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The PhD Premium: Diverging Occupational Returns to the PhD Credential in 20 European Countries

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Abstract
In recent years, the number of PhD titles awarded has increased globally, as it did in most countries. What is the relationship between such expansion and the occupational condition of PhDs? Is there a PhD premium, that is an occupational advantage of PhD holders with respect to college graduates? In this paper, we provide empirical evidence for 20 European countries by estimating two-step models on European Labor Force Survey data (2009–2020). Our results show that the association between PhD expansion and returns to the title changes depending on the outcome considered. Concerning income, no significant associations are observed, whereas concerning the probability of becoming a professor, there is a negative association: where there are more PhD holders, the PhD premium decreases. Conversely, regarding the probability of obtaining a nonacademic good job, there is a positive association between the participation rate and the PhD premium. Controlling for expenditures in Research and Development (R&D) adds detail to the picture: the proportion of title holders drives the negative association concerning the probability of becoming a professor, while expenditures in R&D drive the positive association concerning the probability of getting a good job outside academia.

Keywords Higher Education · PhD · Returns to higher education · Inflation of educational credentials · Skill-biased technological change

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Introduction

A doctoral degree (PhD) represents the highest academic qualification awarded by contemporary universities. Historically, it has served as a gateway to prestigious positions, particularly as a university professor or researcher within specialized institutions. However, concerns have recently emerged regarding the limited career opportunities available to PhD holders. In many countries, in fact, public policies aimed at promoting technological development and addressing potential shortages of advanced skills have led to a rise in the number of PhD graduates. Unfortunately, this growth has not been accompanied by a proportional increase in academic and research positions (Gokhberg et al., 2016; Sarrico, 2022).

Such an imbalance could diminish the labor market value of PhD degrees, thereby worsening the occupational conditions of their holders, following the well-known pattern of inflation of educational credentials (Collins, 1979). However, an alternative scenario might also emerge, where PhD holders increasingly secure good jobs outside academia. Indeed, the growing importance of Research and Development (R&D, hereafter) and technological applications in the contemporary 'knowledge economy' has heightened the demand for personnel with advanced skills (Garcia-Quevedo et al., 2012), in line with the mechanism of skill-biased technological change (Acemoglu, 2002).

Which of these two scenarios comes closer to reality? This paper contributes to the debate by describing the 'PhD premium' in 20 European countries, comparing the occupational status of PhD holders to that of college graduates. Specifically, we first examine whether a PhD premium can be observed across Europe and whether holding a doctoral degree is associated with higher income, a greater likelihood of securing a professorial position, and a higher probability of obtaining a top-level nonacademic job. Additionally, we explore whether and how the (potential) PhD premium varies in relation to the expansion of PhD participation across European countries. In other words, do the occupational outcomes of PhD graduates tend to improve or deteriorate as their numbers rise?

This paper offers a threefold contribution to the literature. First, it provides comparative evidence on PhD holders, which has been limited in prior research. Second, it examines their occupational outcomes through a multidimensional lens, moving beyond the single indicators commonly used in prior studies. Third, it situates the analysis within broader theoretical perspectives linking educational systems and social stratification, and their changes over time. In doing so, we aim to bridge a gap between specialized research on higher education and more general socioeconomic studies on returns to education, which we believe is much needed.

The paper is structured as follows. After the introduction, Sect. "The expansion of doctoral education" provides an overview of the expansion of doctoral education, while Sect. "Occupational returns to PhD" discusses theories and empirical evidence regarding the occupational returns to PhD education. Sect. "Research design" outlines the research design, and Sect. "Data, variables and statistical models" presents the data, variables, and methods. Empirical results are discussed in Sect. "Empirical results", and finally, Sect. "Discussion and conclusion" offers the conclusion.

The Expansion of Doctoral Education

The PhD, or research doctorate, represents the highest qualification conferred by contemporary higher education systems, typically requiring a minimum of three years of study, mostly devoted to original research. Historically, PhD graduates were expected to pursue prestigious careers as university professors or researchers in specialized institutions, and their employment prospects were generally not a cause for concern. However, the dynamics of the 'knowledge economy' (Powell & Snellman, 2004) have significantly altered this landscape. As noted by the OECD (2021: 29), PhD holders today are not limited to specialized roles in research institutions but "play an outsized role in the education system and the modern economy. Contemporary societies rely on innovation, R&D, and knowledge and information sharing for economic development and growth".

Globally, there has been a notable surge in the number of master's graduates pursuing PhD degrees. Data compiled by Sarrico (2022) indicate that from 1998 to 2017 the number of doctoral degrees awarded worldwide nearly doubled. However, remarkable variation exists between countries: while nations like Australia, the US, Portugal, and the Netherlands have experienced substantial increases in the number of PhDs awarded, others, such as Germany and Switzerland, have remained relatively stable.

Similar findings are reported in other international and review studies. Cyranoski and colleagues (2011) observe that from 1998 to 2006, the number of PhDs awarded rose dramatically in developing countries such as China, Mexico, and India, as well as in countries like Denmark, Japan, Australia, and the UK. In contrast, only a modest increase was seen in the US, with no growth in Germany. An OECD report (Auriol et al., 2013) further notes that the number of doctoral degrees awarded by universities in OECD countries grew by 38% between 2000 and 2009. The countries experiencing the most pronounced growth include Portugal, Greece, Slovakia, the Czech Republic, and Italy, whereas no significant increase was observed in Spain, the Netherlands, and Poland. Importantly, none of these studies recorded a notable decline in the number of awarded PhDs in any of the countries examined (Auriol et al., 2013; Cyranoski et al., 2011).

Many factors appear to have contributed to this increase. First, the relevance of R&D and technological applications in production and services in the contemporary knowledge economy has stimulated the demand for personnel with high-level skills in science, technology, communication, and other fields (Garcia-Quevedo et al., 2012). Second, to meet this demand, governments have invested in the creation of such high-level skills, which are supposedly created in formal high-level academic training, such as that provided by PhD courses (OECD, 2010). This demand pattern is reinforced from the supply side, as in most countries, particularly in Europe and East Asia, the number of college graduates has been on the rise since the 1990s (Schofer & Meyer, 2005). This provides a larger pool of possible applicants to doctoral courses. In many countries, moreover, the employment challenges frequently faced by college graduates have reduced the opportunity costs of pursuing doctoral studies. This phenomenon, where young people extend their education due to a lack of appealing job prospects, was observed decades ago among high school and college graduates and is referred to as the 'parking lot' or 'warehouse' effect (Barbagli, 1982; Walters, 1984).

Another supply-side mechanism incentivizing the expansion of doctoral training relates to the interests of university faculty. Although, to our knowledge, there is no systematic

research on this issue, it is widely recognized that the recruitment of doctoral candidates often meets more the short-term needs of teaching and research assistance on the part of professors than the labor market demand, be it academic and non-academic (National Academy of Sciences, 2012). While everywhere a high number of PhD students gives more prestige to departments, and helps faculty to improve their publication record, in those countries where PhD candidates receive state-funded grants having many PhD students might also provide professors with skilled research assistance at no cost to their own research budgets.

Although few data disaggregated by field of study are available, it is reasonable to assume that the demand and supply mechanisms outlined above may operate differently across fields of study. In particular, the expansion of PhD positions in STEM fields may primarily be driven by demand for specialized skills, whereas in the humanities, this growth is likely influenced by supply-side factors such as the employment challenges faced by bachelor's and master's graduates and the reliance on PhD students (and postdocs) as low-paid, fixed-term research and teaching assistants (OECD, 2021).

Some country-specific studies offer indirect evidence supporting this view. In Italy, for instance, a 2000 law significantly loosened government restrictions on the creation of PhD positions, particularly removing the requirement that all PhD students be funded by grants. In the following decade, there was a fourfold increase in the number of PhD graduates overall, and this expansion was even more pronounced in certain fields: over ninefold in the 'soft' social sciences (excluding economics) and approximately sixfold in the humanities (Argentin et al., 2014).

Occupational Returns to PhD

Theories and Scenarios on PhD Expansion and Occupational Outcomes

How is the expansion of participation in doctoral education associated to the occupational prospects of PhDs? The global debate on the issue seems polarized around two contrasting scenarios. A pessimistic position, prevailing in the media and public opinion in the Anglophone world and in most European countries, highlights the decline in the occupational value of the title typically associated with the increasing number of holders (Cyranoski, 2011). This perspective aligns with the pattern of *inflation of educational credentials* (IEC, see Collins, 1979). The key mechanism explaining the IEC is the signaling value of educational titles, which are used by employers as screening devices among job candidates (Spence, 1973; Stiglitz, 1975). The more individuals acquire a particular degree, the less useful it is for employers as a screening device, resulting in a lower occupational value of the degree itself.

On the other hand, a more optimistic scenario is depicted. The key point centers on the knowledge economy's demand for advanced skills, as argued by the *skill-biased technological change* argument (SBTC), based on the growing wage advantage of college graduates observed in most developed countries, particularly Anglophone, since the 1980s (Acemoglu, 2002). Similarly, a 'PhD premium' could arise from the same mechanism: technology substitutes for unskilled labor but complements skilled labor, thereby enhancing the occupational advantages for highly skilled workers relative to their less skilled counterparts.

Moreover, this market mechanism might be supported by public investment, which plays a key role in both financing PhD training and promoting the creation of skilled jobs, particularly in R&D. This allows for the supply and demand of PhD graduates to grow consistently over time, potentially avoiding the inflation of their credentials and expanding the pool of skilled workers in the economy, according to a pattern of 'coevolution' (Heitor et al., 2014).

Another key aspect of the optimistic scenario is the emergence of new career paths for PhD graduates outside academia (Sarrico, 2022), alongside the introduction of new types of doctoral programs—often referred to as 'industrial PhDs'—which aim to better prepare students for such careers (Compagnucci & Spigarelli, 2024). In fact, it has been observed that at least five types of nonacademic employment opportunities are currently available to PhDs (Kehm & Teichler, 2016): i) research positions in public or non-profit organizations; ii) jobs in the private sector, requiring R&D skills; iii) other professional positions in the private sector, requiring highly specialized or research skills; iv) professional jobs where a PhD title provides additional prestige and revenues, such as lawyer or doctor; and v) lower-level jobs, in both the public and private sectors, for which a PhD title is not required. The latter category, of course, challenges the optimistic scenario, as it suggests potential over-education among PhDs and the 'crowding out' of non-PhD holders, as will be argued below.

In theoretical terms, the IEC argument relates to social reproduction theory, as it views educational qualifications primarily as entry tickets to occupations, with their signaling value being disconnected from the actual productivity of degree holders. Conversely, the SBTC argument is grounded in modernization theory, as it gives a key role to productivity in explaining returns to education. However, adjudicating between the two scenarios is an empirical matter. Indeed, both the IEC and SBTC hypotheses revolve around the issue of the 'race between education and technology', that is, the demand and supply pattern linking, on one side, the production of degrees by educational institutions and, on the other side, the labor market's demand for skilled workers (Goldin & Katz, 2008). When education 'leads the race', that is when more degrees are awarded than the available positions for graduates, then inflation of educational credentials occurs, as seen with college degrees in the US during the 1970s, when graduates first experienced the possibility of unemployment. Conversely, when technology 'leads the race', creating demand for more skilled workers than the education system produces, then the market situation of degree holders improves with respect to non-degree holders, as was the case for U.S. college graduates from the 1980s to the 2000s, when the SBTC argument was developed.

In the case of PhD graduates, evidence suggests that in recent decades the race has been won by education, which has outpaced demand at the global level. Indeed, the increase in awarded PhD degrees has exceeded the increase in R&D investment, which serves as a proxy for employment opportunities in research (Sarrico, 2022). Concerns have been raised about the growing uncertainty of academic careers, as competition for tenured positions has intensified, resulting in a growing number of young PhD holders working on fixed-are largely consistent with those based 40s (OECD, 2021). Moreover, the global expansion of the population of PhD holders is occurring at a faster rate than that of college graduates overall, pointing to an increasing rate of transition from lower-level titles (Sarrico, 2022). This creates the possibility of a 'crowding-out' mechanism (Thurow, 1975): PhDs unable to secure suitable employment move into labor markets traditionally occupied by non-PhD graduates and then might be preferred by employers due to the higher skills signaled by their degrees. This crowding-out effect might compensate for the inflation of educational

credentials for PhD holders, although at the cost of making the occupational opportunities of non-PhD graduates worse.

Empirical Evidence on the Evolution of Returns to PhD

Existing research points to a relevant heterogeneity of returns to PhD education and their trend over time, depending on the context and the methodological approaches, often related to data constraints. However, a comparative OECD study takes a critical stance with respect to the pessimistic position, particularly regarding "reported concerns in the media about excessive graduation rates and claims that advanced skills are being underutilized" (Auriol et al., 2013: 13). In fact, according to their data, the average employment rate of PhD holders, 93%, is much greater than that of tertiary graduates, approximately 81%. However, the authors also note that "the position of recent doctoral graduates may be less favorable than for those who have received their doctorate a longer time ago" (Auriol et al., 2013: 14).

In the US, for instance, between 2004 and 2014, the proportion of PhD graduates securing employment before graduation declined (but not in the case of graduates in science and engineering). Moreover, while around 80% of PhDs in non-science and non-engineering fields work in academia, the reverse is true for science and engineering graduates. For instance, only 15% of engineering PhDs find academic positions. Over the observed period, the rate of academic employment increased for the former and decreased for the latter (National Science Foundation, 2015: 8). Despite these trends, the wage premium for PhDs compared to bachelor's and other postgraduate titles increased during the 2000s (Auriol et al., 2016). In Australia (2000–2007), PhD employment rates remained stable and similar to those of tertiary graduates, but as in the US, the proportion of PhD holders obtaining a non-academic job increased, particularly in scientific fields (Neumann & Tan, 2011).

In Europe as well, significant heterogeneity can be observed. In Germany, studies report good and stable employment conditions for PhD graduates in all disciplines, related to the relatively modest expansion of enrollments and to the traditionally good employment opportunities of PhDs in the private sector (Enders, 2002; Mertens & Röbken, 2013). In the UK, a relatively low proportion of PhD graduates obtains an academic job (Royal Society, 2010), while wage premia to PhD (compared to MA/MSc) are observed only in fields like medicine, science, and business, with systematically higher returns for women (Casey, 2009). On average, the premium for PhDs compared to other university titles increased during the 2010s (Auriol et al., 2016). In Denmark and the Netherlands, however, no wage premium for PhDs with respect to master's degrees has been found, controlling for both individual and employment sector characteristics (Pedersen, 2016; Wouterse et al., 2017).

In France, PhDs who graduated in 2015 saw a rise in fixed term contracts when pursuing academic careers, while those entering the private sector (about 40%) secured permanent positions more quickly but were also more likely to feel their skills underutilized (Calmand et al., 2017). In Italy, the average occupational outcomes of PhDs do not differ much from the ones of master's graduates, with PhDs holding less stable jobs but reporting higher satisfaction and lower overqualification (Argentin et al., 2014). Over the recent decades, while occupational conditions for PhDs declined (Passaretta et al., 2019), non-PhD graduates experienced even greater declines, resulting in a small but growing PhD premium, especially in the humanities, where the expansion of enrollments was stronger (Ballarino, 2022).

Despite national differences, it appears that while the number of PhDs is increasing worldwide, they are more likely to pursue careers outside of academia than in the past. Both phenomena are associated with a changing organization of the courses. While in the past, PhD students had personal relationships with their supervisors similar to those of premodern apprenticeships (Collins, 2000), today their activities are increasingly formalized and bureaucratized (Gumport, 1992). Bureaucratization is required to cope with the increasing number of students, which is difficult to manage on a personal and informal basis. Moreover, the revision of doctoral training includes the introduction of activities aimed at making PhDs more employable outside academia (Bogle et al., 2011; Main et al., 2022) and avoiding the "organizational culture shock" often experienced by PhD graduates who enter non-academic organizations (Skakni et al., 2022).

Research Design

This paper contributes to the debate on the relationship between the expansion of PhD education and returns to this credential by examining the PhD premium from a comparative, cross-sectional perspective.[1] We compare the occupational outcomes of PhDs to those of non-PhD tertiary graduates in 20 European countries, focusing on three dimensions: i) income; ii) access to the professoriate; and iii) access to a high-quality, nonacademic job.

We address two primary research questions. First, we aim to "establish the phenomenon" (Merton, 1987) by describing the possible existence of a 'PhD premium'. Specifically, our first research question asks whether holding a PhD is associated with an occupational advantage over tertiary graduates without a PhD. Second, we explore the relationship between this premium—or the gap, should it be negative—and participation rates in doctoral education. Thus, our second research question asks whether the PhD premium differs across European countries according to the prevalence of doctoral education. In other words, does the PhD premium tend to be higher (or lower) in countries where doctoral education has experienced greater expansion?

Building on the literature discussed above, we propose two potential answers to this question, corresponding to two ideal–typical scenarios, as reported in Table 1 below. The first scenario, a pessimistic one, is based on the *inflation of educational credentials* (IEC) argument, which suggests that the PhD premium should be lower where the proportion of PhD holders is higher. The key mechanism underlying this scenario is the lower signaling value of the title, which is associated with its diffusion.

The second, more optimistic scenario is inspired by the *skill-biased technological change* (SBTC) argument and the coevolution hypothesis. According to this scenario, the PhD premium should be higher where the share of PhD holders is larger, as the demand for PhDs is driven by the development of the knowledge economy, namely, by the greater relevance of technology for work and jobs. This development underlies both the expansion of doctoral

[1] Unfortunately, we cannot observe changes in the occupational condition of PhDs over time in a reliable way due to sample size constraints. Among other limitations, only a few countries in our data have sufficiently large samples to make such an analysis feasible. However, this would require a shift in focus towards country-specific trends and their causes, that falls outside the broader scope of the current study. We consider this type of small-N analysis a promising avenue for future research. In the meantime, we refer the reader to Sect. "Supplementary analysis: variation by field of study and between- vs. within-country differences" for a brief discussion of cross-country differences and temporal variation within countries.

Table 1 How the occupational condition of PhDs might change with an increasing numbers of title holders: Two ideal–typical scenarios

	Scenario 1: Pessimistic	Scenario 2: Optimistic
General theoretical approach	Social reproduction	Modernization
Theory of reference	IEC: Inflation of educational credentials	SBTC: Skill-biased technological change
Empirical expectation	Returns decrease when number of PhDs increases	Returns increase when number of PhDs increases
Key mechanism at work	Lower signaling value of PhD title makes it less relevant to employers	Co-evolution: increasing supply of PhDs is matched by increasing demand, since both are driven by technological change

education and an increasing demand for PhD skills, leading to a stable or even increasing PhD premium despite doctoral expansion.

To provide additional evidence related to the second scenario, in our analysis we also consider investment in R&D, a measure of the development of the knowledge economy. This is important for two reasons. First, a positive association between R&D investment and the PhD premium would be consistent with the coevolution argument, whereas a weak or negative association would challenge its empirical validity. Second, incorporating this measure allows us to explore whether any positive association between the number of PhDs and the PhD premium is driven, at least in part, by demand-related factors.

Data, Variables and Statistical Models

Data and Sample

We use data from the European Labor Force Survey (EU-LFS) for the years 2009 to 2020. The EU-LFS serves as the primary data source for labor market information at the household level in Europe. It offers standardized cross-sectional data encompassing various aspects, such as occupation, income, education, and other sociodemographic characteristics, for all members of surveyed households.[2] Its large sample size allows us to distinguish PhD graduates from college graduates for a good number of European countries. Specifically, we focus on 20 countries: Austria (AT), Belgium (BE), Switzerland (CH), the Czech Republic (CZ), Germany (DE), Denmark (DK), Estonia (EE), Spain (ES), Finland (FI), France (FR), Greece (GR), Hungary (HU), Ireland (IE), Italy (IT), Lithuania (LT), Luxemburg (LU), The Netherlands (NL), Portugal (PT), the Slovak Republic (SK) and the United Kingdom (UK).

[2] The EU-LFS is carried out by the National Statistical Institutes of each participating country and subsequently harmonized and processed by Eurostat. The national institutes are responsible for sample selection, questionnaire design, data collection through household interviews, and transmission of results to Eurostat following a common coding framework. As a result, sample sizes may vary across countries (see Table 2), reflecting differences in factors such as the compulsory or voluntary nature of participation, response rates, unit non-response, etc. Nevertheless, cross-country comparability is ensured by the EU-LFS through the adoption of shared concepts, definitions, classifications, and the collection of a standardized set of variables in each country.

Our analytical sample includes all employed individuals aged 35 to 64. We obtained an analytical sample of 11,471,630 individuals, among whom 128,561 held a PhD—approximately 1.1% of the total and 3.7% of the tertiary graduates.[3] Table 2 reports these numbers for each country.

Variables

We examine the possible PhD premium (or gap) relative to a college degree across three different occupational outcomes, which serve as the dependent variables in our statistical models. The first one is income. The EU-LFS survey collects information on the monthly net income decile of the main dependent job. We focus on the probability of being in the top three deciles of the income distribution, that is, being in the top 30% incomes.[4] In addition to income, we compare the occupation of PhDs and college graduates. We define a good occupation as one classified in the service class, based on a version of the EGP social class scheme (Erikson and Goldthorpe, 1992), the standard class scheme for social stratification

Table 2 College and PhD graduates, by country. Absolute and percentage frequencies. *Source*: Own elaboration of EU-LFS data (2009–2020)

	College graduates		PhD graduates			
	N	%	N	%	% over tertiary graduates	Total
Austria	188,493	26.7	11,041	1.6	5.5	706,405
Belgium	116,726	41.2	2,477	0.9	2.1	283,390
Switzerland	132,175	38.4	14,221	4.1	9.7	344,457
Czech Republic	46,108	16.9	1,559	0.6	3.3	273,551
Germany	429,600	29.5	26,795	1.8	5.9	1,454,695
Denmark	161,672	39.8	4,907	1.2	3.0	405,942
Estonia	39,281	39.3	726	0.7	1.8	99,879
Spain	141,531	39.0	4,221	1.2	2.9	363,294
Finland	41,040	44.8	1,523	1.7	3.6	91,556
France	507,670	32.6	15,673	1.0	3.0	1,555,486
Greece	196,518	26.6	5,039	0.7	2.5	738,019
Hungary	156,923	19.7	4,308	0.5	2.7	797,891
Ireland	258,990	43.3	6,762	1.1	2.5	597,952
Italy	356,475	18.8	9,556	0.5	2.6	1,893,130
Lithuania	94,950	37.0	1,492	0.6	1.6	256,360
Luxembourg	30,925	38.9	2,046	2.6	6.2	79,469
Netherlands	136,579	38.8	3,493	1.0	2.5	352,251
Portugal	106,688	18.7	6,998	1.2	6.2	570,322
Slovak Republic	66,196	19.7	1,973	0.6	2.9	336,483
United Kingdom	104,534	38.6	3,751	1.4	3.5	271,098
Total	3,313,074	28.9	128,561	1.1	3.7	11,471,630

[3] The EU-LFS does not collect income information for self-employed individuals. Therefore, the income analyses are restricted to dependent employees (N = 7,106,734). Supplementary analyses—available upon request—excluding self-employed respondents also from the models on access to the professoriate and high-quality nonacademic employment yield results largely consistent with those presented here.

[4] Sensitivity analyses using stricter definitions of top incomes (e.g., above the first or second decile) confirm the results reported here, although with greater uncertainty (results available on request from the authors).

research. The service class includes employers, professionals and managers, and constitutes the top class in the social hierarchy of contemporary industrial and post-industrial societies.

As an implication of the discussion concerning the occupational outcomes of PhD graduates and their change over time, it is important to distinguish between academic and non-academic positions. In fact, according to IEC theory, the key parameter underlying occupational returns to PhDs is the ratio between the number of PhD holders and the available professorial and research jobs. By contrast, the SBTC theory and the coevolution argument posit that technological change, and its application to work processes, enhances non-academic opportunities for PhDs, thereby mitigating the mismatch between the number of PhD holders and academic positions. We then separately analyze the probability of holding an academic position—defined by ISCO-88 code 231—and the probability of securing a non-academic service class job, which includes all ISCO groups with one-digit codes 1 and 2, excluding 231.

At the micro level, the main independent variable is individual educational attainment, which is categorized into five levels: primary or less, lower secondary, upper secondary, tertiary (non-PhD),[5] and PhD. Since our interest lies in the comparison between the occupational conditions of PhD holders with those of non-PhD tertiary graduates, we focus our discussion on these two categories, but all employed respondents are included in the analytical sample. Models at the micro level also control for a set of covariates, including sex, foreign-born status (born in the country of residence or abroad), region of residence (NUTS-2 level), age (six five-year interval dummies), and survey year (twelve year-specific dummies).

At the macro level, our primary independent variable is the proportion of PhD holders over the population aged 35 to 64, calculated from the EU-LFS data.[6] As a macro-level covariate, we include public spending in R&D as a percentage of gross domestic product, based on data retrieved from Eurostat.[7]

Models

Since our first research question focuses on a micro-level empirical regularity and our second research question examines its relationship to macro-level phenomena, we adopt a two-step modeling approach, commonly used in research on returns to education (Bernardi & Ballarino, 2014; Müller & Shavit, 1998). This approach is appropriate for multilevel hierarchical data, particularly when there is a large number of observations at level 1 (individuals) nested within a smaller number of observations at level 2 (country-period clusters) (Bryan & Jenkins, 2016).

In the first step, we estimate a series of individual-level linear probability models to assess the association between educational attainment and the three occupational outcomes under consideration. To maximize the number of observations at level 2 and reduce the

[5] The EU-LFS classification of degrees does not distinguish between bachelor's and master's degrees. We do not consider this an issue since up to the early 2000s, before the Bologna process, this distinction did not exist in most of the European countries we study.

[6] We replicated our macro-level analysis using the annual number of PhD students relative to the population aged 20–34, derived from Eurostat data, as an alternative indicator of the expansion of PhD participation. The results—available from the authors upon request—are quite consistent with those obtained using our own measure based on EU-LFS data. As a preliminary finding, we also report the trend of this indicator over time and across countries (see Sect. "The expansion of PhD education").

[7] https://ec.europa.eu/eurostat/databrowser/view/TSC00001/default/table.

uncertainty of estimation, we estimate these models separately by country-period clusters, distinguishing three four-year periods for each country (2009–2012; 2013–2016; 2017–2020). With 20 countries and three four-year periods, we end up with 60 models in the first step, which are specified as follows:

$$y_{ik} = \alpha + \beta_{1k} Prim_{1ik} + \beta_{2k} LowSec2_{ik} + \beta_{3k} UppSec3_{ik} + \beta_{5k} PhD_{5ik} + \gamma_k z_{ik} + \varepsilon_{ik}.$$

In this equation our interest lies in the β_{5k} parameter, which for each country-period cluster k estimates the 'PhD premium', defined as the difference in the occupational returns between PhD holders and individuals with tertiary, non-PhD education (the reference category), after controlling for a set of confounders z_{ik}, including sex, foreign-born status, region, age, and year of survey (see Sect. "Variables").

As a second step, we extract the β_{5k} coefficients and use them as dependent variables in a set of country-period-level regressions, estimating the association between the proportion of PhD holders and the PhD premium (β_{5k}) over country-period units. The following three models are estimated:

Model 1: $b_{5k} = \omega + \delta_k PropPhD_k + u_{ik}$.

Model 2: $b_{5k} = \omega + \theta_k SpendR\&D_k + u_{ik}$.

Model 3: $b_{5k} = \omega + \delta_k PropPhD_k + \theta_k SpendR\&D_k + u_{ik}$.

where δ_k denotes the expected variation in the PhD premium b_{5k}, i.e., the occupational returns to a PhD compared to tertiary, non-PhD education, associated with a one-unit variation in the proportion of PhD holders. Model 1 estimates the gross association between the proportion of PhD holders and the PhD premium; Model 2 estimates the gross association between the investment in R&D and the PhD premium, enabling us to investigate the coevolution argument reported above; Model 3 includes both macro-level variables to study whether the association between PhD expansion and the premium is driven by demand-related factors.

Following the standard procedure for two-step modeling, models in the second step are estimated using weighted least squares (WLS) regressions, with weights proportional to the inverse of the squared standard errors of β_{5k} (King, 1997). This approach ensures that the macro-level estimates account for the fact that the dependent variables originate from a first-step estimation, giving more weight to observations with more precise estimates of β_{5k}. Additionally, we cluster the standard errors by country to account for within-country correlations.

As mentioned above, our analysis primarily focuses on the comparison between PhD holders and tertiary graduates without a PhD, thereby examining the 'relative' returns to PhD education. While the SBTC argument pertains to these relative returns, which are based on a comparison of occupational outcomes between individuals with different educational qualifications, the IEC theory predominantly examines the 'absolute' returns to education (Bernardi & Ballarino, 2016). This involves comparing the occupational outcomes of individuals with the same educational levels across time and space. To account for this distinction, we replicated our analysis using an absolute measure of returns to education, calculated based on the average predicted values of our three outcomes for the group of PhD holders. In other words, as a robustness check, we computed average predictions for being in the top 30% of income, holding an academic position, and securing a non-academic service class job from the first-step models, and these are used as dependent variables in the WLS regressions in the second step. Results using this absolute measure are largely consistent with those based on the relative measure (see Table 6 in the appendix).

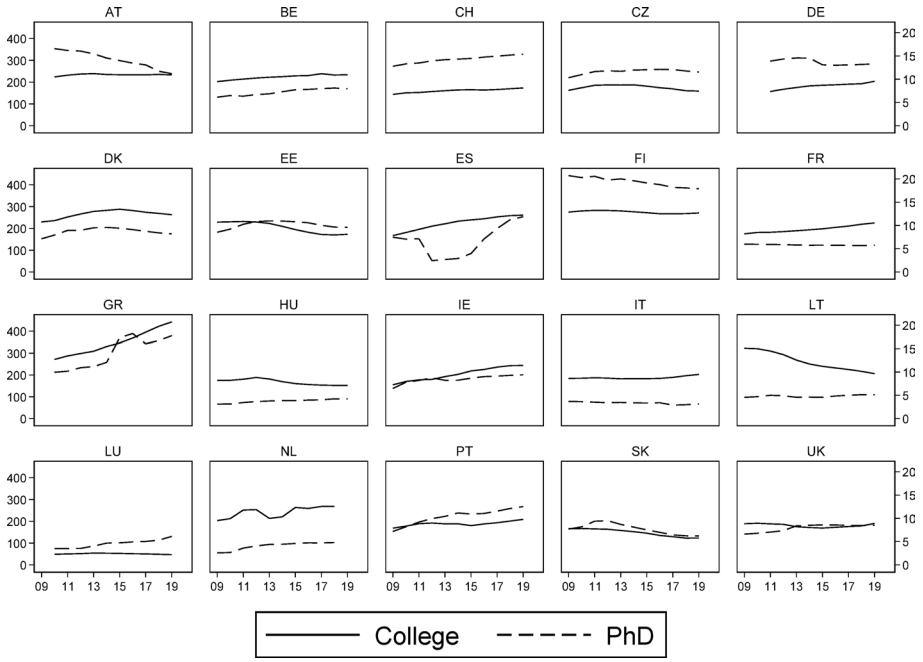

Fig. 1 College and PhD students by country and calendar year—per 1000 of population aged 20–34. *Source*: own elaboration on Eurostat data. *Note*: left y-axis refers to college students rate; right y-axis refers to PhD students rate

Empirical Results

The Expansion of PhD Education

Before delving into our research questions, it might be useful to examine the expansion of doctoral education across the countries and periods considered in our study. Figure 1 reports by country and year the number of college and PhD students for 1000 units of population aged 20–34, while Fig. 2 reports the rate of change, with the 2009 figure set to zero.[8]

The graphs show both differences and commonalities among countries. In terms of levels of PhD participation, significant heterogeneity is observed (Fig. 1). Using the most recent data (2019) as a reference point, Finland ranks highest with 17.9 PhD students per 1,000 people aged 20–34, closely followed by Greece (17.8), Switzerland (15.4), and Germany (12.5). While the high figures for Finland, Switzerland, and Germany are unsurprising given their substantial investment in education, the one for Greece might be puzzling. However, over the last two decades, Greece has made considerable efforts to expand educational participation at all levels, including postgraduate education (OECD, 2020). At the other end of the spectrum, Italy ranks lowest with a ratio of 3.1, followed by Hungary (4.2), Lithuania (5.1), and France (5.7).

Concerning the trends (Fig. 2), the clearest commonality is a pattern of growth, with the Netherlands leading the way with a remarkable increase of 86.5% in PhD participa-

[8] https://ec.europa.eu/eurostat/databrowser/view/educ_uoe_enrt01/default/table?lang=en.

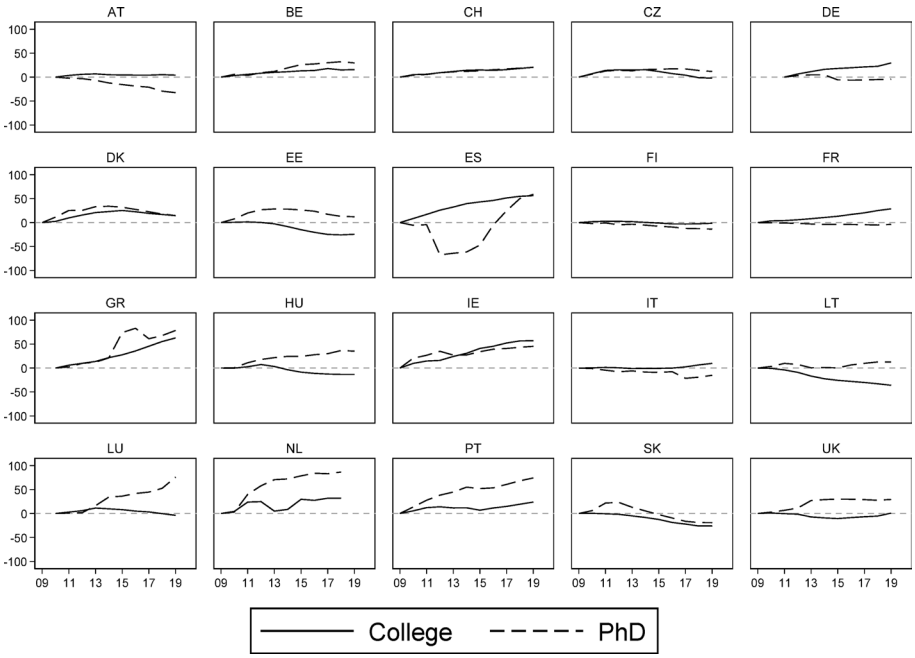

Fig. 2 Percentage change in the number of college and PhD students (per 1000 population aged 20–34), by country and calendar year. Source: own elaboration on Eurostat data. Note: percentage change is computed using 2009 as the reference timepoint, except for Austria, Greece, Luxembourg (2010) and Germany (2011)

tion between 2009 and 2019, followed by Greece (78.4%), Luxemburg (75.8%) and Portugal (74.3%). There are some exceptions to this trend, as seen in countries such as Austria (-32.5%), Slovakia (-19.2%), Italy (-15.1%), and Finland (-13.6%). However, when comparing the rate of expansion of PhD education to that of college education (by calculating the ratio between the former and the latter), substantial heterogeneity emerges: eight countries exhibit a negative ratio, with college education expanding more rapidly than PhD education; two countries display a ratio of one, suggesting similar growth rates for both levels of education; and ten countries show a positive ratio, indicating that the expansion of PhD education outpaced that of college education. The countries with the highest ratios are Portugal (2.7), the Netherlands (1.8), Belgium (1.7), and Spain (1.5). Conversely, the countries with the lowest ratios are Estonia, Slovakia, Czechia, and Denmark, all with ratios of approximately 0.7.

The PhD Premium

Our first research question investigates the existence of a PhD premium. Figure 3 reports the beta coefficients from regression models estimating, for each of the three occupational measures considered, the difference between PhD holders and college graduates who did

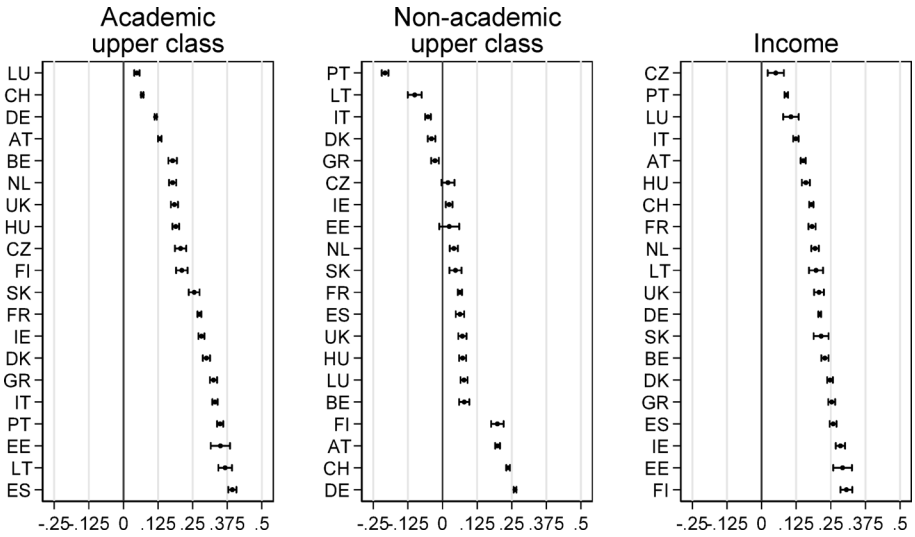

Fig. 3 Difference between PhDs and other college graduates in the probability to have **a** an upper-class academic job; **b** an upper-class non-academic job; **c** a job in the top 30% of the income distribution, by country. Linear probability models. Beta coefficients and 95% confidence intervals. Source: own elaboration on EU-LFS data (2009–2020). Note: models control for sex, foreign-born status, region, age, and year of survey

not enter doctoral studies across countries. These models resemble those utilized in the first step of our two-step approach but do not differentiate between periods.[9]

A quick glance at the figure shows that the answer to our first research question is generally positive. In almost all the regressions, the beta coefficient comparing the occupational conditions of PhDs and college graduates is positive, suggesting an occupational advantage for PhDs. Unsurprisingly, the premium is universally positive when it comes to the probability of becoming a professor (left-hand panel): in no country does holding a PhD fail to provide an advantage in securing a professorial position. However, there is noticeable variation, with the advantage ranging from 40 percentage points (p.p.) in Spain to 5 p.p. in Luxembourg.

In terms of income (right-hand panel), the coefficients—indicating the difference between PhDs and college graduates in the likelihood of earning an income within the top three deciles—are also consistently positive. These range from 31 p.p. in Finland to 5 p.p. in the Czech Republic. The only exceptions to this pattern concern the probability of obtaining a high-status nonacademic job (center panel), where negative estimates are found in five countries: Portugal, Lithuania, Italy, Denmark, and Greece. The countries with the highest PhD premiums in this regard are Germany and Switzerland, with estimated advantages of 26 and 24 p.p., respectively. It is noteworthy that the countries where the PhD premium for accessing professorial positions is highest—mostly located in Southern and Eastern

[9] The Beta coefficients estimated by country and period and used in our two-step strategy are shown in Table 4 in the appendix.

Europe—tend to show a lower PhD premium, or even a penalty, for securing high-status nonacademic jobs.[10]

Expansion and the PhD Premium

We now turn to our second research question, focusing on the association between the proportion of PhD holders and the PhD premium. Table 3 reports the results of our WLS models relating, for each occupational measure, the PhD premium to the expansion of PhD participation and expenditure in R&D.[11]

In terms of the probability of attaining a professorship, a negative and statistically significant association is observed at the bivariate level between the proportion of PhD holders and the PhD premium: for each unit increase in the proportion of PhDs, there is a 6 p.p. decrease in the PhD premium (Model 1). Similarly, a negative and significant bivariate association is found between public R&D expenditures and the PhD premium, with an increase of one unit in R&D spending resulting in an 8 p.p. decrease in the PhD premium (Model 2). When both variables are included in the model, the coefficient for the proportion of PhD holders

Table 3 PhD premium, proportion of PhD holders and R&D expenditures. Weighted least squares regressions. Beta coefficients and standard errors clustered by country. *Source*: Own elaboration of EU-LFS data (2009–2020)

	Model 1		Model 2		Model 3	
	δ_k	σ_k	δ_k	σ_k	δ_k	σ_k
	Academic upper class					
Proportion of PhD holders	−0.06***	(0.01)			−0.05**	(0.02)
Spending on R&D			−0.08***	(0.03)	−0.04	(0.03)
Constant	0.26***	(0.03)	0.31***	(0.06)	0.31***	(0.05)
Observations	60		60		60	
R^2	0.48		0.37		0.55	
	Nonacademic upper class					
Proportion of PhD holders	0.07***	(0.02)			0.03	(0.02)
Spending on R&D			0.13***	(0.02)	0.11***	(0.03)
Constant	0.03	(0.04)	−0.10**	(0.04)	−0.10**	(0.04)
Observations	60		60		60	
R^2	0.32		0.57		0.60	
	Income					
Proportion of PhD holders	0.00	(0.01)			−0.02*	(0.01)
Spending on R&D			0.02	(0.02)	0.03	(0.02)
Constant	0.18***	(0.03)	0.15***	(0.04)	0.15***	(0.04)
Observations	60		60		60	
R^2	0.00		0.09		0.13	

***$p<0.01$; ** $p<0.05$; * $p<0.10$

[10] A comparison between Fig. 3 and Fig. 4 in the appendix suggests that the countries with the highest PhD premia for holding an academic position and securing a non-academic service-class job also exhibit the highest predicted probabilities for PhD holders being in such positions. In other words, there is a positive correlation between the relative and absolute measures of returns to PhD education for these two occupational outcomes.

[11] The values of the macro-level variables for each country-period cluster are presented in Table 5 in the appendix.

does not substantially change, while the coefficient for R&D investment becomes statistically insignificant (Model 3).

In contrast, for the probability of securing a desirable non-academic job, the relationship is reversed. A positive bivariate association is found between the proportion of PhD holders and the PhD premium, with each unit increase in PhD participation associated with a 7 p.p. increase in the PhD premium (Model 1). Additionally, the bivariate association between public spending on R&D and the PhD premium, as estimated in Model 2, is positive and statistically significant ($\theta_k = 0.13$). The results from Model 3 suggest that R&D expenditure emerges as a key driver of the relationship between PhD participation and premiums outside academia, as the coefficient related to the proportion of PhD holders becomes statistically not significant when accounting for this demand-related factor.

Concerning income, the results across all models suggest weak associations between both the proportion of PhD holders and R&D investment and the PhD premium. In other words, although a PhD premium is found in terms of income, it does not appear to substantially change depending on these supply and demand factors.

Taken together, these findings indicate that in countries (and periods) with a higher proportion of PhD holders, the relative advantage of holding a PhD is smaller for securing a professorship, but greater for obtaining a high-status position outside academia. Contextualizing these patterns reveals important regional differences. In Southern and Eastern European countries, where the expansion of doctoral education is still in its early stages, the academic PhD premium remains relatively high (see also Fig. 6 in appendix). By contrast, in Nordic and Continental Europe—particularly in countries such as Switzerland, Germany, and Finland, where the proportion of PhD holders is comparatively higher—the premium is more pronounced outside academia. These countries also tend to exhibit higher levels of investment in R&D and a robust presence of technologically advanced service sectors, which likely foster greater demand for highly qualified workers, including PhDs.

Finally, the negative association between the expansion of PhD education and the probability of becoming a professor, as well as the positive association with the probability of securing a non-academic service class job, are confirmed in absolute terms, as shown in Table 6 in the appendix. In other words, as the proportion of PhDs increases, both relative and absolute returns to PhD education tend to decrease for the probability of securing an academic position, while they increase for obtaining a high-status job outside academia. In contrast, no substantial associations are found between the proportion of PhD holders and their occupational outcomes, either in relative or absolute terms, when it comes to income.

Supplementary Analysis: Variation by Field of Study and Between- vs. Within-Country Differences

As we have argued above, a key issue concerns whether the PhD premium—and its association with the expansion of the PhD-holding population—varies by field of study. A further question, given our focus on country-period clusters, is whether this relationship is primarily driven by cross-country differences in the extent of PhD expansion or by within-country variation over periods. Unfortunately, our data does not allow us to adequately address either of these questions.

On the one hand, the EU-LFS provides complete information on the field of study only up to 2013. From 2014 onwards, this variable is collected only for individuals aged 15–34 or

for those who attained their highest educational qualification within the previous 15 years. In our case, this would have posed a substantial limitation: not only would the sample size—already constrained by the small share of PhD holders—have been considerably reduced, but the restriction would have also introduced potential selection bias, as the analysis would have been limited to younger individuals or, among older respondents, to those who obtained their PhD relatively late.

On the other hand, the relatively short time span of our dataset, combined with both the limited number of observations at the higher level (i.e., country-period combinations) and the small sample size of PhD holders for some countries at the individual level, poses challenges for reliably examining within-country temporal variation. In addition, the EU-LFS does not collect information on respondents' first job, preventing us from distinguishing temporal changes based on cohorts from those stemming from career progression or age-related factors.[12]

Keeping these limitations in mind, we conducted additional analyses to explore these two issues, the results of which are presented in the Appendix. Regarding field of study, Fig. 5 displays the difference between PhD holders and tertiary graduates who did not pursue a doctorate, net of a binary indicator distinguishing between STEM and non-STEM disciplines. The reported coefficients derive from regression models estimated on a subsample of tertiary graduates aged 35 to 44 who attained their highest educational qualification within the past 15 years. While some estimates differ slightly from those based on the full analytical sample without controls for field of study (see Fig. 3), the overall ranking of countries in terms of the PhD premium remains largely consistent. In addition, Tables 7 and 8 correlate the country-level PhD premium with the proportion of PhD holders among tertiary graduates within each field (STEM and non-STEM), as well as with R&D spending.[13] The association between the share of PhD holders and the PhD premium closely mirrors the results in Table 3, suggesting limited variation across fields. However, a stronger negative association between PhD expansion and access to professorships is observed in non-STEM disciplines. By contrast, more marked differences between STEM and non-STEM fields emerge when considering R&D spending. In STEM disciplines, countries with higher R&D expenditure tend to show lower PhD premia for academic employment, but higher premia in terms of access to high-income and high-status non-academic jobs. In other words, the higher PhD premium in countries with greater investment in R&D appears concentrated among STEM graduates.[14]

Regarding between- and within-country differences, Figure 6 in the appendix presents scatterplots for each occupational outcome, displaying the relationship between the propor-

[12] The lack of information on individuals' first job also limits our ability to examine how the associations of interest may vary across career stages. Early career phases, for instance, might be more exposed to the risks of credential inflation or technological change. To address this issue, we conducted separate analyses by age group (35–44 vs. 45–64; results available from the authors), which revealed largely consistent patterns across age categories. Nonetheless, cross-sectional data including information on both first and current jobs—or, ideally, longitudinal data tracking individuals over their career—would be better suited to investigate these dynamics, a task we leave to future research.

[13] These tables can be read analogously to Table 3, with the sole exception that, due to limited sample size at the individual level when disaggregating by field, the unit of analysis is the country rather than the country-period.

[14] We replicated the analyses by field of study, excluding individuals with medical or health-related degrees due to the distinctive nature of their education and employment pathways. These additional analyses—available from the authors—largely confirm the results presented here.

tion of PhD holders (x-axis) and the PhD premium (y-axis) across country-period clusters. To disentangle cross-national variation from temporal changes within countries, the plots include both an overall fitted line and separate fitted lines for each country. The slope of the average line is negative for the probability of securing an academic position, positive for securing a high-status non-academic job, and relatively flat for attaining a high-income position. However, country-specific slopes vary: in some countries, a higher share of PhD holders is associated with a greater PhD premium, while in others the association is flat or negative. This suggests that the overall relationship is primarily driven by cross-country differences rather than within-country temporal variation.

This interpretation is further supported by Table 9 in the appendix, which reports weighted least squares regression estimates at the country-period level of the association between the share of PhD holders and the PhD premium for each occupational outcome, including country fixed effects. Once country fixed effects are accounted for (Model 2), i.e., exploring variation within countries over time, the negative association between the proportion of PhD holders and the premium for accessing academic positions disappears. Additionally, the association with the PhD premium for high-status and high-income non-academic jobs turns negative, though not statistically significant. Taken together, these findings suggest that while countries with a greater overall share of PhD holders tend to systematically offer larger premiums for high-status non-academic employment—consistent with the SBTC argument—PhD expansion within individual countries may either increase or reduce the premium over time, lending support to both theoretical scenarios. However, further investigation with larger-sample and longer-span data is needed to corroborate this interpretation.

Discussion and Conclusion

In this paper, we compared the occupational outcomes of PhD holders with those of college graduates across 20 European countries, addressing two research questions. First, we asked whether there is a PhD premium, i.e., whether PhD holders enjoy an average occupational advantage compared to college graduates who do not pursue doctoral education. Second, we explored the relationship between this premium and the expansion of doctoral education: how does the premium change when the proportion of PhD holders in the population is higher?

We framed our research questions within two contrasting scenarios that reflect ongoing debates surrounding PhD education. On the one hand, a pessimistic scenario is inspired by reproduction theories and by the *inflation of educational credentials* theory. According to this perspective, an increase in the number of PhD holders would decrease the signaling value of the title to employers and thus worsen the average occupational outcomes of the holders. Since the production of PhD graduates by educational institutions has generally outpaced the creation of jobs requiring PhD-level skills, particularly in academia and research, the occupational standing of PhD holders is expected to decline.

On the other hand, a more optimistic scenario draws on modernization theories and the argument of *skill-biased technological change*. In this view, the rise of the knowledge economy increases the premium to skills since demand for them grows across all industries, expanding beyond academia and research. A related argument, the coevolution thesis, maintains that the interplay of market forces and governmental investment makes it possible

for the demand and supply of PhD titles to evolve in a consistent way, thus ensuring good occupational prospects for PhDs.

In response to our first research question, our findings confirmed the existence of a PhD premium across all countries, particularly concerning income and the likelihood of obtaining a professorship. However, in a few countries, predominantly located in Southern and Eastern Europe, where the PhD premium for entering academia is especially high, a 'PhD penalty' emerged in terms of securing nonacademic upper-class jobs.

Concerning our second research question, no significant associations were observed between the proportion of PhD holders and the PhD premium in terms of income. However, our models revealed substantial and statistically significant associations regarding the PhD premium for securing favorable occupations both inside and outside academia. Notably, the nature of these associations varied depending on the specific occupational outcome. On the one hand, the PhD premium concerning the probability of attaining a university professorship strongly decreased with increasing PhD participation rates. On the other hand, the PhD premium for the probability of securing a non-academic upper-class job demonstrated a substantial increase with higher proportions of PhD holders. Moreover, this latter positive association appeared to be primarily driven by public spending on R&D, serving as a proxy for demand for qualified workers in the knowledge economy, which exhibited a positive correlation with the PhD premium.

We interpret these results as providing support for both scenarios. The pessimistic scenario, consistent with the IEC hypothesis, holds well in the case of academic careers: in countries (and periods) where the expansion of PhD education has outpaced the creation of professorial positions, the likelihood of PhDs securing academic jobs is lower, as well as their occupational advantage compared to college graduates. However, in the case of non-academic jobs, the findings support a more optimistic outlook. Where the proportion of PhDs is higher, also their occupational premium relative to college graduates is higher. This association, though, seems to be spurious, since the actual force driving the premium appears to be the diffusion of the knowledge economy, measured in our models by R&D investment. This is in line with the SBTC argument: where the application of technology to the economy is more diffuse, the occupational premium to skilled personnel, such as PhDs, is greater. This finding is also consistent with the coevolution argument, according to which well-designed government policies might maintain a balance between the supply and demand of high skills.

A key finding of this paper is then that the relationship between the expansion of doctoral studies and the occupational outcomes of PhDs changes depending on the type of occupation considered. Concerning academic jobs, the relationship is negative: as the number of PhD holders increases, the probability of securing a university professorship decreases. In contrast, for non-academic high-status jobs, the relationship is positive: a greater number of PhD holders corresponds to an increased likelihood of obtaining a desirable nonacademic job as well as to an increased occupational advantage compared to college graduates without a PhD. Our analyses suggest that two different mechanisms are at work. For non-academic positions, the key mechanism is technological change and its application to jobs, which increases the market demand for high-skilled workers such as PhDs. In the case of academic jobs, the key mechanism is the inflation of educational credentials, that is, the lower signaling value of an educational title where the title becomes more diffuse in a population (holding constant the number of jobs for which the title is required). In addition, the

PhD premium in academia may be constrained by structural factors, most notably the fact that the number of professorships is largely limited by the availability of public funding and cross-subsidies from student fees. As a result, an increase in the number of PhD graduates does not necessarily translate into a proportional increase in academic job opportunities, thereby limiting the positive association between PhD expansion and the PhD premium.

The main limitation of our study lies in the fact that the associations we were interested in could only be observed cross-sectionally due to data constraints. In fact, we examined the two theoretical scenarios defined by the literature by comparing countries (and periods) with different levels of PhD participation. Future research should test our conclusions using larger samples spanning a longer period of time, to determine the relationship between the expansion of participation in PhD and the occupational outcomes of graduates as a change within a given country, thereby controlling for compositional effects in a way that was hardly possible here. This would also make it possible to better assess the causal nature of these relationships. While our study has described robust associations—representing a first step toward a more comprehensive understanding of how the expansion of doctoral education relates to the occupational conditions of PhD holders—further research adopting quasi-experimental designs, such as those exploiting policy reforms that expand or restrict doctoral enrolment, could more directly assess whether increases in the share of PhD holders exert a causal influence on the PhD premium.

Furthermore, employing a diachronic approach spanning an extensive period would further strengthen the empirical basis for assessing the two scenarios. Indeed, some of our additional analyses indicate that our results appear to be primarily driven by cross-country differences rather than temporal variation within countries. In other words, while countries with a higher overall share of PhD holders tend to consistently exhibit a lower premium for entering academia and a higher premium for securing high-status non-academic positions, the expansion of PhD participation within individual countries does not always lead to declining returns in academic employment or increasing returns in non-academic employment over time. This also highlights the importance of cross-country differences in the primary labor market opportunities for PhDs to explain our results. For instance, the PhD premium related to academia entry is higher in countries with fewer PhD holders and where the PhD title primarily serves as a gateway to university professorships. Conversely, it is lower in those countries with a greater number of PhD holders, where there is also a more 'heterogeneous' perception of PhD holders in the labor market.

Another limitation is that the picture we provided is likely to be a gross average between different fields of study. Indeed, both theory and the (scarce) existing research looking at doctoral studies by field of study suggest that the IEC scenario mostly concerns the humanities, while the SBTC scenario mostly concerns STEM disciplines. While our additional analyses found no substantial differences by field of study, more detailed data—including comprehensive information on the field of study for all working-age individuals—could allow for a systematic test of this hypothesis and could also reveal how disciplinary cleavage works in different country contexts.

Appendix

See Figs. 4, 5 and 6.

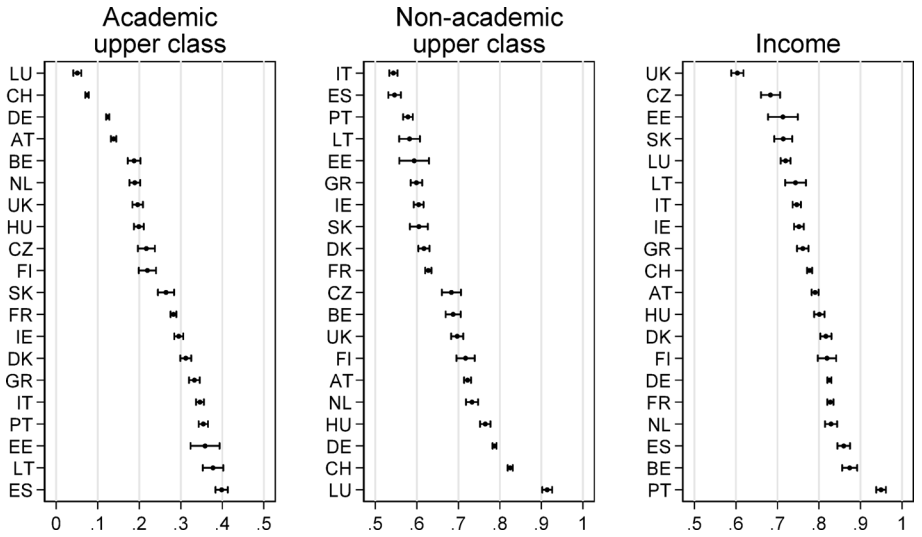

Fig. 4 Predicted occupational outcomes of PhD holders, by country. Linear probability models. Average predictions and 95% confidence intervals. *Source*: own elaboration on EU-LFS data (2009–2020). *Notes*: models control for sex, foreign-born status, region, age, and year of survey

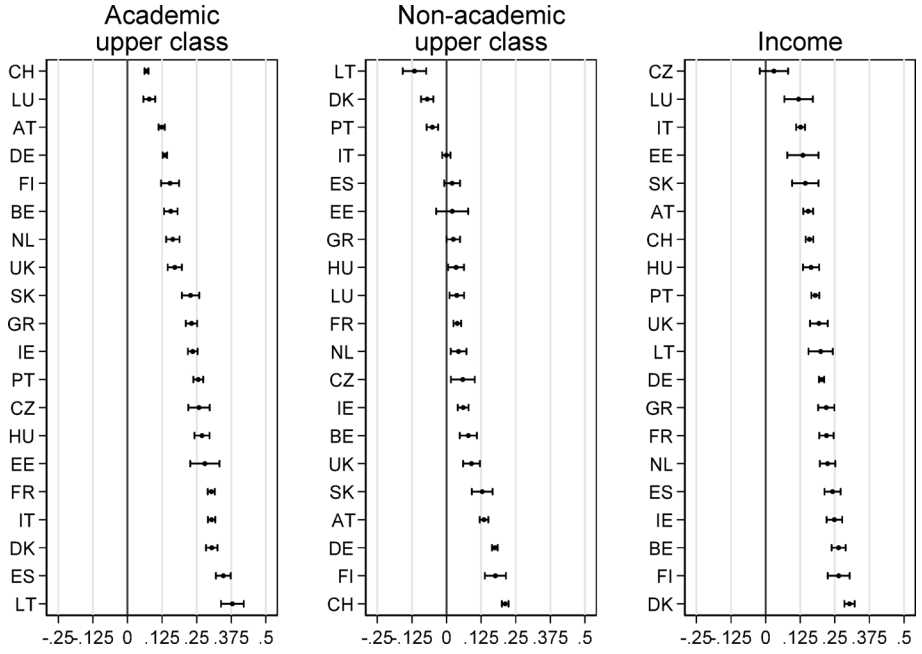

Fig. 5 Difference between PhDs and other college graduates in the probability to have **a** an upper-class academic job; **b** an upper-class non-academic job; **c** a job in the top 30% of the income distribution, by country. Linear probability models with control for field of study. Beta coefficients and 95% confidence intervals. *Source*: own elaboration on EU-LFS data (2009–2020). Notes: models control for sex, foreign-born status, region, age, year of survey, and field of study (STEM vs. non-STEM)

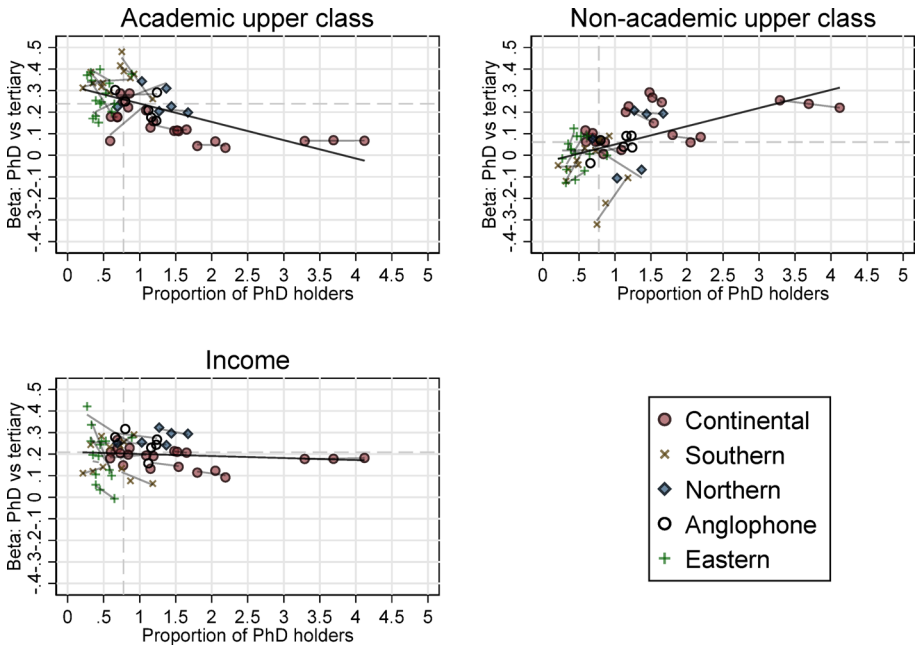

Fig. 6 Correlation between beta coefficients (first step) and proportion of PhD holders, by country-period clusters and occupational measure.Note: reference lines correspond to the average PhD premium and the average proportion of PhD holders across country-period clusters. *Source*: own elaboration on EU-LFS data (2009–2020)

See Tables 4, 5, 6, 7, 8 and 9.

Table 4 The PhD premium: difference between PhDs and college graduates in income and in the probability of having an upper-class job, academic and non-academic, by country-period clusters. *Source*: own elaboration on EU-LFS data (2009–2020)

	$\beta_{academic}$			$\beta_{nonacademic}$			β_{income}		
	2009–12	2013–16	2017–20	2009–12	2013–16	2017–20	2009–12	2013–16	2017–20
Austria	0.11	0.13	0.16	0.15	0.20	0.23	0.14	0.13	0.19
Belgium	0.18	0.18	0.18	0.06	0.08	0.10	0.21	0.23	0.27
Switzerland	0.07	0.07	0.07	0.26	0.24	0.22	0.18	0.18	0.18
Czech Republic	0.18	0.24	0.24	0.03	0.01	0.01	0.06	0.03	−0.01
Germany	0.11	0.12	0.12	0.29	0.27	0.25	0.21	0.21	0.21
Denmark	0.23	0.34	0.31	0.08	−0.11	−0.07	0.25	0.25	0.24
Estonia	0.37	0.29	0.38	−0.02	0.09	0.00	0.42	0.26	0.28
Spain	0.42	0.39	0.38	0.02	0.07	0.09	0.24	0.26	0.29
Finland	0.20	0.23	0.20	0.21	0.19	0.19	0.32	0.30	0.29
France	0.25	0.29	0.29	0.07	0.06	0.06	0.15	0.20	0.23
Greece	0.39	0.32	0.29	−0.12	−0.02	0.03	0.24	0.28	0.23
Hungary	0.17	0.15	0.25	0.05	0.12	0.03	0.20	0.19	0.11
Ireland	0.30	0.25	0.29	−0.04	0.07	0.04	0.28	0.32	0.27
Italy	0.31	0.34	0.34	−0.05	−0.06	−0.04	0.11	0.12	0.14
Lithuania	0.38	0.40	0.33	−0.13	−0.11	−0.07	0.26	0.24	0.13
Luxembourg	0.03	0.04	0.06	0.08	0.09	0.06	0.09	0.11	0.12
Netherlands	0.07	0.22	0.21	0.12	0.01	0.02	0.18	0.20	0.19
Portugal	0.26	0.36	0.48	−0.10	−0.22	−0.32	0.06	0.08	0.13
Slovak Republic	0.35	0.25	0.20	−0.07	0.09	0.09	0.34	0.26	0.10
United Kingdom	0.21	0.18	0.16	0.04	0.09	0.09	0.16	0.23	0.24

The table reports the β_{5k} coefficients estimated in the first step through linear probability models (see the text for additional details). Models control for sex, foreign-born status, region, age, and year of survey

Table 5 Proportion of PhD holders and expenditure in R&D, by country-period cluster. *Source*: own elaboration on EU-LFS (proportion of PhD holders) and Eurostat (expenditure in R&D) data

	Proportion of PhD holders			Public spending on R&D		
	2009–12	2013–16	2017–20	2009–12	2013–16	2017–20
Austria	1.54	1.15	1.19	2.73	3.05	3.12
Belgium	0.60	0.69	0.69	2.13	2.41	3.04
Switzerland	3.29	3.69	4.12	2.85	3.04	3.09
Czech Republic	0.39	0.45	0.65	1.48	1.86	1.90
Germany	1.48	1.52	1.65	2.79	2.90	3.12
Denmark	0.69	1.03	1.37	2.97	3.01	2.94
Estonia	0.27	0.53	0.89	1.85	1.47	1.53
Spain	0.73	0.78	0.92	1.34	1.23	1.28
Finland	1.27	1.44	1.67	3.61	3.00	2.80
France	0.77	0.73	0.86	2.20	2.24	2.24
Greece	0.32	0.47	0.58	0.66	0.91	1.28
Hungary	0.35	0.43	0.39	1.17	1.31	1.48
Ireland	0.66	0.80	1.24	1.58	1.36	1.22
Italy	0.21	0.35	0.49	1.22	1.34	1.45
Lithuania	0.32	0.45	0.58	0.85	0.97	1.00
Luxembourg	2.19	1.80	2.05	1.41	1.24	1.18
Netherlands	0.59	0.84	1.09	1.79	2.16	2.20
Portugal	1.18	0.87	0.75	1.49	1.28	1.42
Slovak Republic	0.33	0.47	0.61	0.63	0.91	0.87
United Kingdom	1.12	1.16	1.23	1.63	1.63	1.69

Table 6 Predicted occupational outcomes of PhD holders, proportion of PhD holders and R&D expenditures. Weighted least squares regressions. Beta coefficients and standard errors clustered by country. *Source*: Own elaboration of EU-LFS data (2009–2020)

	Model 1		Model 2		Model 3	
	Beta	SE	Beta	SE	Beta	SE
	Academic upper class					
Proportion of PhD holders	−0.06***	(0.01)			−0.04***	(0.01)
Spending on R&D			−0.10***	(0.02)	−0.06	(0.02)
Constant	0.27***	(0.03)	0.36***	(0.04)	0.35***	(0.04)
Observations	52		52		52	
R-squared	0.52		0.53		0.66	
	Non-academic upper class					
Proportion of PhD holders	0.07***	(0.02)			0.04***	(0.01)
Spending on R&D			0.09***	(0.02)	0.05*	(0.03)
Constant	0.63***	(0.03)	0.56***	(0.04)	−0.57***	(0.04)
Observations	52		52		52	
R-squared	0.48		0.43		0.57	
	Income					
Proportion of PhD holders	−0.01	(0.01)			−0.01	(0.01)
Spending on R&D			0.02	(0.03)	−0.01	(0.04)
Constant	0.84***	(0.04)	0.85***	(0.07)	0.85***	(0.07)
Observations	52		52		52	
R-squared	0.02		0.03		0.03	

*** $p<0.01$; ** $p<0.05$; * $p<0.10$

Table 7 PhD premium, proportion of PhD holders and R&D expenditures: non-STEM fields of study. Weighted least squares regressions. Beta coefficients and standard errors clustered by country. *Source*: Own elaboration of EU-LFS data (2009–2020)

	Model 1		Model 2		Model 3	
	δ_k	σ_k	δ_k	σ_k	δ_k	σ_k
	Academic upper class					
Proportion of PhD holders	−0.07***	(0.01)			−0.07***	(0.02)
Spending on R&D			−0.05*	(0.02)	−0.01	(0.02)
Constant	0.36***	(0.03)	0.31***	(0.04)	0.37***	(0.03)
Observations	20		20		20	
R-squared	0.61		0.16		0.61	
	Nonacademic upper class					
Proportion of PhD holders	0.04**	(0.02)			0.04*	(0.02)
Spending on R&D			0.01	(0.02)	−0.01	(0.03)
Constant	−0.03	(0.03)	0.00	(0.03)	−0.03	(0.03)
Observations	20		20		20	
R-squared	0.24		0.02		0.24	
	Income					
Proportion of PhD holders	−0.01	(0.02)			−0.01	(0.01)
Spending on R&D			−0.03**	(0.01)	−0.03*	(0.01)
Constant	0.19***	(0.02)	0.21***	(0.02)	0.23***	(0.02)
Observations	20		20		20	
R-squared	0.08		0.22		0.25	

*** $p<0.01$; ** $p<0.05$; * $p<0.10$

Table 8 PhD premium, proportion of PhD holders and R&D expenditures: STEM fields of study. Weighted least squares regressions. Beta coefficients and standard errors clustered by country. *Source*: Own elaboration of EU-LFS data (2009–2020)

	Model 1		Model 2		Model 3	
	δ_k	σ_k	δ_k	σ_k	δ_k	σ_k
	Academic upper class					
Proportion of PhD holders	−0.04***	(0.00)			−0.03***	(0.01)
Spending on R&D			−0.10***	(0.03)	−0.02	(0.03)
Constant	0.25***	(0.03)	0.28***	(0.05)	0.27***	(0.04)
Observations	20		20		20	
R-squared	0.78		0.53		0.79	
	Nonacademic upper class					
Proportion of PhD holders	0.04***	(0.01)			0.03**	(0.01)
Spending on R&D			0.11***	(0.02)	0.06*	(0.04)
Constant	0.01	(0.03)	−0.04	(0.04)	−0.04	(0.04)
Observations	20		20		20	
R-squared	0.59		0.57		0.68	
	Income					
Proportion of PhD holders	0.00	(0.01)			−0.02*	(0.01)
Spending on R&D			0.04*	(0.02)	0.07**	(0.03)
Constant	0.20***	(0.04)	0.14***	(0.03)	0.15***	(0.03)
Observations	20		20		20	
R-squared	0.00		0.24		0.41	

*** $p<0.01$; ** $p<0.05$; * $p<0.10$

Table 9 PhD premium and proportion of PhD holders. Weighted least squares regressions with country fixed effects. Beta coefficients and standard errors clustered by country. *Source*: Own elaboration of EU-LFS data (2009–2020)

	Model 1		M1 + country FE (M2)		M2 + Spending on R&D (M3)	
	δ_k	σ_k	δ_k	σ_k	δ_k	σ_k
Academic	−0.06***	(0.01)	−0.01	(0.02)	−0.01	(0.02)
Nonacademic	0.07***	(0.02)	−0.03	(0.03)	−0.03	(0.03)
Income	0.00	(0.01)	−0.03	(0.02)	−0.03	(0.02)

*** $p<0.01$; ** $p<0.05$; * $p<0.10$

model 1 presents the gross association between the proportion of PhD holders and the PhD premium; model 2 controls for country fixed effects; model 3 adds the public R&D expenditures

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