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Knowledge or science-based economy? The employment of UK PhD graduates in research roles beyond academia

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ABSTRACT
In recent decades, governments have sought to increase the number of PhD graduates and support their transition into non-academic employment. The UK is no exception to this trend: investing significantly in doctoral funding, skills training and programme reform to facilitate progression into the non-academic labour market. To an extent, these aspirations have been fulfilled, with a growing proportion of PhD graduates forging non-academic careers. However, it is less clear if the types of roles that PhD graduates occupy fulfil the promise of a high-skilled, knowledge-based economy. This article focuses on the absorption of UK PhD graduates into research employment outside of academia and considers how entry into research roles varies by academic and demographic characteristics. To explore this question, data from two cohorts of UK domiciled PhD-holders in the 'Destination of Leavers of Higher Education Longitudinal Survey' are analysed ($n = 4{,}731$). Over two-thirds of PhD graduates enter non-academic employment. However, a significantly higher proportion of science graduates from the prestigious Russell Group of universities secure research employment and report greater career satisfaction. The analysis signals the existence of a science-based knowledge economy into which certain PhD holders fit, but research employment opportunities for humanities and social science PhD graduates are less evident. The implications of these differentiated trajectories for continued doctoral expansion are discussed. While the dataset is a valuable resource, its limitations illustrate the need to advance empirical and conceptual understanding of PhD employment beyond academia.

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Doctoral education; knowledge economy; doctoral employment; labour market outcomes; research careers

Introduction: doctoral expansion and the rise of the knowledge economy

As part of the global trend to high participation systems of higher education (Marginson 2016), the number of PhDs awarded by universities has risen substantially in recent decades (Sarrico 2022). While rates of expansion and labour market conditions vary by country, in most national systems a majority of PhD graduates eventually occupy non-academic employment (Hayter and Parker 2019; OECD 2021). These developments align with an international political consensus over the ascendency of knowledge-based economies, in which research, development and a highly-skilled workforce are forecast to underpin future prosperity (Hancock, Hughes, and Walsh 2017). Within this vision, PhD graduates are framed as human capital of the highest value: prized for their expertise, research training and the potential to broker knowledge transfer between academia, private and public sectors (Hancock 2019; Kyvik and Bruen Olsen 2012; Maheu et al. 2014).

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The UK shares this outlook, having introduced policies and investment to expand doctoral education and broaden skills training to prepare PhD graduates for diverse careers for over two decades (since Roberts 2002). Such is the perceived importance of building research capacity for economic growth and security, the UK government recently declared its ambition to become a 'science and technology superpower' (DSIT 2023). This national strategy places a particular emphasis on enabling PhD graduates to forge 'varied and diverse careers' and 'flow freely between academia, business and other sectors' (DBEIS 2021, 2).

Beyond the political rhetoric, there is a significant absence of data on the labour market outcomes of PhD graduates amid changing political and economic circumstances. In the UK, understanding of PhD graduates who occupy non-academic careers is severely limited – both in terms of international standards of knowledge, and in relation to available research on first degree graduates (Hancock, Wakeling, and Chubb 2019). There is a distinct opaqueness surrounding PhD graduates who undertake research employment beyond academia (Hancock 2021). The assumption that PhD graduates working across 'academia, business and other sectors' have comparable and meaningful opportunities to apply their research training has not previously been explored at scale in the UK context.

This article seeks to address this omission by examining the absorption of UK PhD graduates into research employment beyond academia, and considering how entry into non-academic research roles varies by academic and demographic characteristics. It does so by analysing a large-scale quantitative dataset on PhD graduates in the UK. The analysis generates valuable insights for prospective and current students, PhD graduates, supervisors, graduate schools, employers and policy makers. It extends empirical and conceptual understanding of what non-academic PhD employment entails and raises strategic questions in relation to ongoing doctoral expansion, equity in doctoral outcomes and the knowledge economy agenda. Given the international interest in doctoral expansion and post-PhD careers, the analysis and discussion presented in this article will have resonance beyond the UK context.

Having introduced the trend of doctoral expansion, recent developments in doctoral education in the UK are outlined. This is followed by an overview of existing international research on the employment of PhD graduates in non-academic sectors. The research design is then set out, including an account of methods, data, variables and limitations. The statistical results are subsequently presented. The article concludes with a discussion of the implications of these findings and future research priorities.

Doctoral education in the UK: recent strategy, policy and reception

UK government policy on doctoral education has followed the international 'knowledge for growth' agenda of recent decades (European Commission 2008), leading to considerable investment in skills training and programme reform, with the objective of stimulating progression into the non-academic labour market (Hodge 2010). Though early initiatives focused on science, technology, engineering and mathematics (Roberts 2002); doctoral students across all fields are now expected to undertake transferable skills and professional development training to prepare for diverse careers (Smith et al. 2010). Most UK universities offer training to meet these aims, with many being signatories of the Concordat to support the career development of researchers (Vitae 2019).

The majority of UK PhD graduates today leave academia after completing their programme, with competition for academic jobs varying by subject (Hancock 2021; Vitae 2022). Many initially occupy postdoctoral research positions, but these are usually fixed-term roles and do not translate into permanent academic roles (OECD 2021). High departure rates from academia are, however, not necessarily confirmation that PhD graduates secure high-skilled, knowledge-based economy or 'science superpower' employment outside of the academic sector. Indeed, research with non-academic employers of PhD holders in the UK suggests an initial unwillingness to hire these candidates and limited awareness of which employees hold the qualification (Tazzyman et al. 2021).

UKRI and the subject area research councils have prioritised to resolve these concerns and ensure that investment in doctoral education is of benefit to wider society and the economy (DBEIS 2021). In order to prepare PhD graduates for mobility across employment sectors, several doctoral funding bodies recently commissioned reviews of their training programmes and are collectively consulting on a 'new deal' for postgraduate research which aims to secure inclusive and diverse career pathways (EPSRC 2021; ESRC 2021; UKRI 2022). Initiatives to formalise 'research in practice' placements and non-academic internships during the doctoral programme (BBSRC 2022; ESRC 2021), follow a longer-term shift away from a student-supervisor model of the doctorate to cohort-based ones, where training in research skills, interdisciplinary collaboration, knowledge exchange and research impact are provided through a structured programme (Lunt, McAlpine, and Mills 2014).

The employment of PhD graduates in non-academic roles: an overview of research

While the normative and empirical shift for PhD graduates to enter non-academic employment is increasingly acknowledged, it cannot be assumed that all PhD graduates find roles that utilise their research training. Existing studies depict a complex interplay of factors shaping doctoral career pathways.

Among nations with developed research systems, the share of PhD graduates employed in and beyond academia varies sharply. In the UK, it is estimated that across all subject areas, just under half of PhD graduates remain in academia six months following completion (Vitae 2022). Departure rates rise each year thereafter, explained by the prevalence of fixed-term contracts which do not lead to permanent academic research posts (OECD 2021; Royal Society 2010). In Australia, the Netherlands and Norway, minority rates of continuation in academia are reported. Data from the 2016 Australian census suggest that some 41.9% of PhD holders are employed in the academic sector (McCarthy and Wienk 2019, 8). A similar percentage is reported in Norway (Kyvik and Bruen Olsen 2012, 205). In the Netherlands and United States, the proportion is lower, with approximately one-third of PhD holders remaining in academia (McCarthy and Wienk 2019; van de Schoot, Yerkes, and Sonneveld 2012). Germany documents yet lower rates of retention, with one-quarter of PhD holders in the academic system one year after completion (Hauss, Kaulisch, and Tesch 2015). Notwithstanding the global nature of research (Marginson 2022a); these data highlight the importance of studying PhD labour market transitions within national contexts. This is further important since doctoral training is structured differently across national higher education systems (Bao, Kehm, and Ma 2018; Sarrico 2022).

To date, most studies of PhD employment have focused on the binary of *academic* and *non-academic* employment, with insight into the latter category being least well developed (Hancock 2021). The tendency to privilege understanding of academic career pathways may in part be driven by studies with PhD students themselves, which consistently portray academic careers as the preferred outcome from doctoral study (Hancock, Hughes, and Walsh 2017; Parada and Peacock 2015; Sauermann and Roach 2012). Supervisor influence, disciplinary culture, and institutional embeddedness exert a significant influence on PhD students' career preferences and the reported disinterest in non-academic opportunities (Hayter and Parker 2019; McAlpine and Amundsen 2016; Neumann and Tan 2011). Far from the optimism of knowledge economy discourse, PhD students frequently characterise non-academic employment as an inferior outcome that is less well aligned with their training (Suomi et al. 2020). However, the linear model of the academic career (doctorate, postdoctoral work, independent researcher/lecturer and professor) is an increasingly rare experience; particularly the transition from postdoc to academic post (Whitchurch, Locke, and Marini 2021).

The employment of PhD graduates beyond academia

Despite the attention granted to the precarious nature of contemporary academic careers (OECD 2021), Skovgaard Pedersen (2014) examined European economies to find that PhD graduates

entering non-academic employment experience a similarly protracted route, with permanent contracts often difficult to obtain. Skovgaard Pedersen also found limited evidence of intersectoral mobility; noting that once PhD graduates leave academia, they seldom engage in cross-sector collaboration or return to academic research. The assumption that PhD graduates are readily welcomed into non-academic sectors is further undermined when employer perspectives are examined. Although empirical research with doctoral employers is limited, existing studies convey a reluctance among non-academic employers to consider PhD graduates, owing to uncertainty over the value that the qualification may bring to an organisation (Couston and Pignatel 2017). Where employers are agentive in hiring PhD graduates, this is often informed by individual managers themselves holding a PhD (McAlpine and Inouye 2022), or limited to specific, research-intensive sectors with a tradition of hiring PhD graduates.

Research and non-research roles beyond academia

Distinguishing further between *research* and *non-research* roles outside of academia affords a more nuanced understanding of the work that these PhD holders undertake. In Germany, where the tradition of a dual-purpose PhD is well established, PhD graduates have long regarded securing a high-status research position outside of academia as a success (Enders 2002). Analysis of Swiss and Swedish PhD graduates indicates that they view employment with high-status non-academic research organisations in equal regard to research positions at prestigious universities; and more favourably than employment with a lower-tier university (Conti and Viscentin 2015). Recent analysis of Italian PhD holders found both high job satisfaction and a sizeable earnings premium for those occupying research roles outside academia (Gaeta, Lavadera, and Pastore 2022). Non-research roles, however, are less positively characterised. Bazeley (2003) observed that career frustration is highest when PhD graduates cannot find work appropriate to their research training; while Auriol, Misu, and Freeman (2013) found that PhD graduates who leave research entirely experience reduced professional motivation and satisfaction. Reports of such disappointing prospects have led some to argue that continued doctoral expansion represents an unwise investment for individuals and universities (The Economist 2016).

Emerging evidence indicates that certain PhD routes may offer an advantageous basis for securing non-academic research roles. Analysis of German PhD holders found that a doctorate entailing an industrial sponsor is predictive of a private sector research role (Hottenrott and Lawson 2017). The importance of industry sponsorship for obtaining non-academic employment was also identified in the Italian context (Marini 2022). Drawing on Belgian data, Balsmeier and Pellens (2014) observed that doctoral students who submitted patents reported a higher rate of pursuing non-academic research roles. From data collected across Sweden, Norway and the UK, Germain-Alamartine et al. (2020) demonstrated that PhD students who develop networks with industry professionals experience a more harmonious transition into non-academic research employment.

Across the literature, and in contrast to the uncomplicated policy view, PhD employment emerges as complex, varied and nationally specific. The following analysis is focused on UK PhD graduates' transitions into research employment beyond academia, and the significance of academic and demographic characteristics in shaping differentiated trajectories.

Research design and methods

A study of PhD employment in the UK

The analysis presented in this article draws from secondary data on PhD employment in the UK; an approach that has been followed in other contexts (Li and Horta 2021; Skovgaard Pedersen 2014). Data on PhD employment in the UK are collected by the Higher Education Statistics Agency

(HESA), through the Destinations of Leavers from Higher Education (DLHE) survey (now 'Graduate Outcomes'), but are not routinely published. Previous research has drawn from this source (for example, Vitae 2022), however, the analysis presented here builds on this earlier work by incorporating academic and demographic information. This is beneficial because such variables are associated with inequalities across first-degree employment outcomes and academic career progression (Britton et al. 2016; Royal Society 2010).

Data and variables

Higher education graduates are invited to participate in the DLHE survey six months after the completion of their course. A representative subset of participants are invited to complete the 'longitudinal' survey (Long DLHE), three and a half years after graduation. This study utilised the Long DLHE dataset, since PhD employment transitions may take a number of years. The most recent Long DLHE data were requested (2011/12 and 2013/14).

The variables included in the analytical dataset are shown in Table 1. PhD graduates employed outside of academia are identified by the variable 'non-academic sector role', which has two values of: 'research' and 'non-research'. In contrast to the evolving notion of a 'graduate job' (Green and Henseke 2016), there is currently no agreed framework for categorising PhD level research work undertaken outside of academia.

Categorisation of research and non-research roles beyond academia

To distinguish research and non-research roles outside of academia, an inductive coding approach was deployed. Participants' occupational titles were first assessed to omit those employed in academia and generate a subsample of non-academic employees ($n = 3{,}006$). The occupational titles of these employees were checked for evidence of a research element. Certain occupational titles straightforwardly imply this, such as 'Biological scientists and biochemists' or 'Social and Humanities scientists'. Such employees were coded as holding a research role, meaning that the creation, application or dissemination of research is understood to be a duty of their post. If it could not be assumed that the role involved a responsibility to create, apply, or disseminate research – or if it was obviously not, such as in the case of 'Primary education teaching professional' – employees were coded to a non-research role. The coding of research roles was reviewed against participant information on the formal requirements of their role. Coding to a research role required participants

Table 1. Variables included in analytic dataset.

Variable	Description
Doctoral institution	Russell Group; Other.
Doctoral subject	Arts and Humanities; Biological sciences; Biomedical sciences; Physical sciences and engineering; Social sciences (including education).
Entry qualification	Highest qualification prior to PhD: Undergraduate degree; Taught Master's degree.
Gender	Male; Female.
Ethnicity	White British; Asian; Black; Other.
Survey age	Under 30; 30 and over.
Parental home	Neighbourhood higher education participation rate of parental home: Low participation neighbourhood; Other.
Employment sector	Coded to the Standard Industrial Classification 2007.
Occupational title	Coded to the Standard Occupational Classification 2010.
Academic sector role	Higher education teaching professional; Postdoctoral researcher.
Non-academic sector role	Research; Non-research.
Formal requirement of role	Doctoral qualification; Doctoral subject knowledge; Doctoral skills and competencies; Doctoral work or practical experience; Work experience since doctorate; Qualifications since doctorate.
Reasons for undertaking role	Career fit; Earn living; Broaden skills or experience; Best or only offer; Career progression; Gain experience; See if like; Repay debt; Other.
Career satisfaction	Very; Fairly; Not very; Not at all satisfied.

to have stated that either: the qualification, subject knowledge, skills and competencies, or practical experience and work placements gained during the PhD were a formal requirement of employment. This step was taken to affirm that the role both incorporated a research element, and formally required PhD level training.

Sample

The total sample comprised 4,731 UK domiciled PhD graduates who obtained their degrees in 2008/9 and 2010/11 (response rate: 39.5%). This represents around one-fifth of the total UK domiciled PhD population graduating in those years. Data were weighted by HESA prior to analysis to reflect key academic variables. All analyses were conducted in Stata. Table 2 shows the distribution of academic and demographic characteristics in the sample.

Limitations of data

The limitations of using secondary data to explore PhD employment in the UK are addressed in earlier work (Hancock 2021). The UK is unusual for its lack of longitudinal data on doctoral outcomes, and bodies such as the Researcher Development Concordat Strategy group are seeking to rectify this (Buckingham 2022). Relevant to this analysis, there are a few specific matters to note. Firstly, the DLHE survey describes employment destinations but does not capture aspirational, decision-making and circumstantial factors that are known to shape PhD pathways (McAlpine and Amundsen 2016). There is little information on the conditions of the PhD, such as the extent of training undertaken, supervisory arrangements or publication records, which may explain differences in academic and non-academic outcomes. Doctoral institutions are provided by university mission groups, preventing a detailed exploration of institutional differences. This is noteworthy because even within

Table 2. Academic and demographic characteristics of survey sample ($n = 4{,}288$).

	%
Survey year	
2011/12	46.7
2013/14	53.3
Doctoral institution	
Russell Group	61.7
Other	38.3
Doctoral subject	
Arts and Humanities	14.8
Biological sciences	21.2
Biomedical sciences	16.9
Physical sciences and engineering	32.0
Social sciences (including education)	15.1
Entry qualification	
Undergraduate qualification only	54.2
Taught Master's degree	45.8
Gender	
Male	49.7
Female	50.4
Ethnicity	
White	90.4
Asian	5.3
Black	1.2
Other (including Mixed)	3.1
Age	
Under 30	49.3
30 and over	50.7
Parental home	
Low participation neighbourhood	7.6
Other neighbourhood	92.4

the Russell Group – a self-selecting body of twenty four research-intensive UK universities that are often characterised as the most prestigious – there are sizable differences in research income, culture and outcomes (Boliver 2015).

While the coding of research and non-research roles outside academia utilises all available variables, the absence of a common classification framework, together with limited detail on the actual work done by PhD graduates, lessens the robustness of this categorisation. It is not possible to ascertain, for example, how much working time is dedicated to research. There are also likely to be inconsistencies in the extent to which PhD graduates perceive a connection between their doctoral training and current employment. It is plausible that PhD graduates who have recently left academia will be uncertain of how the qualification aligns to the demands of a new professional context. Arts and Humanities PhD graduates in particular may find this association difficult to articulate (British Academy 2020). For this reason, despite the presentation of research and non-research roles as a binary variable, it is likely that these occupations are positioned on a spectrum of research engagement or intensity. This idea is returned to in the recommendations for future research.

Analysis

Doctoral employment by sector

Turning first to the employment of PhD graduates by academic and non-academic sectors, Table 3 shows that the majority enter non-academic employment (70.1%). Within this group, just over half report research employment (53.8%).

Non-academic employment: sector and occupational titles

Table 4 details the largest employing sectors of PhD graduates working outside academia. For research employees, the prevalence of the professional, scientific and technical sector is clear. Also notable is human health and social work. All PhD graduates employed in a non-academic research role are located in these five sectors. In contrast, non-research employees are distributed across a more diverse set of sectors. Here, the five largest employing sectors account for only two-thirds of such graduates. One-fifth are employed in banking, finance and insurance, while a similarly high proportion are employed in non-tertiary education.

The occupational titles of non-academic employees are shown in Table 5. Consistent with the data presented in Table 4, the five most frequent titles for research employees belong to the scientific and technical domain. The most common occupational titles for non-research employees relate to non-tertiary teaching and education, and business and management.

The formal requirements of non-academic employment

Figure 1 displays the formal role requirements of non-academic employment. These data convey the requirements as understood by PhD graduates, rather than the views of non-academic employers.

Table 3. Employment of PhD graduates by academic and non-academic sectors (*n = 4,288*).

	%
Employment sector	
Academic	29.9
Non-academic	70.1
Non-academic sector	
Research role	53.8
Non-research role	46.2

Table 4. Sector of PhD graduates in non-academic employment ($n = 3{,}006$).

	%
Research role	
Professional, scientific and technical activities	56.1
Human health and social work activities	26.1
Banking, finance, insurance	8.1
Information and communication	6.3
Construction (includes civil engineering)	3.4
Non-research role	
Banking, finance, insurance	20.9
Education (schools and colleges)	19.2
Human health and social work activities	9.6
Information and communication	9.2
Arts, entertainment and recreation	8.4

Table 5. Occupational titles of PhD graduates in non-academic employment ($n = 3{,}006$).

	%
Research role	
Natural and social science professionals	12.4
Medical practitioners	11.3
Clinical psychologists	10.8
Biochemists	9.6
Programmer and software development professionals	6.3
Non-research role	
Senior professional of educational establishments	5.8
Secondary education teaching professionals	5.1
Management consultant and business analysts	4.9
Teaching and other educational professionals	3.5
Business and related associate professionals	3.3

A substantially higher proportion of research employees stated that the doctoral qualification, subject knowledge, skills and competencies, and doctoral work and practical experience were a formal requirement of their role. Only a minority of non-research employees recognised these

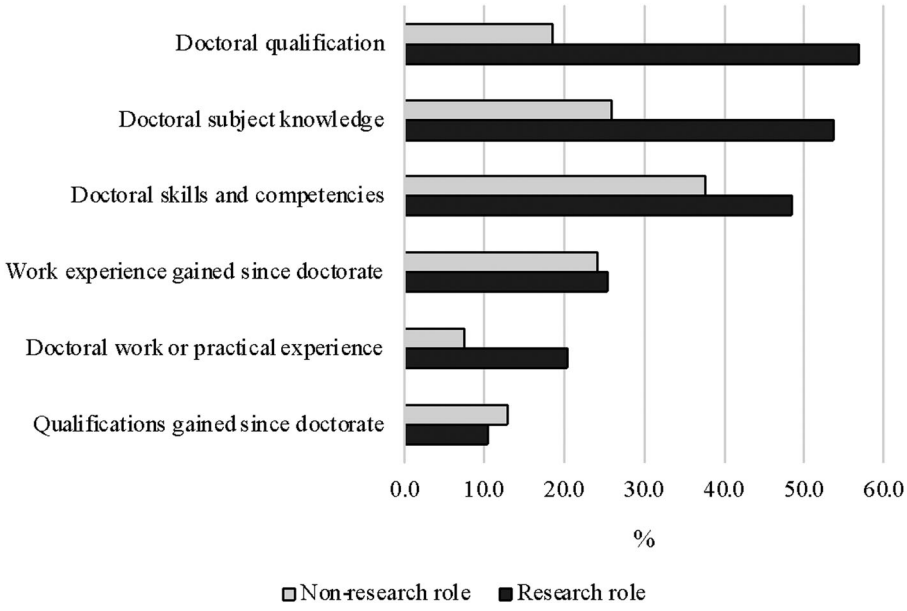

Figure 1. Formal requirements of role in non-academic sectors ($n = 3{,}006$).

specifications as formal requirements. A similar proportion of both types of employees identified work experience since the doctorate to be a formal requirement. Qualifications gained since the doctorate were slightly more important to non-research employees, but the difference is small. The most striking aspect of this is that the doctorate is perceived to have limited formal relevance to non-research employment. This may suggest both that PhD holders are over-qualified for these roles, and that additional role requirements are not captured by the survey, limiting insight into the nature of the work undertaken.

Reasons for undertaking non-academic employment

PhD graduates' reasons for accepting their current role are shown in Figure 2.

The ordering of reasons is not markedly different between research and non-research employees, with concurrence on the four most selected justifications (career fit; earn living; broaden skills or experience; best or only offer). Rates of agreement are, however, mostly higher for research employees, again suggesting that the survey design may better capture the experiences of this set of PhD graduates. Research employees view their role as more tightly aligned with longer-term career aspirations, providing higher agreement for 'career fit' and 'career progression'. The responses of non-research employees may indicate that current circumstances are less part of a well-defined plan; approximately one-third made sense of their role in terms of seeing they enjoyed it, or for pragmatic reasons such as repaying debt and 'other'.

Predicting the research employment of PhD graduates in non-academic sectors

The results of a logistic regression model exploring the association between research employment beyond academia and PhD graduates' academic and demographic characteristics are shown in Table 6. This analysis is limited to PhD graduates who had left the academic sector, for whom relevant academic and demographic information are available ($n = 2{,}428$).

The first column reports odds ratios (OR) in relation to a reference group which is held at 1. The third column details the predictive margins (PM), which can be understood as the average probability of occupying a non-academic research role for each analytical group. The fourth

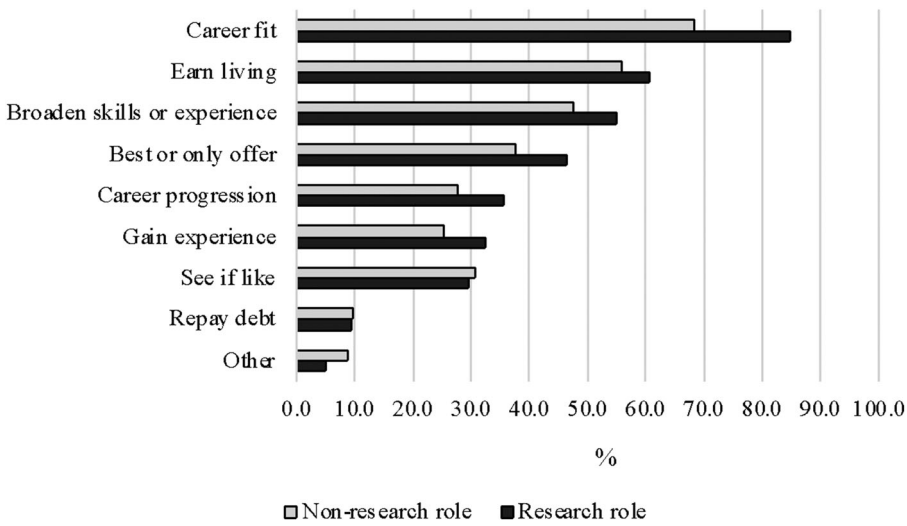

Figure 2. Reasons for undertaking role in non-academic sectors ($n = 3{,}006$).

Table 6. Logistic regression model predicting research employment of PhD graduates in non-academic sectors ($n = 2{,}428$).

Independent variables	OR	SE	PM	AME
Doctoral institution				
Ref: Other institution			0.477***	
Russell Group	1.478***	0.012	0.566***	0.089***
Doctoral subject				
Ref: Arts and Humanities			0.235***	
Biological sciences	6.916***	0.019	0.675***	0.440***
Biomedical sciences	5.147***	0.025	0.608***	0.373***
Physical sciences and engineering	4.243***	0.018	0.562***	0.327***
Social sciences (including education)	1.458*	0.031	0.308***	0.074*
Entry qualification				
Ref: Undergraduate degree			0.527***	
Taught Master's degree	1.125*	0.016	0.553***	0.026*
Gender				
Ref: Male			0.561***	
Female	0.809**	0.014	0.512***	−0.0487**
Ethnicity				
Ref: White			0.539***	
Asian	1.017	0.042	0.543***	0.003
Black	0.585	0.087	0.418***	−0.121
Other	0.886	0.053	0.512***	−0.027
Survey age				
Ref: Under 30			0.541***	
30 and over	0.958*	0.016	0.531***	−0.010
Parental home				
Ref: Other neighbourhood			0.540***	
Low participation neighbourhood	0.865	0.034	0.507***	−0.033
Constant	0.258***	0.049		
Pseudo R-squared	0.072			
Chi-squared	241.49***			

Odds radios (OR), Standard errors (SE), Predictive margins (PM), Average marginal effects (AME), *** < 0.001, ** < 0.01, * < 0.05.

column reports the difference between the predictive margins of the reference and other analytical groups. This is known as the average marginal effects (AME).

Graduates with a PhD from a Russell Group university report a significantly higher rate of research employment (56.6%) than those from all other institution types (47.7%). PhD graduates from the scientific and technological subjects report the highest rates of research employment (biological sciences 67.5%; biomedical sciences 60.8%; physical sciences and engineering 56.2%), followed by the social sciences (30.8%). PhD graduates from the arts and humanities report significantly lower rates of research employment (23.5%).

PhD graduates who also hold a Master's degree report a small but significantly higher rate of research employment than those with a first degree only. Male PhD graduates report a significantly higher rate of research employment than females. White British PhDs report a similar rate of research employment to Asian graduates, but higher than Black and Other ethnic groups. These differences are not, however, statistically significant. PhD graduates aged under 30 and those from a family address in an area of average or above higher education participation, also report higher rates of research employment – but these differences are not statistically significant.

The career satisfaction of PhD graduates

Briefly considering the career satisfaction of PhD graduates can offer some insight into the extent to which individuals are content with these differentiated employment outcomes. Across the whole sample, career satisfaction is high (91.8%). Average career satisfaction does not vary greatly between academic and non-academic employment (94.2% academic employees; 92.8% non-academic employees).

Focusing on non-academic employment, occupying a research role is associated with higher career satisfaction (95.7%; compared to 89.3% for non-research employees). As this difference is

observed across all subject areas, it would seem that the higher rates of non-research employment reported by social science and arts and humanities graduates are often not the result of choice. Arts and humanities graduates employed in non-research roles report the lowest career satisfaction of any group (79.3%), followed by social science PhDs in non-research roles (81.3%). Considered alongside the reasons for undertaking non-academic employment (Figure 2) and the results of the logistic regression, it appears that there are specific groups of PhD graduates who are less likely to secure research roles, and who in turn are less satisfied with this outcome.

Discussion and concluding remarks

This article has explored non-academic research employment among UK domiciled PhD graduates, and the academic and demographic characteristics associated with these outcomes. Consistent with other nations, the majority of UK domiciled PhD graduates enter non-academic employment. The extent to which PhD graduates are absorbed into research roles beyond academia varies significantly by doctoral subject area and institution. This is unsurprising in a stratified higher education sector such as the UK, where science and Russell Group first-degree graduates similarly enjoy enhanced labour market rewards (Britton et al. 2016). PhD holders who are Male or holding a Master's degree also occupy research roles at a higher rate on leaving academia. Across ethnic groups, White British PhD graduates are most likely to secure non-academic research roles, although these differences are not statistically significant. The analysis therefore suggests that known inequalities in graduate outcomes persist at doctoral level.

Given the characteristics of PhD graduates who occupy research positions beyond academia, it is not evidently true to speak of a knowledge economy in its broadest sense, but rather of a UK science-based economy, which privileges certain PhD holders. PhD holders from arts, humanities, social sciences and non-Russell Group institutions are significantly more likely to occupy non-research employment and report lower career satisfaction. Although, as noted, this difference could in part be one of perception – specifically, the insecurity of arts, humanities and social science graduates in relating their research training to non-academic employment (British Academy 2020) – certainly, it would seem that the wider economic value of doctoral training in these subjects is not well captured by current methods, and that non-academic workplaces are less likely to seek research training in these subject areas.

At a structural level, such differentiated trajectories raise timely questions about the rationale and ethics of continued doctoral expansion, particularly as this coincides with worsening mental health and wellbeing among the doctoral population (Woolston 2019) – and, in UK higher education, the expectation for doctoral study to be in part privately financed by individuals and their families. The highest uptake of the UK's doctoral loans is among non-science scholars (Bennett 2020), but the data presented here suggest that the outcomes for these graduates are furthest removed from the promises of knowledge economy policy. The problem with a universal approach to doctoral expansion is that it conceals differentiations in supply and demand by doctoral subject and institution. PhD holders do not have equal access to high-skilled research employment in the wider economy.

Across all doctoral programmes, the importance of preparing students for non-academic employment and involving non-academic partners in doctoral training is clear. Connecting PhD students with industry partners during the doctoral candidacy forms the basis of a more harmonious transition into non-academic research employment, for both graduates and employers (Germain-Alamartine et al. 2021; Hottenrott and Lawson 2017; Marini 2022). These reflections lend support to the current strategy of the UK research councils and universities, but more should be done, particularly in relation to informing prospective and current PhD students of likely career outcomes and the prospects for research employment. Following the lead of countries in East Asia, it may be timely to reconsider current methods of assessing the knowledge and competencies required by PhD holders. The longstanding practice of preparing a written thesis and undertaking a viva voce

examination may be of limited formative value to PhD holders entering non-academic employment (Shin, Postiglione, and Ho 2018).

There are many forms of value to undertaking doctoral study (Bryan and Guccione 2018), but the economic imperatives of growth and prosperity continue to dominate the drive for expansion globally. From the limited data available, PhD employment trajectories in the UK emerge as highly differentiated by doctoral institution and subject. Future research endeavours should prioritise the collection of richer longitudinal data on the employment of PhD graduates beyond academia, in order to explore the spectrum of research occupations and assess the research component of roles held by arts, humanities and social sciences graduates in particular. Since the UK is a leading destination for doctoral study internationally, expanding the analysis to include UK PhD holders of all nationalities would be further insightful to understanding employment patterns in an age of global science (Marginson 2022b; Mathies and Cantwell 2022). Without this evidence base, the longer-term consequences of doctoral expansion are difficult to forecast, and the disconnect between policy and individual experience will likely persist.

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Availability of data and material

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