



The expansion of doctoral education and the changing nature and purpose of the doctorate

Cláudia S. Sarrico^{1,2}

Accepted: 12 September 2022
© The Author(s) 2022

Abstract

Doctorate level attainment has increased significantly in developed economies. In 2019, the average share of 25–64-year-olds with a doctorate across the OECD was around 1%. However, if current trends continue, 2.3% of today’s young adults will enter doctoral studies at some point in their life. This essay starts by describing the expansion of doctoral education. It then reflects on the causes of this growth and the consequences for the nature and purpose of the doctorate. This reflection is mostly based on published research in *Higher Education* in the last 50 years and the author’s work on policy analysis for the OECD on this topic. The paper finishes with a research agenda on doctoral education and the career of doctorate holders.

Keywords Doctorate · Doctoral education · Postdoctoral training · Predoctoral · Permadoct · Academic career

Introduction

Doctorate level attainment has increased significantly in developed economies. In 2019, the average share of 25–64-year-olds with a doctorate across the OECD was around 1%. However, if current trends continue, it is estimated that 2.3% of today’s young adults will enter doctoral studies at some point in their life (OECD, 2019b). This growth in doctoral level attainment has been poorly recorded and the careers of doctorate holders are not systematically tracked in most countries (graduate tracking, where it exists tends to relate to bachelor and sometimes master’s graduates, where numbers are much higher). This essay seeks to open the doorway on research into why this expansion is taking place, and what it means for all involved.

Talk about a “PhD glut” is not new. The topic was already featured in *Higher Education* four decades ago, in a 1982 article discussing labour market outcomes, the quality of doctoral candidates and the cost–benefit analysis of the production of more doctorate holders (Zumeta, 1982). Since then, concerns of an expansion in doctorate holders have not

✉ Cláudia S. Sarrico
c.s.sarrico@eeg.uminho.pt

¹ School of Economics and Management, University of Minho, Braga, Portugal

² Centre for Research in Higher Education Policies, Porto, Portugal

dampened growth. Demands of the knowledge economy, economic growth and innovation are frequently cited as encouraging expansion, which are bolstered by government financial incentives for universities to award doctorates and produce publications. The continued trend of expansion has fed discussion on the benefits and effects of the doctorate for the individual, organisations and society (Halse and Mowbray, 2011).

The status of the doctorate today is the motivation for this reflective essay, which is grounded in the literature published in *Higher Education* in the last 50 years (approximately 60 articles were read on the topic in the journal for the present paper). This historical perspective is complemented by other relevant literature in the field of higher education studies (circa other 60 references were read), and the author's participation in policy analysis regarding doctoral education, postdoctoral training and the career of doctorate holders. It analyses the reasons for the growth in doctoral level attainment and the implications of this growth. It discusses the drivers of the growth, at individual, institutional and system level. It focuses on high-level and general trends, even though we are aware of national specificities and contexts, heterogeneity in academic systems and labour markets for doctorate holders, which often mean that individual jurisdictions, and indeed some disciplines, may somewhat diverge from what is being described. The article follows from the examples of contributions to understanding the expansion of higher education from Martin Trow's (1973) discussion of the transition from elite to mass higher education, to Simon Marginson's (2016) reflection on high-participation systems of higher education (Cantwell et al., 2018).

This work focuses on the developed economies of the OECD, where doctoral education is more established. Higher education has expanded massively, but research activity (as measured by publications in indexed peer-review journals) has been, for a long time, very much concentrated in the developed economies. Of the more than 18,500 higher education institutions listed by the International Association of Universities, less than 10% of institutions had at least 50 publications indexed in Scopus, the largest bibliometric database, in the period 2007–2010. Of this small group, 82% were based in European and North-American universities, and 18% in Asia–Pacific (Sarrico & Godonoga, 2021), almost all based in OECD countries. The situation has changed significantly in more recent years, with diversification of research capacity to more countries and a growing multi-polarity of that capacity, with the notable rise of China (Marginson, 2022). The CWTS Leiden University Ranking 2022 includes 1318 universities from 69 countries with at least 800 Web of Science indexed publications in the period 2017–2020.¹ Nonetheless, this reflection focuses on the systems with longer established doctoral education and higher doctoral level attainment among the population.

In the conclusions, this paper offers a research agenda regarding doctoral education, postdoctoral training and the career of doctorate holders.

The expansion of doctoral education

Doctoral graduates have the highest educational attainment and are primarily trained to conduct research. Doctoral education in the International Standard Classification of Education (ISCED) is defined as an advanced research qualification, resulting from advanced

¹ CWTS Leiden Ranking provides bibliometric indicators on over 1,300 universities worldwide, <https://www.leidenranking.com/> (accessed 22 August 2022).

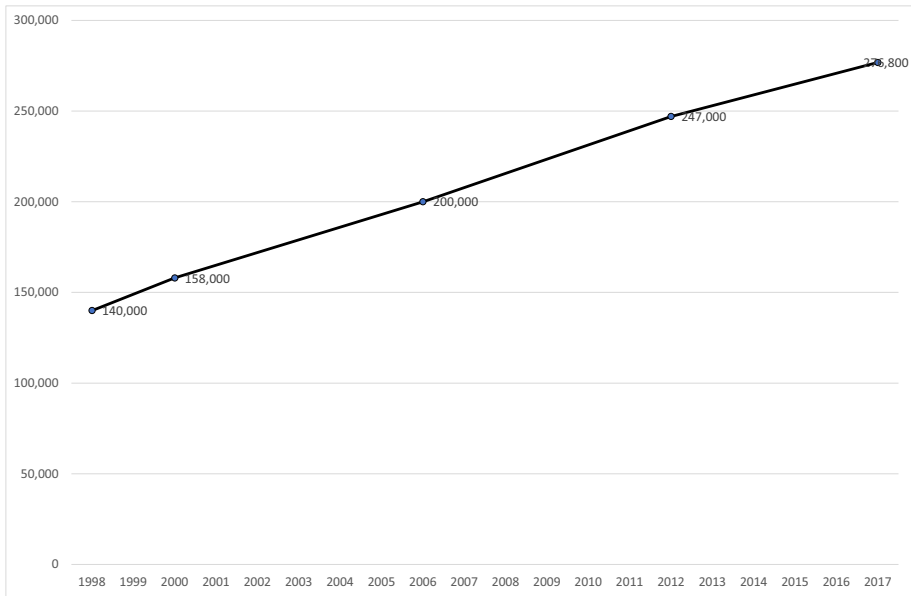


Fig. 1 New doctorates awarded, OECD countries. Source: Auriol (2010), Auriol et al. (2013), OECD (2014), OECD (2019b)

study and original research typically offered by research-oriented universities, in both academic and professional fields, requiring the submission of work of publishable quality that is the product of original research and represents a significant contribution to knowledge in a field of study (OECD/Eurostat/UNESCO, 2015).²

Statistics on doctoral level attainment presented by the World Bank data bank³ start only in 2010. No information is available for many countries (e.g. China) and for other countries many years of data are missing (e.g. UK, Germany, France, Japan). Looking at this data set shows that in 2020 there were only 36 countries with doctoral level attainment above 0.6%, including only a few non-OECD countries (United Arab Emirates, Saudi Arabia, Jordan, Malta, South Africa).

There is also no good international comparable data on the number of new doctorates being awarded in different countries. Only 5 years' information is available for OECD countries, showing that the number of new doctorates has almost doubled in the two decades to 2017 (Fig. 1). Recent work underlines this growth, finding that doctoral level attainment in the OECD has increased by 25% over the 5-year period 2014–2019 (OECD, 2021a). By comparison, research activity, a traditional occupation for doctorate holders, has grown much more slowly. Gross domestic spending on R&D, carried out by

² This definition includes doctorates referred by different terms, such as PhD, DPhil, D.Lit, D.Sc and LL.D, with a significant component of original research work, but it excludes professional practice qualifications which include the word “doctor”, such a M.D. (medical doctor) and J.D. (juris doctor), which are graduate-entry professional degrees with no substantive original research work.

³ The World Bank's DataBank is an analysis and visualisation tool that contains collections of time series data on a variety of topics, including higher education, <https://databank.worldbank.org> (accessed 7 July 2022).

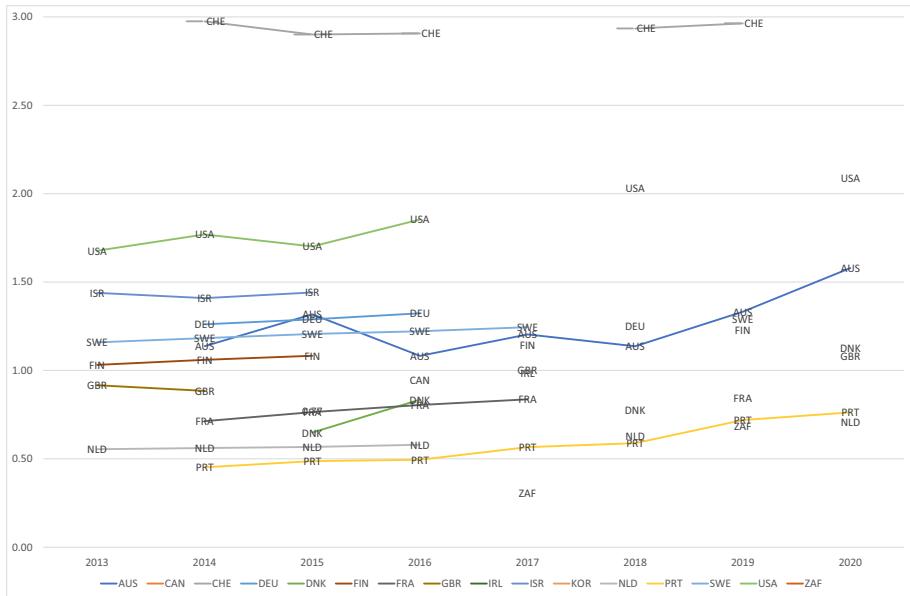


Fig. 2 Doctoral level attainment, selected countries. Source: UNESCO Institute for Statistics (uis.unesco.org). Data as of June 2022. The percentage of population ages 25 and over that attained or completed doctoral or equivalent education. <https://databank.worldbank.org/> (accessed 6 July 2022). Note: AUS, Australia; CAN, Canada; CHE, Switzerland; DEU, Germany; DNK, Denmark; FRA, France; GBR, United Kingdom; IRL, Ireland; KOR, Korea; NLD, Netherlands; PRT, Portugal; SWE, Sweden; USA, United States; ZAF, South Africa

companies, research institutes, university and government laboratories grew by 18% in the last two decades (2000–2020) (OECD, 2022b). This probably means there is not enough research activity in the economy to provide research occupations for many of the doctorate graduates being produced.

The recent growth in doctorate level attainment in the OECD is well above that of tertiary education attainment: between 2014 and 2019, doctoral education grew 25% (0.93–1.16%), while tertiary education grew 12.7% (33.65–37.90%) (OECD, 2022a). Data for countries outside the OECD is difficult to obtain, and even for the OECD there are many gaps (e.g. Japan). For instance, World Bank statistics on doctorates start in 2010 and omit many countries and many years (Fig. 2).

According to the US National Science Foundation, between 2000 and 2018, the number of science and engineering doctoral degrees awarded grew on average by 9.9% per year in China, 2.0% in France, 1.4% in Germany, 5.2% in Korea, 7.1% in Spain, 5.0% in the UK and 2.8% in the USA (NSB-NSF 2022, Fig. 5, p. 8).

The doctorate is no longer an entry ticket to academia

The expansion of doctoral education seems likely to continue as governments increase funding for doctoral education in an attempt to boost competitiveness and talent pools in an internationally competitive environment. However, there are attempts to diversify away from traditional “academic doctorates” with “collaborative PhDs”, “professional

doctorates”, “industrial doctorates”, or simply introducing professional development and career development opportunities. In addition, the scope of doctoral education is widening, seeking to prepare people for diverse careers and include doctorates that cross disciplinary boundaries (Powell and Green, 2007, p. 238).

Academia can no longer employ increasing numbers of doctorate holders (OECD, 2021b). It is unclear to what extent the labour market, especially beyond academia, is absorbing recent doctoral graduates, and how well doctoral education and postdoctoral training adequately prepare people for jobs outside academia. The debate about an “oversupply of PhDs” has reached mainstream media (The Economist, 2010).

New graduates surpass demand for academics at universities. A grim picture emerges of early-career academics as “cheap labour” in a “feudal system”, resting on the principles of “up or out” and “survival of the fittest” (OECD, 2021b). Using doctoral and postdoctoral researchers to teach undergraduates also reduces the number of full-time permanent positions. Even countries with less developed higher education systems seem to have plateaued in their capacity to absorb new doctorates into permanent positions (e.g. South Africa in Mouton et al., 2021, pp. xxiv-xxvi).

The postdoc, here defined as a fixed-term position in academia after the doctorate with no guarantee of continuation, has been the norm in many systems where permanent positions have been extremely limited (e.g. Germany and Switzerland). In other systems, entering a tenure-track with some prospect of continuation was the initial step in the academic ladder, but this has been changing over time (e.g. USA). Nonetheless, postdocs now perform a large part of university research work in many OECD academic systems, and, in some areas, the postdoc has become a de facto prerequisite to be considered for a permanent full-time job. Doctoral and postdoctoral researchers boost the research capacity of their universities and countries, but when they cannot find a job in academia, they may have difficulty transitioning to jobs outside the academic career. In some areas, the financial return on a PhD is now negative or not much different from a master’s degree, which can be attained in a fraction of the time. When controlling for self-selection into doctoral education and labour market choices after graduation, the wage premium reduces (Pedersen, 2016). Master’s holders accrue work experience while the doctoral researchers are pursuing their studies, increasing their relative value in the labour market. Doctorate holders may then occupy positions that only require a master’s, due to oversupply relative to the needs of the labour market, resulting in over skilling. Questions are then raised about the continuing investment in more doctoral education.

However, we know little of the career paths of doctorate holders, when and how they transition from academia to employment, and how useful their doctoral education is to their career and their life. Some may find their training so specialised that they find it difficult to find suitable work outside academia and linger there on fixed-term contracts. Some may pursue a doctorate simply for education’s sake, and enjoy the lifestyle, but in the long run they may become less satisfied, less productive and more likely to have to move to jobs beyond academia for which they had not planned.

There is a belief that there are spill over effects from knowledge being produced in universities. Nonetheless, for the individual it may not work well. People embarking on PhDs are likely to have been the best in their class, raising the question of whether a PhD is always the best use their talent. It may also be the case that the best are no longer attracted by the idea of doing a PhD, as they realise the precarity involved.

The incentives for universities and principal investigators (PIs) are not aligned with the interests of doctoral and postdoctoral researchers, who support the research endeavour and are key to keeping it going. And many governments offer funding incentives and rewards linked to performance, where the number of PhD graduates is part of the formula.

In most OECD countries, the majority of doctorate holders already work outside academia (OECD, 2015), and many countries have moved to a more structured environment of doctoral programmes and doctoral schools where they can offer training in skills that can be transferred to the labour market beyond academia, smoothing the transition.

The expansion of doctoral education was accompanied by changes in its nature, from an apprenticeship-type period under the supervision of a “master” to a highly structured education programme in most countries, with doctoral schools, formal processes, and a defined duration and expectations. Paradoxically, it has been accompanied by an increasingly unstructured phase of postdoctoral studies in the academic professional ladder—postdoctoral researchers are in a limbo: neither staff nor students (OECD, 2021b), and in some fields preceded by a pre-doctoral programme of 1 to 2 years prior to entry into the doctoral programme itself. The postdoctorate position now seems to be the “apprenticeship” stage under the supervision of a senior academic, and sits between completion of the doctorate and a permanent position. A postdoctoral position was meant to be transitional and a “defined period of advanced training and mentoring in research” (National Academy of Sciences, National Academy of Engineering, and Institute of Medicine, 2014); instead, it became a safety net for those waiting for an academic position that is more likely than not to fail to materialise (Larson et al. (2013), Milojević et al. (2018)). Institutions tend to rest their research prowess on a few tenured star researchers that head teams populated by postdoctoral and doctoral researchers (and predoctoral researchers) that feed the research endeavour. They now depend on the “permacos” and the labour of an academic precariat to sustain it (Teixeira, 2017). Although many are on fixed-term contracts, they are a significant share of the research labour force, their papers obtain more citations, and they tend to publish in more prestigious journals than those on indefinite contracts (OECD, 2021b).

This means that doctoral education and postdoctoral training is no longer necessarily a path to the professoriate. Most doctorate holders will end up working beyond academia, in business, government or the social sector—some in research occupations, although many will not. The vast majority of researchers with a doctorate in the OECD work in the higher education and the government sectors. Since in many countries, most doctorate holders work outside the academic sector, this indicates that many employed doctorate holders are not doing research.⁴

The lack of positions in the academic career proper has not stopped the expansion, and many countries continue to provide incentives to universities to produce doctoral graduates and individuals to pursue doctoral studies. Under the EC-OECD STIP Compass,⁵ countries mostly cite funding levers as the mechanism to increase doctoral and postdoctoral participation.

This is accompanied by a discourse that society and the economy need the advanced skills of these individuals to sustain a knowledge economy and spur innovation, and that the doctorate ought to prepare individuals for diverse careers. Employment rates of doctorate holders are systematically higher than among other tertiary level graduates in the working age population (OECD, 2015), but for young doctorate holders, those aged 25–34, their comparative advantage over their peers with a master’s degree tends to be more variable (OECD, 2019b).

In addition, many doctorate graduates are not particularly young—the median age at entry is 29 on average across OECD countries (OECD, 2019b). After a prolonged

⁴ See R&D personnel by sector of employment and qualification in the OECD Research and Development Statistics (<http://oe.cd/rds>), and distribution of doctorate holders by economic activity in the OECD work on careers of doctorate holders (<http://oe.cd/cdh>).

⁵ STIP Compass is a joint initiative of the European Commission (EC) and the OECD that aims to collect in one place qualitative and quantitative data on national trends in science, technology and innovation (STI) policy, <https://stip.oecd.org/stip/> (accessed 7 July 2022) The statement here refers to the answer to the question on policies supporting doctoral education.

postdoctoral period in academia, many transition to employment beyond academia well into their forties, which has implications for how easy the transition will be.

The supply side strategies from governments to promote the production of doctorate holders are often not in line with demand from employment sectors beyond academia, and with the experiences of doctorate holders. Many doctorate holders that transition to employment beyond academia will not work as researchers. From a macro level, this raises the issue of inefficiency: the advanced skills of doctorate holders are not necessarily used, notably in non-research occupations (Stephan, 2012). It compounds the inefficiency already observed in many countries during doctoral studies, where entry rates are well above graduation rates.

For the individual, while many doctorate holders will find successful and satisfying alternative careers, they often report challenges in making the transition associated with giving up long-held ambitions of an academic career and a loss of social identity (Vitae, 2016). Career choices beyond academic research are mostly seen as second options, or as a signal of failure by postdoctoral researchers and their PIs and are often made quite late into the professional career of doctorate holders. Those that do transition may experience organisational culture shock, especially those who enter jobs beyond academia directly after the PhD with little or no prior work experience (Skakni et al., 2022).

Reasons for the growth of doctoral education

There are several explanations for the growth in doctoral education. Supply side factors relate to factors that encourage the supply of more doctorate graduates, such as policies to fund doctoral education, and reward institutions for increased production of doctorates and publications. Demand side factors increase the demand for doctorates and represent the attractiveness of doctoral education to the individual, such as the perceived career prospects, social gain or self-realisation, and to the organisations employing doctorate holders because they value their expertise and skills. Another driver is the international import of talent in a global race for competitiveness among economies.

Government policy

Governments, especially in developed economies, have embraced economic theories of the knowledge economy, targeting knowledge as fundamental to economic growth and prosperity. They have promoted postgraduate study, doctoral education and postdoctoral training to foment the development of advanced skills, knowledge generation, complex problem solving and, more generally, innovation. Research funders increasingly try to assess and incentivise the research impact of the research they fund, in terms of scientific impact, but also economic, social, cultural and environmental impact.

Funders have realised that the increased number of doctorates means they no longer will find a position in academia. Hence, policies now encourage doctoral and postdoctoral researchers to engage in some form with organisations beyond academia to encourage the next generation of researchers to explore diverse careers in other sectors (OECD, 2021b). There is evidence, however that most continue to prefer an academic career, an attraction that often increases as students advance in their programme, even when it involves industrial contacts (Gemme & Gingras, 2012).

An unintended consequence of increasing the supply of research funding may be to support the aspiration to an academic career, albeit a precarious one, given the fixed-term, project-based nature of most research funding, including for those with less scientific capital and less job prospects elsewhere.

Changes in academic work

In addition to an increase supply of research funding, the nature of that funding has also changed. There is an increasing share of project-based funding relative to core basic funding, and the development of earned income streams, in addition to public appropriations and student fees, from continuing education, service provision, contract research, philanthropy and endowments. This changed academic work (Cantwell, 2011; Cantwell & Taylor, 2015), with increasing use of non-standard employment contracts and specialisation of work in both teaching and research. It gave rise to contingent instructors and postdoctoral researchers mostly dependent on fixed-term funding, to the detriment of combined teaching and research positions in the academic career proper. The expansion of doctoral education ensures a constant supply for these positions.

Demand for doctoral researchers

Even if an academic career has not become more attractive per se, given the general expansion of higher education at bachelor and master's levels, the number of potential doctoral candidates has substantially increased. Most students pursuing a doctoral degree have a "taste for science" and are strongly attracted to an academic career, but not all (Roach & Sauermann, 2010). Curiously even those that had considered an alternative career often change their minds as their studies progress (Gemme and Gingras, 2012).

In some cases, doctoral education is also valued beyond academia. Employers of doctorate holders seem to value the technical competence of those from the hard sciences and the transferable competences from the soft sciences (Passaretta et al., 2019). Unemployment is generally lower for doctorate holders compared with other higher education graduates (Auriol et al., 2013). However, we do not know how much of this is the consequence of their doctoral education, and how much is related to their intrinsic ability to learn and work.

We know little about the companies that employ doctorate holders, but some evidence suggests that cooperation between universities and the world of business fosters the recruitment of doctorate holders, and that the effect is cumulative (Garcia-Quevedo et al., 2012). This suggests that fostering mobility of people and cooperation in research activities between universities and business will increase the demand for doctorate holders. However, the willingness to recruit PhDs is related to the degree of development of the economy, and especially to the R&D and technology intensity of businesses. This also explains the brain drain from less to more developed countries, as people move from less to more knowledge intensive economies.

Credentialism

Arguably, some individuals may be also searching for differentiation in a crowded graduate market in high-participation systems of higher education (Zusman, 2017). This form of credentialism is probably at play in some professional disciplines, such as business, public administration and health, where mid-career professionals may be using the doctorate to improve their professional status, autonomy and income rather than to respond to labour market needs or increased complexity of their jobs. Indeed, it may be also occurring in the higher education sector among other professional staff supporting students or involved in the management and administration of institutions, and operating in hybrid roles between academia and other professions. Some of these new doctorates are not compliant with

existing definitions, such as the ISCED classification mentioned above, and may not be recognised as such by some organisations (see footnote 2 of this article and footnote 3 of Zusman, 2017, regarding recognition by the National Science Foundation in the USA).

Import of international talent

On average across OECD countries, 22% of enrolled doctoral students are international or foreign students, compared to 13% at master's level and 4% at bachelor's (OECD, 2019b). Doctorate holders are highly mobile and the labour market for them is globalised (Auriol, 2010), although mobility varies by discipline. Many countries deliver their doctorates (and increasingly their master's) in English, although concerns about the role of minority languages are being raised in some countries, such as the Netherlands, Finland and Denmark (Powell and Green, 2007, p. 240).

There are also issues of brain drain from poorer to richer countries, and many early-career researchers must be prepared to move to enter the academic profession. Some countries, such as the USA, rely on importing talent to feed their academic system. Migrating academics seek out better conditions in terms of salaries, quality of life, career perspectives, research organisation, balance between teaching and research, funding, and being among high-quality peers (Janger et al., 2019). The best, "star performers" seek the most reputable and prestigious institutions, others move to simply look for an occupation they cannot find in their home countries (Cattaneo et al., 2019).

Some early career researchers are indeed encouraged to have international mobility as a requisite or to improve their chances for a job in their home country (Musselin, 2004), although if the return is not timely reintegration can be difficult because of a loss of social capital in their home country (Cañibano et al., 2020).

Less developed countries like India and especially China are transitioning from being exporters of students to becoming competitors of European, North American and Australian higher education systems. It is also important to note that new doctorate holders are needed to improve the qualifications of academic staff in many systems in the developing world, where the production of doctorates has not been able to keep pace with the enrolment expansion of recent decades (Altbach et al, 2012, p. 18).

Consequences of the growth of doctoral education

The permadoc phenomenon

Postdoctoral training has benefits: it fosters research productivity and integration in the international scholarly community (Horta, 2009), while positively contributing to the possibility of working in a higher education institution and securing a tenure-track appointment. However, while taking one postdoctoral position does increase research productivity, there is little or no advantage from taking two or more (Yang and Webber, 2015).

Slower progression within academic careers has become more common in younger cohorts of academics, characterised by a long pre-tenure phase, with many still occupying postdoctoral positions in their forties. In some cases, this long path is even experienced by those that are recruited as assistant professors, where they may remain for most of their careers (Benz et al., 2021). Paradoxically, in many countries mobility from the business sector to the higher education sector is higher than the other way around (Auriol et al., 2013).

The emergence of the academic precariat

The early stages of the academic career are characterised by insecurity and have been so for some time now (Rosenblum & Rosenblum, 1996). Those outside of the career proper, on fixed-term contracts, have provided most of the instruction, and most of the research, in many systems, with no guarantee of continuing employment. The difference is that younger cohorts of academics are now faring less well in transitioning from the external to the internal labour market. Those that manage to make the transition need to be geographically mobile, self-confident and devote a high proportion of their time and effort to research and networking (Ortlieb & Weiss, 2018). However, not all institutions assist early-career academics with contacting colleagues abroad, provide financial support for conferences and stays abroad, and provide support with family commitments for them to be able to succeed.

Precarity also raises issues of equity, diversity and inclusion. It has been found that academics who come from the upper social class have access to higher-quality undergraduate education, subsequently progress to more prestigious research universities for doctoral education, and later report higher earnings (Chiappa & Perez Mejias, 2019). In addition, they can better afford the precarity associated with academia, especially in its early stages (OECD, 2021b).

In doctoral education, as in academic employment, women are now on a parity in most fields. At the same time, women are less represented in fields that may offer more opportunities outside academia, such as engineering, manufacturing and construction, are less internationally mobile, and more often work part-time, which may hinder their prospects for advancement in the academic career. Women are also under-represented in tenure track positions, particularly when recruitment is based on invitation. All these factors may explain why women and minority groups tend to be more vulnerable to precarity (OECD, 2021b).

To find a position, postdoctoral researchers often need to be prepared to move within and increasingly beyond their countries. This may be beneficial for the scientific endeavour, as less mobile academics have more inward oriented information exchange dynamics and lower scientific productivity (Horta, 2013), but it often signifies a personal toll. It often means losing the social networks necessary to access positions back home, and conditions for international researchers are often worse, in relation to access to employment contracts, right to stay and welfare benefits. It may also mean having to postpone family formation.

Academia may no longer be attractive to the most talented

The poor career prospects of academia do not cause a shortage of academic researchers, but may push the most talented to jobs beyond academia (Waaiker, 2017). Doctorate holders working in research are particularly satisfied with the intellectual challenges of the job (Auriol et al., 2013). However, younger doctorate holders in higher education are about 2.5 times less likely to be employed on a permanent basis than those working in other sectors (OECD, 2019a, p. 186). While temporary positions are increasingly common in academia, coinciding with the rise of postdoctoral positions, they are less so in business. Earnings also tend to be higher in the business sector, although there are exceptions in some disciplines (Auriol et al., 2013). Natural scientists and engineers are more likely to find employment in research outside academia, while social scientists find more opportunities in non-research occupations. Still, even when not in research, jobs are in most cases related to the subject of doctoral degrees and doctoral graduates tend to be satisfied with their employment situation (Auriol et al., 2013).

If academia is to attract and retain the best talent, funding agencies need to have dedicated provision for early career researchers, who otherwise leave for more stable and

promising careers beyond academia (Bazeley, 2003). And should countries continue to produce more doctorate holders than academia can possibly absorb, then it is important to broaden the job skills that doctoral students acquire during their training to better prepare them for the needs of a wider job market (Cattaneo et al., 2019).

Questions about the quality of doctoral education

Despite the growth in doctoral level attainment, the truth is that many doctoral candidates do not complete their degrees: looking at the OECD entry rate for those under 30 and the graduation rates for those under 35, an estimated 1 in 3 drop out.⁶ There are many reasons for withdrawal, including the personal situation of the candidate, but institutional factors are paramount. Institutional issues revolve around the difficulty in achieving work-life balance, and problems with socialisation, often due to a “culture of institutional neglect” (Castelló et al., 2017; McAlpine et al., 2012), as well as contact with the supervisor and exchange with other PhDs (Jaksztat et al., 2021). In addition, admission standards of doctoral programmes may not necessarily pursue high-quality doctoral students (Cattaneo et al., 2019).

The increase in doctorate level attainment does not necessarily mean that all attain what is planned in the definition of International Standard Classification of Education for doctoral level attainment (OECD/Eurostat/UNESCO Institute for Statistics, 2015) or the Dublin Descriptors (EHEA, 2005). The current level of doctoral education attainment in the population, at 1.0%, may not be matched by the level of advanced skills in the population. Less than 0.5% of the adult population in the OECD reaches the highest levels of literacy, i.e. 5 in a scale of 1 to 5, where 3 is considered the necessary level to operate in today’s society and assumed to be provided by upper secondary education (OECD, 2019c). Level 5 description of proficiency⁷ is arguably the closest to the description of outcomes achieved in doctoral level education in the Dublin Descriptors.⁸

Often, doctorate holders that find themselves in employment outside academia experience an over-development of research skills relative to what is required of the job, but an under-development in personal effectiveness, management and communication skills (Waijjer et al., 2017), which means they may be both over- and under-qualified. These

⁶ Entry and graduation rates represent an estimated percentage of an age group expected to enter or graduate, respectively, a certain level of education at least once in their lifetime. The OECD entry rate for those under 30 was 1.407% whereas graduation rate for those under 35 was only 1.074% for doctoral education in 2019. Data extracted on 25 Jul 2022 08:27 UTC (GMT) from OECD.Stat.

⁷ At this level, tasks may require the respondent to search for and integrate information across multiple, dense texts; construct syntheses of similar and contrasting ideas or points of view; or evaluate evidence-based arguments. Application and evaluation of logical and conceptual models of ideas may be required to accomplish tasks. Evaluating the reliability of evidentiary sources and selecting key information is frequently a requirement. Tasks often require respondents to be aware of subtle, rhetorical cues and to make high-level inferences or use specialised background knowledge.

⁸ Qualifications that signify completion of the third cycle are awarded to students who: have demonstrated a systematic understanding of a field of study and mastery of the skills and methods of research associated with that field; have demonstrated the ability to conceive, design, implement and adapt a substantial process of research with scholarly integrity; have made a contribution through original research that extends the frontier of knowledge by developing a substantial body of work, some of which merits national or international refereed publication; are capable of critical analysis, evaluation and synthesis of new and complex ideas; can communicate with their peers, the larger scholarly community and with society in general about their areas of expertise; can be expected to be able to promote, within academic and professional contexts, technological, social or cultural advancement in a knowledge-based society.

findings call for doctoral education to include not only the development of research skills but also skills in other areas relevant to the labour market. However, the premise that education should provide all the skills that the labour market requires is not universally supported. Employers are also responsible for training and developing the employees they recruit, and that responsibility should not be fully transferred from employers to the employee or education institutions (Cappelli, 2015).

The changing nature of doctoral education

As it has grown doctoral education has become more formalised, supervisory practice more regulated and the curriculum more explicitly structured. On the other hand, growth has also brought diversity of approaches to doctoral education, in response to evolving disciplinary practices, interactions with outside organisations and the career expectations of doctoral researchers (Pearson et al., 2008).

Following the crisis discourse that universities are producing too many doctorates for the few academic jobs available, the concerns with the efficiency of doctoral programmes have shifted to preoccupation with the lack of skills of doctorate holders for productive jobs beyond academia (Cuthbert & Molla, 2015; Kniola et al., 2012). This discourse presents the inevitable tension between outcomes of research prowess and the relevance of doctorates to the needs of society.

New cooperative doctoral programmes between academia and industry have emerged, which place new demands for both academia and industry, as it involves necessarily the interaction between different cultures, that need to be addressed, and that are different from other more traditional forms of knowledge transfer between academia and industry (Salminen-Karlsson & Wallgren, 2008). Preoccupation with the value of the doctorate to industry became common in all disciplines. In addition, doctoral researchers have also become more diverse. Many doctoral candidates are not in their twenties and have pre-existing professional experience, particularly in occupation-oriented disciplines, including in the Humanities, Arts and Social Sciences (HASS) (Bazeley, 2003). They see value in engaging with industry, within and beyond the private commercial sector (Barnacle et al., 2020). And in some systems, especially in applied disciplines, doctorate holders leave academia, gain professional experience, and convert that practical capital into a tenured position, or maintain parallel careers in both the corporate and academic worlds (Benz et al., 2021).

The calls to change doctoral education are not new (Pearson, 1996), and the professionalisation of doctoral education both for jobs in academia and beyond is now a perennial discussion. Enders (2005) describes the shifting paradigms for doctoral training away from the traditional so-called Humboldtian model towards the so-called professional model. On the one hand, some defend that the traditional discipline-based doctoral training is sufficiently comprehensive to accommodate the new needs of knowledge production, others that new modes of doctoral training are needed that cross discipline and organisational borders. Enders (2005) makes a compelling case that diversity of organisational and structural forms as well as different validation criteria and procedures will probably determine the future face of research training. Instead of a single role model, it would be more appropriate to recognise and value a multi-functional role of the PhD by a diversity of training approaches, i.e. one size fits all approach is not adequate.

Along the same lines Mills and James (2020) argue that doctoral collaborations with non-academic organisations (such as placements and internships, partnerships and knowledge exchange) have expanded from the hard sciences to become a feature in the social sciences as well. It does, however, raise important challenges regarding how the questioning

and critique characteristic of doctoral education is met through the learning opportunities of collaborative arrangements. How these challenges are addressed and made integral to doctoral education in the social sciences is not clear.

It is not just preparation for a career outside academia that is at stake. Even preparation for an academic career needs to be wider. Coates and Goedegebuure (2012) call for “apprentice academics” to have some training and experience in several functional areas, such as research, education, integration, application, and leadership and management to prepare them for academic work. Coates et al. (2020) even question the binary categorisation of research and professional doctorates, calling for a re-design of doctoral education to accommodate the growth and diversity of this offer that is preparing people for different career trajectories.

Gu et al. (2018) have also found that the career expectations of doctoral researchers change over time, are influenced by doctoral training in their university environment, their relationships with supervisors, and their experiences of collaboration with organisations outside academia. Doctoral researchers show dissatisfaction with doctoral training that does not encourage and prepare them for diverse career paths. As such, they also conclude that the goal of doctoral training should not only be the reproduction of “academic successors” but also the cultivation of “versatile experts”.

Conclusion and a research agenda on doctoral education

Enders (2005) points out that since we must train people for the world of research, we need to ask for what “research”, and since we must train people for the world of work outside academia and science as well, then for which job roles and career trajectories should we prepare them. To answer these questions, we need to study the career paths of doctorate holders.

There is a dearth of cross-country comparative data on doctorate holders and their career paths, even though some countries already have very good longitudinal data (e.g. Survey of Earned Doctorates in the USA). Some international comparable data has been produced by the OECD-Eurostat project on the career of doctorate holders. However, that project has been discontinued, and a specific module whose purpose was to gather data on the working conditions of those who are on temporary or short-term contracts, i.e. “post-doctorates” was never implemented (Auriol, 2012).

Universities ought to be more transparent from the beginning of doctoral education about the diverse career paths of their doctoral graduates, and that most will not secure an academic position. The integration of research-related work experience and placements outside academia, professional development, and training of supervisors, may reduce the stigma and difficulty of transitioning to diverse careers within and beyond academia (Hancock, 2019). However, it is also difficult to conceive that higher education ought to take full responsibility for developing the skills that employers of doctorate holders may want, instead of the latter contributing to the professional development of the employees they recruit (Cappelli, 2015).

From the reflections contained in this essay, several issues emerge that merit additional further research:

- What is the role of doctorate holders in the economy and society? Do they follow research careers, in what sectors of employment, in what fields of research?
- How many doctorates are needed? Do we have too many or too few doctorate holders?

- Why do people pursue doctoral education and postdoctoral training? What information do they possess about their job prospects, and how does that influence their career preferences?
- How to better support success in doctoral education? In what ways different academic career frameworks support the careers of doctorate holders within and beyond academia?
- What are the barriers and promoters of intersectoral mobility of doctorate holders? Why do doctorate holders chose a career in the higher education, of government, business enterprise or private non-profit sectors? Why do they stay or leave research? When do doctorate holders transition to employment beyond academia? How does the job relate to their doctoral degree?
- How to promote diversity, equity and inclusion in doctoral education and postdoctoral training?

Acknowledgements The author was involved in the OECD Global Science Forum’s projects *Reducing the Precarity of Academic Research Careers* and *Career Options for Doctoral and Postdoctoral Scientists* referenced in the text. However, the opinions expressed in this chapter are those of the author and do not necessarily reflect the views of the OECD or its members. The author would like to thank the editors-in-chief and a coordinating editor of *Higher Education* for useful constructive feedback on a previous version of this article.

Funding The author would like to acknowledge the support given by the Portuguese National Funding Agency for Science, Research and Technology (FCT), within the Centre for Research in Higher Education Policies (CIPES), project UIDB/00757/2020.

Data availability Not applicable.

Code availability Not applicable.

Declarations

Conflict of interest The author declares no competing interests.

Open Access This article is licensed under a Creative Commons Attribution 4.0 International License, which permits use, sharing, adaptation, distribution and reproduction in any medium or format, as long as you give appropriate credit to the original author(s) and the source, provide a link to the Creative Commons licence, and indicate if changes were made. The images or other third party material in this article are included in the article’s Creative Commons licence, unless indicated otherwise in a credit line to the material. If material is not included in the article’s Creative Commons licence and your intended use is not permitted by statutory regulation or exceeds the permitted use, you will need to obtain permission directly from the copyright holder. To view a copy of this licence, visit <http://creativecommons.org/licenses/by/4.0/>.

References

- Altbach, P. G., Reisberg, L., Yudkevich, M., Androushchak, G., & Pacheco, I. F. (Eds.). (2012). *Paying the professoriate*. Routledge.
- Auriol, L. (2010), "Careers of doctorate holders: Employment and mobility patterns", *OECD science, technology and industry working papers*, No. 2010/04, OECD Publishing, Paris. <https://doi.org/10.1787/5kmh8phxvfvf5-en>
- Auriol, L., M. Schaaper and B. Felix (2012), "Mapping careers and mobility of doctorate holders: Draft guidelines, model questionnaire and indicators – Third edition", *OECD science, technology and industry working papers*, No. 2012/07, OECD Publishing, Paris. <https://doi.org/10.1787/5k4dnq2h4n5c-en>
- Auriol, L., M. Misu and R. Freeman (2013), "Careers of doctorate holders: Analysis of labour market and mobility indicators", *OECD science, technology and industry working papers*, No. 2013/4, OECD Publishing, Paris. <https://doi.org/10.1787/5k43nxgs289w-en>

- Barnacle, R., Cuthbert, D., Schmidt, C., et al. (2020). Vectors of knowledge exchange: The value of industry engagement to HASS PhDs. *Higher Education*, 80, 973–987. <https://doi.org/10.1007/s10734-020-00528-z>
- Bazeley, P. (2003). Defining ‘early career’ in research. *Higher Education*, 45, 257–279. <https://doi.org/10.1023/A:1022698529612>
- Benz, P., Bühlmann, F., & Mach, A. (2021). The transformation of professors’ careers: Standardization, hybridization, and acceleration? *Higher Education*, 81, 967–985. <https://doi.org/10.1007/s10734-020-00590-7>
- Bryan, K. A. (2019). Young “stars” in economics: What they do and where they go. *Economic Inquiry*, 57(3), 1392–1407. <https://doi.org/10.1111/ecin.12762>
- Cañibano, C., D’Este, P., Otamendi, F. J., et al. (2020). Scientific careers and the mobility of European researchers: An analysis of international mobility by career stage. *Higher Education*, 80, 1175–1193. <https://doi.org/10.1007/s10734-020-00536-z>
- Cantwell, B., Marginson, S., & Smolentseva, A. (Eds.). (2018). *High participation systems of higher education*. Oxford University Press.
- Cantwell, B., & Taylor, B. J. (2015). Rise of the science and engineering postdoctorate and the restructuring of academic research. *The Journal of Higher Education*, 86(5), 667–696. <https://doi.org/10.1080/00221546.2015.11777379>
- Cantwell, B. (2011). Academic in-sourcing: International postdoctoral employment and new modes of academic production. *Journal of Higher Education Policy and Management*, 33(2), 101–114. <https://doi.org/10.1080/1360080X.2011.550032>
- Cappelli, P. H. (2015). Skill gaps, skill shortages, and skill mismatches: Evidence and arguments for the United States. *ILR Review*, 68(2), 251–290. <https://doi.org/10.1177/0019793914564961>
- Castelló, M., Pardo, M., Sala-Bubaré, A., et al. (2017). Why do students consider dropping out of doctoral degrees? *Institutional and Personal Factors*. *High Educ*, 74, 1053–1068. <https://doi.org/10.1007/s10734-016-0106-9>
- Cattaneo, M., Malighetti, P., & Paleari, S. (2019). The Italian brain drain: Cream and milk. *Higher Education*, 77, 603–622. <https://doi.org/10.1007/s10734-018-0292-8>
- Chiappa, R., & Perez Mejias, P. (2019). Unfolding the direct and indirect effects of social class of origin on faculty income. *Higher Education*, 78, 529–555. <https://doi.org/10.1007/s10734-019-0356-4>
- Coates, H., Croucher, G., Weerakkody, U., et al. (2020). An education design architecture for the future Australian doctorate. *Higher Education*, 79, 79–94. <https://doi.org/10.1007/s10734-019-00397-1>
- Coates, H., & Goedegebuure, L. (2012). Recasting the academic workforce: Why the attractiveness of the academic profession needs to be increased and eight possible strategies for how to go about this from an Australian perspective. *Higher Education*, 64, 875–889. <https://doi.org/10.1007/s10734-012-9534-3>
- Cuthbert, D., & Molla, T. (2015). PhD crisis discourse: A critical approach to the framing of the problem and some Australian ‘solutions.’ *Higher Education*, 69, 33–53. <https://doi.org/10.1007/s10734-014-9760-y>
- EHEA (2005) General report to the Bologna Follow-Up Group to the Conference of European Ministers Responsible for Higher Education - Bergen 19/20 May 2005. http://ehea.info/media.ehea.info/file/2005_Bergen/37/9/2005_Bergen_BFUG_Report_577379.pdf (accessed 24/01/2022).
- Enders, J. (2005). Border crossings: Research training, knowledge dissemination and the transformation of academic work. *Higher Education*, 49, 119–133. <https://doi.org/10.1007/s10734-004-2917-3>
- García-Quevedo, J., Mas-Verdú, F., & Polo-Otero, J. (2012). Which firms want PhDs? An analysis of the determinants of the demand. *Higher Education*, 63, 607–620. <https://doi.org/10.1007/s10734-011-9461-8>
- Gemme, B., & Gingras, Y. (2012). Academic careers for graduate students: A strong attractor in a changed environment. *Higher Education*, 63, 667–683. <https://doi.org/10.1007/s10734-011-9466-3>
- Gokhberg L., Shmatko N., Auriol L. (2016) Rethinking the doctoral degrees in the changing labor market context. In: Gokhberg L., Shmatko N., Auriol L. (eds) The science and technology labor force. Science, technology and innovation studies. Springer, Cham. https://doi.org/10.1007/978-3-319-27210-8_1
- Gu, J., Levin, J. S., & Luo, Y. (2018). Reproducing, “academic successors” or cultivating “versatile experts”: Influences of doctoral training on career expectations of Chinese PhD students. *Higher Education*, 76, 427–447. <https://doi.org/10.1007/s10734-017-0218-x>
- Halse, C., & Mowbray, S. (2011). The impact of the doctorate. *Studies in Higher Education*, 36(5), 513–525. <https://doi.org/10.1080/03075079.2011.594590>
- Hancock, S. (2019). A future in the knowledge economy? Analysing the career strategies of doctoral scientists through the principles of game theory. *Higher Education*, 78, 33–49. <https://doi.org/10.1007/s10734-018-0329-z>

- Horta, H. (2013). Deepening our understanding of academic inbreeding effects on research information exchange and scientific output: New insights for academic based research. *Higher Education*, 65, 487–510. <https://doi.org/10.1007/s10734-012-9559-7>
- Horta, H. (2009). Holding a postdoctoral position before becoming a faculty member: Does it bring benefits for the scholarly enterprise? *Higher Education*, 58, 689–721. <https://doi.org/10.1007/s10734-009-9221-1>
- Jaksztat, S., Neugebauer, M., & Brandt, G. (2021). Back out or hang on? An event history analysis of withdrawal from doctoral education in Germany. *Higher Education*, 82, 937–958. <https://doi.org/10.1007/s10734-021-00683-x>
- Janger, J., Campbell, D. F. J., & Strauss, A. (2019). Attractiveness of jobs in academia: A cross-country perspective. *Higher Education*, 78, 991–1010. <https://doi.org/10.1007/s10734-019-00383-7>
- Kniola, D., Chang, M., & Olsen, D. (2012). Transformative graduate education programs: An analysis of impact on STEM and non-STEM Ph.D. completion. *High Educ*, 63, 473–495. <https://doi.org/10.1007/s10734-011-9453-8>
- Larson, R., Ghaffarzadegan, N., & Xue, Y. (2013). Too many PhD graduates or too few academic job openings: The basic reproductive number R_0 in academia. *Systems Research and Behavioral Science*, 31(6), 745–750. <https://doi.org/10.1002/sres.2210>
- Marginson, S. (2016). High participation systems of higher education. *The Journal of Higher Education*, 87(2), 243–271. <https://doi.org/10.1080/00221546.2016.11777401>
- Marginson, S. (2022). Global science and national comparisons: Beyond bibliometrics and scientometrics. *Comparative Education*, 58(2), 125–146. <https://doi.org/10.1080/03050068.2021.1981725>
- McAlpine, L., Paulson, J., Gonsalves, A., & Jazvac-Martek, M. (2012). ‘Untold’ doctoral stories: Can we move beyond cultural narratives of neglect? *Higher Education Research & Development*, 31(4), 511–523. <https://doi.org/10.1080/07294360.2011.559999>
- Mills, D., & James, D. (2020). Reconceptualising organisational collaborations in social science doctoral education. *Higher Education*, 79, 791–809. <https://doi.org/10.1007/s10734-019-00438-9>
- Milojević, S., Radicchi, F., & Walsh, J. (2018). Changing demographics of scientific careers: The rise of the temporary workforce. *Proceedings of the National Academy of Sciences*, 115(50), 12616–12623. <https://doi.org/10.1073/pnas.1800478115>
- Mouton, J., van Lill, M., Prozesky, H., Bailey, T., Duncan, M., Boshoff, N., Albertyn, C. & Treptow, R. 2021. *A national tracer study of doctoral graduates in South Africa*. Report to the Water Research Commission. DSI-NRF Centre of Excellence in Scientometrics and Science, Technology and Innovation Policy. Project No. 2019/2020–00288. <https://www.wrc.org.za/wp-content/uploads/mdocs/3006%20final.pdf>.
- Musselin, C. (2004). Towards a European academic labour market? Some lessons drawn from empirical studies on academic mobility. *Higher Education*, 48, 55–78. <https://doi.org/10.1023/B:HIGH.0000033770.24848.41>
- National Academy of Sciences, National Academy of Engineering, and Institute of Medicine. 2014. *The postdoctoral experience revisited*. Washington, DC: The National Academies Press. <https://doi.org/10.17226/18982>.
- National Science Board, National Science Foundation. 2022. *Science and engineering indicators 2022: The state of U.S. science and engineering*. NSB-2022–1. Alexandria, VA. Available at <https://nces.nsf.gov/pubs/nsb20221>
- OECD (2014), "Who are the doctorate holders and where do their qualifications lead them?", Education indicators in focus, No. 25, OECD Publishing, Paris. <https://doi.org/10.1787/5jxv8xsvp1g2-en>
- OECD. (2015). “Doctorate holders”, in *OECD science, technology and industry scoreboard 2015: Innovation for growth and society*. OECD Publishing, Paris. https://doi.org/10.1787/sti_scoreboard-2015-10-en
- OECD. (2019a). Benchmarking higher education system performance. *Higher Education*, OECD Publishing, Paris. <https://doi.org/10.1787/be5514d7-en>
- OECD. (2019b). “What are the characteristics and outcomes of doctoral graduates?”, in *Education at a glance 2019: OECD indicators*. OECD Publishing, Paris. <https://doi.org/10.1787/8389c70e-en>
- OECD. (2019c). Skills matter: Additional results from the survey of adult skills. *OECD Skills Studies*, OECD Publishing, Paris. <https://doi.org/10.1787/1f029d8f-en>
- OECD. (2021a). “Challenges and new demands on the academic research workforce”, in OECD science, technology and innovation outlook 2021: Times of crisis and opportunity. *OECD Publishing*, Paris. <https://doi.org/10.1787/72f6f879-en>
- OECD (2021b), "Reducing the precarity of academic research careers", *OECD science, technology and industry policy papers*, No. 113, OECD Publishing, Paris. <https://doi.org/10.1787/0f8bd468-en>
- OECD (2022a), Adult education level (indicator). <https://doi.org/10.1787/36bce3fe-en> (Accessed on 24 January 2022a).

- OECD (2022b), Gross domestic spending on R&D (indicator). <https://doi.org/10.1787/d8b068b4-en> (Accessed on 07 July 2022b).
- OECD/Eurostat/UNESCO Institute for Statistics. (2015). “ISCED 2011 level 8: Doctoral or equivalent level”, in *ISCED 2011 operational manual: Guidelines for classifying national education programmes and related qualifications*. OECD Publishing, Paris. <https://doi.org/10.1787/9789264228368-13-en>
- Ortlieb, R., & Weiss, S. (2018). What makes academic careers less insecure? The role of individual-level antecedents. *Higher Education*, 76, 571–587. <https://doi.org/10.1007/s10734-017-0226-x>
- Passaretta, G., Trivellato, P., & Triventi, M. (2019). Between academia and labour market—The occupational outcomes of PhD graduates in a period of academic reforms and economic crisis. *Higher Education*, 77, 541–559. <https://doi.org/10.1007/s10734-018-0288-4>
- Pearson, M. (1996). Professionalising Ph.D. education to enhance the quality of the student experience. *Higher Education*, 32, 303–320. <https://doi.org/10.1007/BF00138869>
- Pearson, M., Evans, T., & Macauley, P. (2008). Growth and diversity in doctoral education: Assessing the Australian experience. *Higher Education*, 55, 357–372. <https://doi.org/10.1007/s10734-007-9059-3>
- Pedersen, H. S. (2016). Are PhDs winners or losers? Wage premiums for doctoral degrees in private sector employment. *Higher Education*, 71, 269–287. <https://doi.org/10.1007/s10734-015-9901-y>
- Powell, S., & Green, H. (Eds) (2007). *The doctorate worldwide*. McGraw-Hill Education: Maidenhead.
- Roach, M., & Sauermaun, H. (2010). A taste for science? PhD scientists’ academic orientation and self-selection into research careers in industry. *Research Policy*, 39(3), 422–434. <https://doi.org/10.1016/j.respol.2010.01.004>
- Rosenblum, G., & Rosenblum, B. R. (1996). The flow of instructors through the segmented labor markets of academe. *Higher Education*, 31, 429–445. <https://doi.org/10.1007/BF00137125>
- Salminen-Karlsson, M., & Wallgren, L. (2008). The interaction of academic and industrial supervisors in graduate education. *Higher Education*, 56, 77–93. <https://doi.org/10.1007/s10734-007-9090-4>
- Sarrico, C. S., & Godonoga, A. (2021). Higher education system rankings and benchmarking. In Haezelkorn, E. and Mihut, G. (eds) *Research handbook on university rankings: Theory, methodology, influence and impact*. Edward Elgar Publishing, pp. 197–209. <https://doi.org/10.4337/9781788974981.00025>
- Skakni, I., Inouye, K., & McAlpine, L. (2022). PhD holders entering non-academic workplaces: Organisational culture shock. *Studies in Higher Education*, 47(6), 1271–1283. <https://doi.org/10.1080/03075079.2021.1876650>
- Stephan, P. (2012). *How economics shapes science*. Harvard University Press.
- Teixeira, P. (2017). “A bastion of elitism or an emerging knowledge proletariat? Some reflections about academic careers with an economic slant”, in *Challenges and options: The academic profession in Europe*. Springer International Publishing, Cham. https://doi.org/10.1007/978-3-319-45844-1_3
- The Economist (2010), Doctoral degrees: The disposable academic: Why doing a PhD is often a waste of time, Dec. 18th.
- Trow. (1973). *Problems in the transition from elite to mass higher education*. Carnegie Commission on Higher Education.
- Vitae (2016). *What do research staff do next?*, Careers Research and Advisory Centre, Cambridge. <https://www.vitae.ac.uk/vitae-publications/reports/vitae-what-do-research-staff-do-next-2016.pdf>
- Waaijer, C. J. E., Belder, R., Sonneveld, H., et al. (2017). 2017 Temporary contracts: Effect on job satisfaction and personal lives of recent PhD graduates. *High Educ*, 74, 321–339. <https://doi.org/10.1007/s10734-016-0050-8>
- Waaijer, C. J. F. (2017). Perceived career prospects and their influence on the sector of employment of recent PhD graduates. *Science and Public Policy*, 44(1), 1–12. <https://doi.org/10.1093/scipol/scw007>
- Yang, L., & Webber, K. L. (2015). A decade beyond the doctorate: The influence of a US postdoctoral appointment on faculty career, productivity, and salary. *High Educ*, 70, 667–687. <https://doi.org/10.1007/s10734-015-9860-3>
- Zumeta, W. (1982). Doctoral programs and the labor market, or how should we respond to the “PhD glut”? *High Educ*, 11, 321–343. <https://doi.org/10.1007/BF00155622>
- Zusman, A. (2017). Changing degrees: Creation and growth of new kinds of professional doctorates. *The Journal of Higher Education*, 88(1), 33–61. <https://doi.org/10.1080/00221546.2016.124394>