rest	Rest	Rest	Rest	Rest	Rest	Rest	Rest
In both, but leaning towards research		Top	Top	Top		Top		Top	Top	Top	
Primarily in research				Top	Top			Top	Top		Top

a. This category is not used in comparisons because its column proportion is equal to zero or one.

Academic salary stratification

Scientists are also heavily stratified by their academic incomes: a second form of stratification explored in this paper results from the positive relationship between research productivity and academic income. Our research on academic top earners – or highly paid academic scientists – calls into question several common assumptions from traditional studies, which are usually based on single-nation data rather than cross-national comparison. We adopted a cross-national perspective to investigate predictors for entry to the class of top earners, defined as those in the eightieth percentile of gross academic income—that is, the top twenty percent of scientists in each of the five major academic clusters and in each country, at least 40 years old and with at least ten years of academic experience. Interestingly, our results do not support previous findings from single-nation studies, where research time was found to be positively correlated with high academic income, teaching time was negatively correlated with high academic income, and there was a strong correlation between research orientation, gender, and high income (Katz 1973; Dillon and Marsh 1981; Gomez-Mejia and Balkin 1992). Instead, our findings suggest that the link between higher time investment in research and higher academic income—consistently demonstrated for Anglo-Saxon countries over the last four decades—may be less strong across Continental Europe. While top earners in three European countries were found to work longer total hours, they also worked longer service and/or administrative hours in seven countries.

In terms of individual academic careers, top earners as defined here tend to spend more time on all academic activities *except* teaching and research (Table 5; the only exception being the UK where highly paid scientists traditionally spend more time on research and their lower paid colleagues traditionally on teaching); specifically, they spend more time on administration and service. The annualized total weekly working time differential between top earners and others ranges from 5.5 hours in Finland to 7.5 hours in Germany and 8.25 hours in Switzerland. For example, when compared with other German scientists, top German earners work an additional 43.1 days each year. Of particular interest is the high productivity differential between top earners and other scientists, especially in relation to peer-reviewed article equivalents (Figure 3 shows the differential by country), even though teaching time and research time are not statistically significant differentiating factors. In seven countries (Poland, Germany, Finland, Italy, Norway, Portugal, and the United Kingdom), top earners are eighty to one hundred and forty percent more productive than other research-oriented scientists over forty working in the university sector. In the case of internationally co-authored article equivalents (Figure 4 shows the differential by country), the figures rise to 180.49 percent higher in Poland, 178.05 percent higher in the UK and 145.56 percent higher in Germany. In short, the top earners in the majority of these European countries are substantially more productive and publish more internationally co-authored research than other scientists from the same (older) age cohort. Surprisingly, while they work longer administrative and service hours—rather than longer research hours and shorter teaching hours, as traditionally assumed in the productivity literature—they are substantially more academically productive.

Table 5: Working hours differentials. Results of t-tests for the equality of means for top earners (top) vs. the rest of scientists (rest) in ten European countries. Question B1: 'Considering all your professional work, how many hours do you spend in a typical week on each of the following activities? (when 'classes are in session' and when 'classes are not in session'). Only scientists employed full-time in universities and involved in both teaching and research (annualized mean weekly hours).

	PL	DE	AT	FI	IT	NL	NO	PT	CH	UK
Teaching hours										Rest
Research hours										Top
Service hours	Top					Top	Top		Top	
Administration hours	Top	Top		Top			Top			
Other hours		Top					Top			
Total hours		Top		Top					Top	

Table 6: Research productivity and high academic income, summary. Results of t-tests for the equality of means for top earners (Top) vs. the rest of scientists (Rest) in 10 European countries. Group with a significantly larger mean (Top or Rest) shown by country. Only full-time scientists employed in universities and involved in both teaching and research were included.

	PL	DE	AT	FI	IT	NL	NO	PT	CH	UK
Peer-reviewed article equivalent (PRAE)	Top	Top		Top	Top		Top	Top		Top
Internationally co-authored article equivalent (ICAE)	Top	Top		Top			Top			Top
Foreign language article equivalent (EAE)	Top	Top		Top	Top		Top	Top		

One of our research questions asked whether high academic income is positively correlated with high research performance, even though the former does not seem positively correlated with higher research time investment (except for the UK). We concluded that top earners are disproportionately represented among highly productive scientists; for instance, in Germany, an average 43.1 percent of highly productive scientists are also highly paid. Across Europe, an average 31.8 percent of national highly productive scientists are among the national top earners, ranging from 80 percent in the United Kingdom to about 40 percent in Finland, Germany, and Portugal, and 30 percent in Norway (Poland, with a flat and uncompetitive salary system, being the only European exception). This is the first time the prototypical figure of the academic top earner has been identified and discussed cross-nationally in the higher education literature.

Figure 3: Academic productivity and high academic income: top earners vs. the rest of scientists. The average number of ‘peer-reviewed article equivalents’ (PRAE) published in a three-year reference period (top earners in blue, the rest of scientists in red). Only full-time scientists employed in universities and involved in both teaching and research are included. Only countries with statistically significant results are included.

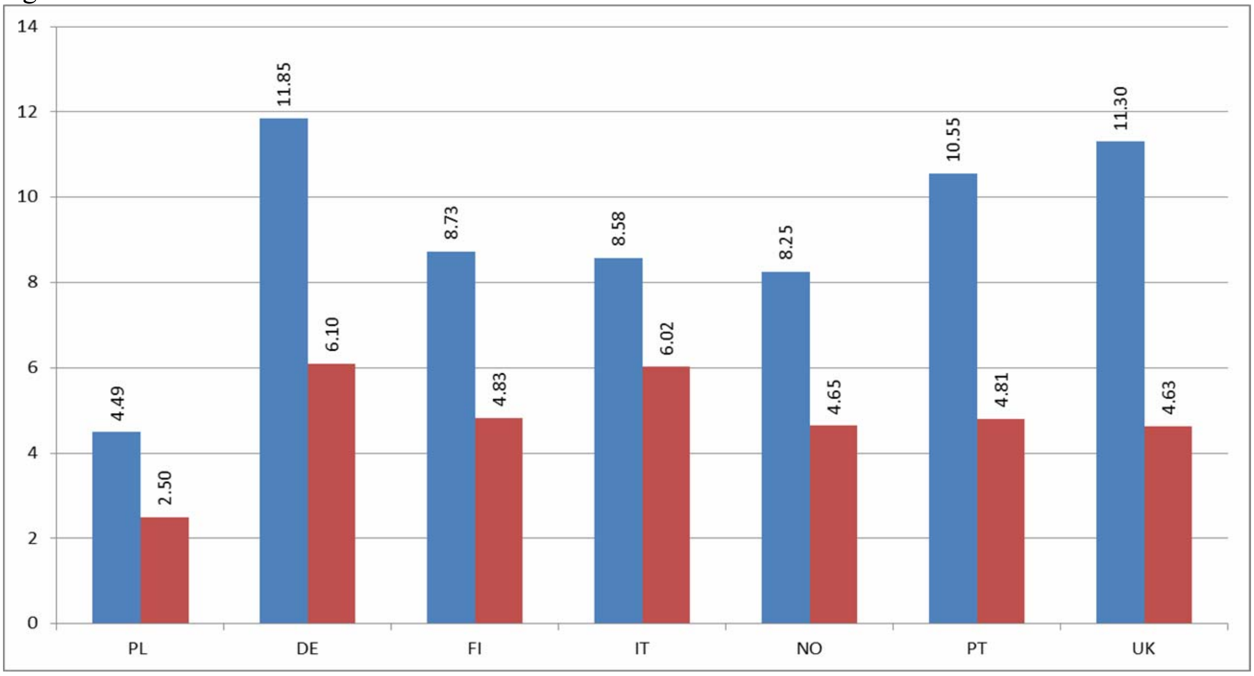
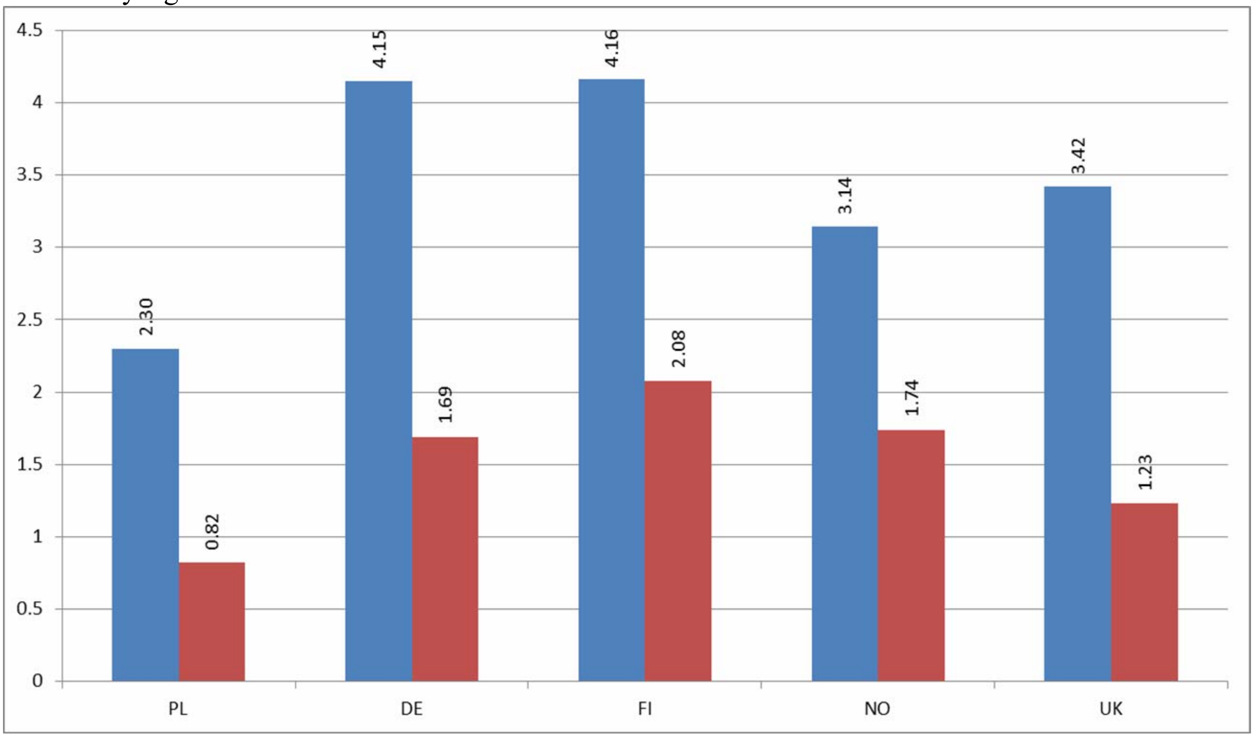


Figure 4: Academic productivity and high academic income: top earners vs. the rest of scientists. The average number of ‘internationally co-authored article equivalents’ (IC-PRAE) published in a three-year reference period (top earners in blue, the rest of scientists in red). Only full-time scientists employed in universities and involved in both teaching and research are included. Only countries with statistically significant results are included.



International research stratification

Finally, individual scientists are also heavily stratified by international research collaboration, which tends to be correlated with higher research productivity. This form of stratification was examined here in terms 'internationalists' and 'locals' as two prototypical figures that emerged from our study: defined as those who collaborate internationally in research and those who do not. Across Europe, we found that some systems, institutions, academic clusters, and scientists were more internationalized than others in terms of research. This was especially true of two relatively small systems: Ireland and the Netherlands, where more than four in every five scientists are collaborating internationally. In Austria, Switzerland, and Finland, about three-quarters of scientists collaborate internationally. The least internationalized systems are relatively large systems of Poland and Germany, with powerful internal research markets (about 48 percent); the remaining European countries in our sample are moderately internationalized.

Our study confirms that international research collaboration contributes to the increasing stratification of the academic profession, as it is positively correlated with higher publishing rates (and citation rates, not studied here). European scientists who do not collaborate internationally suffer increasing losses in terms of research resources and academic prestige. As research-based competition becomes a constant, local prestige and local publication in a regional language may no longer suffice to prosper in academia. Increasingly, internationalists compete directly with locals for national and institutional prestige and for access to project-based research funding, and mechanisms that enable the rich to get richer while the poor get poorer continue to transform the academic profession. It seems clear that academic performance stratification is linked to stratification of research resources, and both are linked to the stratification of international research and publishing. To begin, the international stratification of research was explored across countries, clusters of disciplines, and generations. Additionally, we examined the correlation between international research collaboration and individual research productivity and systematically compared research productivity and international publication co-authorship among internationalists and locals in each of the 11 countries (DELETED).

The relationships between international cooperation and research productivity have been widely discussed in research literature, with a general assumption that international collaborative activities tend to be strongly positively correlated with research productivity (Shin and Cummings 2010; Abramo et al. 2011). International research collaboration is most often found to be a critical factor in predicting high research productivity. However, the national and international collaboration intensity is not uniform across different academic fields (Abramo et al. 2009; Lewis 2013: 103). We found that research productivity is strongly positively correlated with international research collaboration: in all academic clusters and in all 11 countries, average productivity was consistently higher for internationalists than for locals.

At an aggregated European level reported here, the differences between 'internationalists' and 'locals' are consistent across all clusters of academic disciplines. And they can be summed up in a single statement: 'no international collaboration, no international co-authorship'. The average proportion of internationally co-authored publications for 'internationalists' differs across clusters of academic disciplines: consistently with previous research results (for instance, Shin and Cummings 2010), it is the highest for physical sciences and mathematics (34.67 percent) and the lowest for humanities and social sciences (14.20 percent) and professions (19.14 percent). There is a powerful relationship between being involved in international cooperation in research and international co-authorship of articles in books and journals (Table 8). The difference in the share of the latter type of publications between 'internationalists' and 'locals' is huge: the average rate of international co-authorship for 'internationalists' is between 4-5 times higher (in engineering and in life sciences and medical sciences) and 7.5 times higher (in professions).

Academic scientists *not* collaborating internationally report no more than merely 7 percent of their publications being internationally co-authored in the three 'hard' fields and no more than merely 3 percent in the two 'soft' fields only. In the most internationalized cluster of academic disciplines (physical sciences and mathematics), the share of internationally co-authored publications for 'internationalists' is 35.67 percent while the share for 'locals' is only 6.69 percent.

The pattern is consistent for both academic scientists collaborating internationally and those not collaborating internationally across all clusters of academic disciplines studied. Those not collaborating internationally produce only a marginal percentage of their publications as co-authored with colleagues from other countries. Their share in the academic profession in Europe is substantial, though (Table 8, second column; cross-national differences are substantial but not studied here, see DELETED): about half of academic scientists in professions, about four out of ten in engineering, humanities and social sciences, about one third in life sciences and medical sciences, and about a quarter of all academic scientists in physical sciences and mathematics do not collaborate internationally in their research.

However, a reservation needs to be made: the identification of high research productivity correlates (e.g. international research collaboration) does not mean the identification of causal relations (Ramsden 1994: 223). International cooperation in research may be generally undertaken by more productive academic scientists as such academics are sought by most productive academics across all systems (Smeby and Try 2005). Also more productive academic scientists tend to have better access to funding for international cooperation (Lee and Bozeman 2005: 677, Smeby and Trondal 2005: 463). The cooperation with productive academic scientists generally increases individual research productivity but the cooperation with non-productive academic scientists generally decreases it (Katz and Martin 1997: 5, Lee and Bozeman 2005: 676).

Table 7. Peer-reviewed articles (PRA) published by European scientists (11 countries combined) in an academic book or journal by international collaboration in research ('internationals' – Yes, and 'locals' – No) and clusters of academic disciplines. Only scientists full-time employed in the university sector and involved in both teaching and research.

Cluster of academic disciplines	International collaboration	N	%	Mean number of peer-reviewed articles (3 years)	SE	95% confidence interval for mean		t-test for equality of Means	df	p-value
						LB	UB			
Life sciences and medical sciences	Yes	1,542	64.8	7.48	0.26	6.97	7.98	10,927	2285	<0.001
	No	837	35.2	3.34	0.18	2.98	3.71			
Physical sciences. mathematics	Yes	887	74.7	6.92	0.32	6.28	7.55	6,654	1159	<0.001
	No	301	25.3	3.06	0.25	2.56	3.55			
Engineering	Yes	502	60.0	5.19	0.43	4.35	6.03	6,391	799	<0.001
	No	335	40.0	1.61	0.20	1.23	2.00			
Humanities and social sciences	Yes	1,249	62.5	3.34	0.17	2.99	3.68	6,983	1905	<0.001
	No	749	37.5	1.62	0.12	1.39	1.85			
Professions	Yes	503	52.5	3.81	0.27	3.28	4.33	6,367	901	<0.001
	No	455	47.5	1.67	0.18	1.31	2.03			

Table 8. Percentage of articles by European scientists (11 countries combined) published in an academic book or journal co-authored with colleagues located in other (foreign) countries (IC-PRA), by international collaboration in research and cluster of academic disciplines (in percent).

Cluster of academic disciplines	International collaboration	N	%	Mean percentage of internationally-coauthored peer-reviewed articles (3 years)	SE	95% confidence interval for mean		t-test for Equality of Means	df	p-value
						LB	UB			
Life sciences and medical sciences	Yes	1,542	64.8	34.67	0.89	32.92	36.42	20.662	2070	<0.001
	No	837	35.2	6.69	0.73	5.25	8.13			
Physical sciences. mathematics	Yes	887	74.7	41.00	1.23	38.60	43.41	15.450	1081	<0.001
	No	301	25.3	6.16	1.18	3.84	8.48			
Engineering	Yes	502	60.0	25.02	1.34	22.39	27.65	9.373	760	<0.001
	No	335	40.0	6.57	1.19	4.22	8.92			
Humanities and social sciences	Yes	1,249	62.5	14.20	0.70	12.83	15.57	11.602	1701	<0.001
	No	749	37.5	2.39	0.49	1.43	3.35			
Professions	Yes	503	52.5	19.14	1.25	16.69	21.59	11.173	832	<0.001
	No	455	47.5	2.54	0.60	1.36	3.71			

We asked whether those who collaborate internationally ('internationalists') tend to publish more; the answer was that they do (Table 7: lines 'Yes' and 'No'). Across all academic clusters, internationalists publish at least twice as many peer-reviewed articles as locals. However, clusters exhibit considerable differentiation in this regard; in some clusters, internationalists produced over two hundred percent more articles during the reference period (222.35 percent in engineering). In the life and medical sciences, physical sciences, mathematics, and professions, the figure ranged between 120 percent and 130 percent. Researchers in the humanities and social sciences produced 106.17 percent more articles.

While the numbers differ from country to country, the patterns across 11 European countries studied are similar; for instance, the Polish case shows that internationalists are much more productive in terms of internationally co-authored publications (Table 9): 2,320% of the productivity of locals for peer-reviewed articles and 1,600% for peer-reviewed article equivalents. For English language peer-reviewed articles, the figure is 290.9%, and for article equivalents, it is 276.5%. In this sense, Polish internationalists are a world apart from Polish locals in terms of international co-authorships and almost three times as productive in terms of publications in English. They are also about 70% more productive in terms of conference papers and about 50% more productive in terms of peer-reviewed articles, article equivalents, and books, and they tend to produce twice as many reports for funded projects.

Table 9. A national system example: Poland. Average individual research productivity by publication type (internationalists, locals, and all scientists) for the 3-year reference period and difference between internationalists and locals (LOC = 100%) by publication type.

	Internationalists (INT)				Locals (LOC)				All				LOC vs. INT
	Mean	SD	Min	Max	Mean	SD	Min	Max	Mean	SD	Min	Max	LOC = 100%
Books authored/co-authored	0.6**	1.2	0	18	0.4	1.2	0	30	0.5	1.2	0	30	150.0
Books edited/co-edited	0.4***	0.9	0	9	0.3	0.8	0	7	0.3	0.8	0	9	133.3
Research reports/monographs written for a funded project	0.8***	1.8	0	25	0.4	1.3	0	30	0.6	1.6	0	30	200.0
Papers at a conference	5.0***	6	0	30	3.0	5	0	30	4	6	0	30	166.7
Articles (newspaper /magazine)	1.1	3	0	30	1.0	3.1	0	30	1.1	3	0	30	100.0
Peer reviewed articles (PRA)	4.79***	6.63	0	33	3.04	5.17	0	30	3.94	6.03	0	33	157.6
Peer reviewed article equivalents (PRAE)	8.3***	11	0	106.2	5.6	9.1	0	165	7	10.2	0	165	148.2
Int. co-authored peer-rev. articles (IC-PRA)	1.16***	3.15	0	33	0.05	0.47	0	13.3	0.62	2.35	0	33	2,320.0
Int. co-authored peer-rev. article equivalents (IC-PRAE)	1.6***	4.3	0	42.8	0.1	0.7	0	20	0.9	3.2	0	42.8	1,600.0
English language peer-reviewed articles (ENG-PRA)	3.2***	5.3	0	33	1.1	2.8	0	30	2.2	4.4	0	33	290.9
English language peer-rev. article equivalents (ENG-PRAE)	4.7***	7.6	0	58.4	1.7	3.9	0	43.2	3.3	6.3	0	58.4	276.5

*p < 0.05; **p < 0.01; ***p < 0.001

Discussion

European top performers are a homogeneous group of academics whose high research performance is driven by structurally similar factors. They work according to similar working patterns and they share similar academic attitudes. They are similar from a European cross-national perspective and they substantially differ intra-nationally from their lower-performing colleagues. They are a universal academic species and they share roughly the same burden of academic production: the '10/50 rule' holds strongly across Europe (with the upper 10 percent of academics producing 50 percent of all peer-reviewed publications).

The European academic knowledge production thus hinges on European top performers. Kyvik (1989: 209) came to similar conclusions about the skewness of Norwegian productivity (the most prolific 20 percent of the faculty produced 50 percent of the total research output) and Abramo et al. (2009: 143) presented similar findings about Italian productivity patterns (12 percent of authors accounted for 35 percent of the total research output, averaged among the disciplinary areas).

Interestingly, the average research productivity distribution is highly skewed not only for all European academic scientists in the sample, which could have been expected, but also for its segment of top performers. The upper 10 percent of academic scientists is as internally stratified as the lower-performing 90 percent, with a very small number of very high publishers: the right tail of the productivity distribution tends to behave exactly as the entire productivity distribution. This result is consistent with recent findings by Yair et al. (2017: 5) who showed in a sample of Israel Prize laureates that the tail of excellence may behave as the entire productivity distribution. In a similar vein, Abramo et al. (2017: 334) found the same pattern in the Italian national research system: 'research productivity distribution for all fields is highly skewed to the right, both at overall level and within the upper tail.' This is also the case across Europe.

The academic behaviors and academic attitudes of research top performers are worlds apart from those of both middle performers and non-performers. And in terms of research productivity, there is no single 'academic profession' (as has always been the case in the last half a century), only 'professions' in the plural. 'Academic professions' in the plural appear in a similar vein in Enders and Musselin (2008: 127) when they refer to the growing internal differentiation of the academic profession; in Marginson (2009: 110) when he summarizes the impact of globalization on the stratification 'between those with global freedoms and those bound to the soil within nations or localities'; and in Teichler (2014b: 84) when he explores the validity of the traditional Humboldtian teaching-research nexus in Germany and restricts it solely to a group of German 'university professors'. The growing stratification of academic scientists across Europe is the name of the game in town, and the persistent inequality in academic knowledge production is one of its major dimensions.

From a cross-disciplinary perspective, consistent with previous studies (Hoekman et al. 2010; Lewis 2013), at an aggregated European level, academics in the cluster of physical sciences and mathematics are by far the most internationalized in research (with about three-fourths being 'internationalists', or collaborating internationally in research), and academics in the cluster of professions – such as law or education – are the least internationalized. Surprisingly, however, in light of previous studies, the level of research internationalization as viewed through the proxy of international collaboration in research, is similar for the cluster of humanities and social sciences on the one hand and the clusters of engineering, life sciences and medical sciences on the other hand (with about 60-65 percent of researchers in both categories being 'internationalists'). There are national variations – but they generally follow the European pattern.

Implications at the micro-level of individual scientists

Inequalities in academic knowledge production have different implications for scientists pursuing research-oriented careers (often funded through competitive research grants) and those interested predominantly in teaching, and for scientists in research-intensive and those in teaching-focused institutions. However, the implications of highly skewed research performance are especially important for young scientists (see Yudkevich et al. 2015; Horta and Santos 2016). In particular, it is essential for scientists considering a research-oriented academic career to know what to do (and what not to do) and why.

This research implies that to become a top research performer, a scientist must invest higher than average amounts of time in research and, surprisingly, in all other academic activities, including teaching, service, and administration. At the individual level, there seems to be a permanent struggle between research time and non-research time, and between research orientation and teaching orientation. Entry to the class of top performers demands long research hours, long working hours, and high research orientation. Deciding what to do and what not to do is predominantly an individual matter, but it is also partly institutional; a perfect academic working environment is one in which institutional requirements (e.g., a focus on research) align with individual expectations (e.g., publishing a lot in high impact journals).

In terms of academic salary stratification across Europe, consistently with the prestige maximization theory, salaries relate increasingly to research output and the availability of competitive research funding. As the quasi-markets of competitive research funding are both national and international, the implications extend to the individual academic. If administrative and service hours (as well as total working hours) are highly correlated with higher earnings, and if top earners are overrepresented among European high research performers, then European scientists with a taste for research must understand that much of their time will be spent on non-research activities. For individuals considering an academic career, the core distinction is between research and non-research activities; while research time has traditionally been highly valued, non-research time was traditionally considered less valuable.

The implication is that European institutions offering more research time as a proportion of total working time will be more attractive to research-oriented scientists than those offering less research time, especially given more or less similar academic salary levels (when adjusted to living costs) across major Western European countries. Systems that offer various forms of merit-based pay may be more attractive to research-oriented scientists, and specifically to top performers, than systems that still utilize fixed-level, public service-type salaries. While academic prestige remains central to the academic enterprise, the influence of salary stratification on the academic profession cannot be disregarded.

Finally, the implications of international research stratification for individual scientists is that the fierce competition for prestige and research resources hinges increasingly on internationalization in research. Across Europe, internationalists compete directly with locals – in sharp contrast to the United States – and locals increasingly stand to lose out (as in Wagner and Leydesdorff 2005). As the rules governing academic prestige, incentives, and awards become increasingly homogeneous across the continent, individual evaluations based on prestigious international publications become ever more important for individual academic careers. The fundamental divide in science between haves and have-nots, which is another way of understanding the social stratification of higher education, hinges increasingly on individual involvement in international research.

What is important to understand for individual, especially young academics, is that European academic institutions competing nationally and internationally for public funding, high international rankings, and top scientists – tend to use the same research-based metrics because their aggregated institutional success hinges on the disaggregated individual research successes of the scientists they employ. Broad awareness of the role of international research-based university rankings means that scholarly publishing is more than an individual matter. Publishing (and especially international publishing in top journals) and competitive research funding – directly linked to highly selective publishing channels – increasingly determine institutional and/or departmental funding. Employing high-publishing scientists generates research funding; conversely, employing low publishing scientists attracts little funding, of which especially the former should be aware and perhaps use for their own benefit.

Importantly, the modalities of international collaboration depend almost entirely on scientists themselves (Wagner 2018). They decide whether and with whom to collaborate, and the decision to internationalize depends on individual choices based on reputation, resources, research interests, and the attractiveness of the potential partner. There is always a trade-off between the time and energy spent on international collaboration and the research and publishing outcomes (Landry and Amara 1998). *External* international research collaboration has powerful *internal* implications, as those who successfully pursue international collaboration become more competitive both institutionally and nationally. At the same time, attractiveness as an international collaboration partner is based on prior international research visibility and output. Scientists with no current internationally visible research are also invisible for the purposes of future international collaboration (see Horta and Santos 2016).

Conclusions

After decades of comparing nations and institutions, systems of evaluation and assessment now aggressively extend to the level of the individual scientist. For research funding agencies and evaluation panels as well as university recruitment committees, the ready availability of individual-level data makes the workings of higher education and science systems more visible and more quantifiable in every respect. The ongoing evolution of academic job requirements mirrors the increasing stratification of institutions and individual scientists. ‘Winner takes all’ logics may predominate, and judgments of excellence extend beyond institutions to individual scientists, intensifying their experience of the tensions between teaching and research, economic and social values, and the global scientific (fundamental) and local/regional (applied) goals of research. Big-picture issues of institutional differentiation and mission and the changing character, volume, and structure of national research funding now translate into direct anxieties for individual scientists.

Therefore, in these rapidly changing academic environments, scientists need clear professional identities: They need to know how they should function to be among the top layers of the academic enterprise, should they choose to want this. In terms of their own academic careers, they need to know what is important, what is not important, and especially why this is the case. They also need to have clear images of a successful academic scientist and successful academic science, both in general terms and within their specific national contexts. The career stages of successful academic scientists need to be clearly defined in advance in terms of research achievements if the academic science enterprise is to continue successfully. Regarding promotion in the university sector, and especially within its upper layers, what matters and what does not matter need to be clearly stated.

In increasingly stratified higher education systems, both current and prospective scientists must make more considered decisions about where they plan to work in the future—decisions that have important long-term consequences in terms of access to research funding and future career prospects. More international publications in top academic journals increasingly lead to more competitive research funding, and the status of one's university in national and international hierarchies of prestige increasingly determines academic life chances and how one's working time is distributed (especially – what is the overall proportion of research time available).

The contribution of non-publishing and low-publishing authors to scientific progress is beyond the scope of this paper, and the dependence of eminent scientists on less eminent colleagues (as posited by the Ortega hypothesis) is an interesting direction for future research (see Cole and Cole 1973). The belief that all scientists contribute as peers to the collective enterprise of extending knowledge serves to integrate the various strata of scientists and 'provides a degree of stability in a system which is highly competitive and grudging in its major rewards to all but a very few' (Zuckerman 1970: 243).

More generally, the system of higher education today is stable and is perceived as fair and meritocratic – because research achievements are still in its center. The stratification types explored in this paper are all research-based. Scientists accept as legitimate the research-focused criteria by which they are judged, and the legitimacy of the system is not in question; the egalitarian ideology that binds scientists together protects the stratified scientific community against polarization. In Europe, as opposed to the USA, the ideology of commercialism and commercially-oriented reward systems do not threaten to undermine traditional priority-recognition reward systems – and intraprofessional conflicts between the two opposing ideologies of scientific work do not pull the academic profession in two different directions (leading to the emergence of 'a fractured profession', as Johnson termed it, 2017: 135-137). The increasing competition for resources is informed by the legitimate and widely accepted principle that past success in combination with novel research ideas provide future access to resources for research.

Although implications of social stratification at institutional and national levels are not discussed in this paper, one implication binds the three levels: academic performance stratification means that hiring policies must be carefully planned, with clear national strategies in relation to vertical stratification of the system. As national higher education and science systems may be more or less internally competitive and more or less vertically differentiated, top performers may work alongside low performers scattered across national systems (in less internally competitive and less vertically differentiated systems) or may be concentrated in elite universities (in more internally competitive and more vertically differentiated systems). The Italian system is an example of the former type, and the UK system is representative of the latter, with other European systems located somewhere between the two. In light of the sharp inequality in knowledge production, national higher education policies must be clear about how to proceed in the future. Is knowledge production to be concentrated in a small number of well publicly-funded elite institutions, or is it to be maintained across the whole spectrum of institutions, from local and regionally relevant to elite and globally visible? While some European systems (such as Germany, Hüther and Krücken 2018) have traditionally been more equal, others have tended to be more stratified (as in the UK, Leišyte abd Dee 2012). Recent excellence-based funding initiatives across Europe point to increasing pressure for further concentration of research within systems. In practical terms, the concentration of research in selected institutions may translate into further concentration of top performers. The policy dilemma is whether to support high performing scientists – or highly ranked institutions. Beyond theoretical questions of equality versus excellence, these are practical questions about how to distribute research funding fairly and effectively – of which the academic profession needs to be aware.

To conclude: the present research demonstrates that within the academic profession, research, and especially international research collaboration, plays a powerful internally stratifying role. Vertical stratification of institutions (reflected in national and international ranking systems) and scientists (reflected in changing career opportunities) is increasingly reshaping national higher education systems across Europe. The academic profession today, operating in highly competitive environments, is as heavily internally divided as never before. It is divided by research output, salary, academic position, gender, age cohort, working time distribution, access to research funding and to limited space in top journals. Understanding social mechanisms behind these internal divisions today is of critical importance for academic scientists to thrive in the future.

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Stratification, Work Patterns and Research Productivity (Routledge 2019). The support of the Ministry of Science and Higher Education (0021/DLG/2016/10 (EXCELLENCE) is gratefully acknowledged.

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