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International mobility after the PhD: exploring the characteristics and early labour market outcomes of UK doctoral graduates

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Abstract
While the mobility patterns of first-degree students and graduates have been extensively researched, there is limited understanding of the international mobility of doctoral graduates. This article examines the early outbound mobility of UK domiciled doctoral graduates. Informed by human capital and signalling theory, we analyse the Higher Education Statistics Agency's Destination of Leavers from Higher Education survey ($n = 28{,}535$), to consider whether mobility (1) differs by graduates' socio-demographic background and PhD programme characteristics and (2) is associated with different early labour market outcomes. We find that individual socio-demographic background and PhD programme characteristics have a statistically significant effect on international mobility 6 months after graduation. International mobility is significantly higher among Oxbridge and STEM doctoral graduates. We observe a small positive association between international mobility and PhD graduates' salary. International mobility after the PhD is highly associated with the probability of securing an academic and research role or a postdoctoral contract. Our findings are consistent with existing research on scientific careers which identifies a 'mover's advantage'. We propose that international mobility can be framed as a human capital investment that enables self-advancement within the competition for research employment. The norms of the knowledge economy and global science reward doctoral graduates with international experience, which acts as a positive signal of productive capability. Our insights are germane to a variety of stakeholders concerned with continuing doctoral expansion and indicate the scientific and economic importance of ensuring equitable access to mobility opportunities.

Keywords International mobility · Doctoral employment · Research careers · Human capital theory · Signalling theory · Global science

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Introduction

The international circulation of people, ideas and practices across higher education institutions and the research system has been promoted by policymakers since the 1990s (Mathies & Cantwell, 2022). While the mobility patterns of first-degree students and graduates have been extensively reported on, there is comparatively limited research on the international mobility of doctoral graduates. This article proceeds from this knowledge imbalance to examine the outbound mobility of UK domiciled doctoral graduates; focusing specifically on those who move abroad for employment soon after completing their doctorate. Following the outcomes of this group is timely amid ongoing debate over the continued expansion of doctoral education, changing academic employment conditions, the shift to global science, and the positioning of the UK following the 2016 Brexit referendum.

The worldwide expansion of doctoral education in recent decades is well documented (Cyranoski et al., 2011)—as is the associated rationale of developing knowledge-based economies that rely on the research and innovation contributions of doctoral-educated workers (Hancock, 2023; Sarrico, 2022; Skovgaard-Pedersen, 2014). One consequence of expansion is that many doctoral graduates now embark on non-academic careers (Auriol et al., 2013; Buenstorf et al., 2023; Fox & Stephan, 2001; Hayter & Parker, 2019; Sauermann & Roach, 2012). Despite diminishing odds and precarious working conditions, securing an academic research career remains an important career objective for many doctoral graduates (Horta, 2018; OECD, 2021).

Few studies on changing doctoral employment have considered international mobility patterns in their analysis. Research to date has tended to focus on the dynamics of national labour markets and occupational mobility (movement from academic to non-academic sectors). Where mobility has been examined, this has typically been in terms of understanding international postgraduates' decisions to remain in the country of study after graduation (e.g. Zhan et al., 2021; Zhan, 2022; Kim et al., 2011) and academic career outcomes (e.g. Baker, 2015; Fernadez-Zubieta et. al, 2013). This article analyses the international mobility of British national doctoral graduates who were domiciled in the UK for their PhD programme. To theorise the mobility patterns of UK doctoral graduates, we adopt two contributions from the field of behavioural economics: human capital theory and signalling theory. These perspectives enable us to conceptualise international mobility as a strategy for distinction in a crowded academic labour market. Our assertion is that international mobility may be pursued by UK doctoral graduates as a means of establishing positional advantage in the competition for academic and research careers. This behaviour is in turn normatively reinforced and rewarded by universities and research institutions operating within the framework of global science, which prizes international collaboration and overseas experience (Marginson, 2022). The UK provides a contrasting case to the frequent characterisation of migration as a means of accessing high-quality education or leaving a low-skilled economy (Recchi & Favell, 2009). Notwithstanding the complications of Brexit and anti-immigration sentiment (Marini, 2024), successive governments have framed research and innovation as an exceptional area of policy, where facilitating a two-way flow of 'global talent' is crucial to economic prosperity (DSIT, 2023). Indeed, the decision of a UK doctoral graduate to leave the country for employment elsewhere somewhat undermines political efforts to secure the nation as a 'science superpower' (DSIT, 2023).

Using the Higher Education Statistics Agency's (HESA) Destination of Leavers from Higher Education (DLHE) survey, we consider whether mobility (1) differs by graduates' socio-demographic background and PhD programme characteristics and (2) is associated

with different early labour market outcomes, including a continuation in academic and research positions, six months after graduation. Following the research of Jacob et al. (2019) on returns of mobility among European undergraduate students, we use inverse-probability weighted regression adjustment (IPWRA) to understand the association between mobility and early labour market outcomes. We also briefly explore the HESA DLHE longitudinal dataset to understand the association between initial mobility and later mobility 3.5 years after graduation.

Our insights on doctoral mobility will be relevant to many stakeholders for whom furthering understanding of different career pathways and outcomes is important. Knowing where doctoral graduates feature in a research system premised on global exchange can inform institutional strategy and action to support the professional development of doctoral researchers. Tracing outbound mobility is particularly instructive for research funders, who are concerned that opportunities for international collaboration are accessed equitably (Stevenson et al., 2021). Those considering and undertaking doctoral study require greater information about employment destinations and the variables associated with differentiated career pathways (Hancock, 2023; Hancock et al., 2017; Parada & Peacock, 2015). Previous research has explored early-career international mobility and its effect on broader career outcomes; however, the issue of whether international experience is advantageous in pursuing an academic research career has not been explored in the UK context. For policymakers seeking to generate prosperity, recruiting and retaining doctoral researchers—or rather, balancing brain 'drain' and 'gain'—is imperative (Department for Business, Energy & Industrial Strategy, 2021). The significance of understanding the international mobility of doctoral graduates is heightened in the UK case, where changing geopolitical circumstances have the potential to greatly impact the sustainability and status of the higher education and research system.

The article opens by considering recent transformations in doctoral careers and education, before reviewing the existing literature on doctoral mobility. The conceptual framework is then introduced. A section on the study method follows, outlining the research design, dataset and the analytical approach. Next, the findings are presented. The implications of these for future scholarship and policy are explored in the concluding discussion.

Literature review

Changing doctoral careers

The rapid expansion of doctoral education in recent years set in motion a transformation in doctoral career outcomes. The award of doctoral-level qualifications increased by 25% among OECD countries between 2014 and 2019 (Saricco, 2022), explained largely by an international political ambition to develop knowledge-intensive economies dependent on a ready supply of mobile doctoral graduates (Hancock et al., 2017).

Worldwide, the majority of doctoral graduates secure employment outside of academia (Hayter & Parker, 2019; OECD 2021). Transitions into non-academic employment may nevertheless be protracted, with many first embarking an extended 'permadoc' phase of consecutive postdoctoral training contracts before leaving academia (Saricco, 2022). Although the challenging career prospects of academia are increasingly recognised (e.g. Woolston, 2022), this has not translated into a shortage of aspiring academics. Conversely, empirical studies with doctoral researchers and graduates report that academic careers

remain a preference for many, leading to intense competition for these roles (Hancock et al., 2017; Hayter & Parker, 2019; McAlpine & Amundsen, 2016; Parada & Peacock, 2015; Sauermann & Roach, 2012).

These patterns and preferences are also observed in the UK, prompting researcher funders and universities to enhance support for doctoral professional development to better prepare students for diverse career pathways (e.g. Roberts, 2002; Smith et al., 2010). Such initiatives do not, however, appear to have substantially altered the career preferences of doctoral students (Hancock et al., 2017). While longitudinal data on doctoral careers in the UK is limited, initial entry into academia varies significantly by doctoral subject, with about half of arts, humanities and social science graduates finding immediate academic employment, compared to only one-fifth of science and technology graduates (Hancock, 2021).

Doctoral education and mobility

Within the European Union (EU), doctoral education has been identified as a key focus for regional harmonisation. At the turn of the millennium, the Bologna Process established, among other aspirations, a common framework for the 3-year doctorate; while the Lisbon Strategy aimed to create a European Area of Research and Innovation (Kehm, 2009). Later, the Salzburg Principles in 2005 and Salzburg Recommendations in 2010 declared a vision of a shared purpose, experience and content for doctoral education (EHEA, 2005; EUA, 2010). Standardisation was understood as a means of creating equilibrium across doctoral-level skills and knowledge, which would in turn facilitate transitions into the labour market. Harmonisation was driven by the view that creating the Europe of Knowledge depended on promoting the mobility of doctoral graduates across states and sectors (Baptista, 2016; Mathies & Cantwell, 2022; Slaughter & Cantwell, 2012). This is not to say that seamless integration has been achieved in practice; however, significant disciplinary, institutional and national variations endure in the aims and forms of doctoral education, with some acknowledgement that heterogeneity is needed for innovation (Baptista, 2016; Shin et al., 2018).

Following Brexit, harmonisation aspirations to support the flow of knowledge workers continue. This is reflected in the UK government's 'Science Superpower' strategy (DSIT, 2023) and its decision to rejoin the EU's Horizon Science Programme. The UK has long been a net beneficiary of international mobility among doctoral students. In 2019, it was estimated that approximately one in four of all mobile EU doctoral students enrolled at a UK university, making it the most popular host country (Mathies & Cantwell, 2022). In contrast, the number of UK-domiciled doctoral students completing their programme in another EU country is only around one-tenth of the incoming cohort (Mathies & Cantwell, 2022). These trends, consistent with undergraduate international mobility patterns, indicate that only a minority of UK doctoral graduates complete their research training in another nation. The asymmetry in doctoral student mobility highlights the value of monitoring post-doctoral mobility on a country by country basis, since the extent of international experience acquired prior to completion varies considerably. Moreover, such asymmetries typify the competition for people and resources characteristic to marketised systems of higher education and the academic labour market.

While the benefits of international student mobility on labour market outcomes are increasingly evident (e.g. Jacob et al., 2019; Kratz & Netz, 2018; Netz & Cordua, 2021; Netz & Grüttner, 2021; Rodrigues, 2013), far less known about the impact of

post-graduation international mobility. Past research on post-doctoral international mobility has examined why graduates stay on in the country of study. These studies focus not only on how individual or degree characteristics affect graduates' decisions, but also on the role of macroeconomic variables from the country of origin. Consistently, it is shown many doctoral graduates remain in the country where they completed their studies (Zhan et al., 2021, Zhan, 2022; Roh, 2015; Kim et. al, 2011).

Examining doctoral graduates in the USA, Kim et al. (2011) showed a notable rise in the number of international students choosing to stay in the country between 1980 and 2000s. The authors observed a significant variation in the likelihood of staying based on the field of study, likely attributed to the mounting demand for skilled workers in biology and other scientific fields. The unemployment rate in the students' home country was also found to be a determining factor in their decision to stay in the USA. Also in the USA, Finn and Pennington (2018) showed that the field of study and country of origin were the main determinants of the decision of doctoral graduates to stay some 10 years after completion. Science graduates were again found to be more likely to stay than social science graduates. Zhan et al. (2021) and Zhan (2022) analysed the labour market outcomes of international and EEA graduates from the UK higher education system, respectively. Their research showed that the unemployment rate and GDP of the home country were significant factors in determining whether graduates would choose to stay in the UK after completing their education.

Research on academic intra- or international mobility and its impact on career outcomes reveals mixed results. While mobility often decreases productivity in the short term (Baker, 2015), moving to a more prestigious institution has a weakly positive or negligible effect on publication numbers (Bolli & Schläpfer, 2013; Fernández-Zubieta et al., 2013). However, such moves can improve access to international funding and resources (Cañibano et al., 2008). Conversely, academic inbreeding, where institutions hire their graduates, tends to negatively affect productivity (Horta, 2013). Even though there is growing research investigating the impact of mobility on academic career outcomes, little is known about the effect on broader labour market outcomes for PhD graduates.

Conceptual framework

Our conceptual framework draws from two theoretical lenses grounded in behavioural economics: human capital theory and signalling theory. In contrast to the 'push–pull' model often invoked in studies of international student mobility (e.g. Caruso & de Wit, 2015; Restaino et al., 2020), this combined framework enables us to take into account structural considerations, not least the specific labour market circumstances of doctoral graduates, institutional and disciplinary stratification, and affords a theorisation of actors' behaviour on both the supply and demand side (i.e. of the decisions of employees and employers).

Human capital theory

Human capital, developed by the economist Gary Becker, refers to investments in knowledge, skills and experience made by an individual to enhance their position in the labour market (Becker, 1994). From this perspective, international experience can be understood as an investment in human capital that is valued and rewarded by employers (Jacob et al., 2019). If, as assumed, international experience enriches human capital, an individual will

enjoy enhanced labour market returns. Individuals are therefore incentivised to invest in international experience in order to secure a competitive advantage in the labour market.

Within the framework of human capital theory, individual motivations are not the only driving factor of human capital investments. Employer values matter also, and, in this example, organisations employing doctoral graduates must value time spent abroad. In rhetoric, policy and practice, universities and research organisations normatively uphold international experience. These institutions have an international operating model, predicated upon the transnational flow of people and ideas (Kwiek, 2021). These norms are reflected in the wider characterisation of the knowledge economy as being underpinned by cross-sector, border and disciplinary flows (e.g. Castells, 2010; Gibbons, 2010; Etzkowitz & Leydesdorff, 1997). The current age of 'global science' further normalises and rewards transnational collaboration (Marginson, 2022). Early career researchers may find it particularly beneficial to focus on developing an international profile, through a 'preferential attachment' with globally regarded individuals and institutions (Marginson, 2022, p.1568). For Marginson, the demonstration of 'global scientific networking is an unambiguous builder of individual status and careers' (Marginson, 2022, p. 1568).

International experience may be theorised as an investment in human capital if it confers an advantage on individuals in the labour market. The basis of the advantage is twofold: international experience is relatively rare and the labour market conditions are competitive. Few UK-domiciled doctoral graduates acquire international research experience during their doctorate, rendering this an exclusive asset to gain during the post-doctoral stage. The academic labour market is overcrowded, and employers are anticipated to favour applicants with international experience according to the dynamics of the knowledge economy and global science. International mobility can therefore be framed as a human capital investment that enables self-advancement amid the intense competition for academic and research employment.

Signalling theory

Signalling theory (Spence, 1973) extends the insights of human capital theory. Spence's articulation proceeds from the perspective of the employer. For Spence, the decision of whether or not to employ an individual is a process of interpreting signals in a context of significant uncertainty (Spence, 1973, p.356). Such interpretation is most challenging in crowded labour markets, where competing individuals must convey sophisticated signals of their productive capabilities.

Signals may be understood as characteristics that enable an individual to distinguish themselves in the labour market (Spence, 1973). Signals are 'alterable characteristics'—meaning they may be acquired or developed through the actions of the individual (Spence, 1973 p.367). Spence identifies educational qualifications as an exemplar signal, pursued by the individual and positively understood by the employer as an indicator of productivity. This is not to say that all educational qualifications are interpreted equally by employers. Organisations will seek nuance, especially in crowded fields of employment. Education qualifications awarded by well resourced, high-status institutions may be read as more prestigious, thereby reinforcing the stratified nature of higher education systems. Employers may also consider indices such as age, gender or ethnicity to evaluate individual productivity. Indices cannot be influenced by individual actions, but may inform an individual's response to the acquisition of positive signals (Spence, 1973, p.357).

International mobility may be sought by doctoral graduates as a signal of distinction in the competition for academic and research positions. Consistent with our understanding of international mobility as an investment in human capital, internationally mobile doctoral graduates are positioned to send a strong positive signal of high productivity and the traits and experiences normatively encouraged by global science: intercultural competence, an international network, collaborative working (Marginson, 2022). Put simply, signalling decisions and behaviours operate within a 'feedback loop' (Spence, 1973, p. 359). Academic and research employers positively relate the value of transnational exchange, and so it follows that doctoral graduates may seek international experience to enhance their employment prospects. Peer modelling is also relevant here; as individuals with the same preferences are expected to make similar decisions (Spence, 1973, p.360). If doctoral graduates observe international mobility rewarded among their peers, they may be incentivised to reproduce this behaviour. This is not to undermine the potential signalling strength of postdoctoral international mobility, which remains a relatively exclusive experience among UK-domiciled doctoral graduates.

Combining the insights of human capital theory and signalling theory, we anticipate that doctoral graduates with international mobility will experience labour market advantages, particularly in relation to academic and research employment, compared to their counterparts without such mobility. This is attributed to international mobility being perceived as a human capital investment leading to the development of specific skills, knowledge and networks that are explicitly sought after in academic and research sectors. International mobility experience sends a strong positive signal of productivity, intercultural competence and alignment with the global standards of scientific practices to academic and research employers.

Methods

Data

We used the Higher Education Statistics Agency's (HESA) Destination of Leavers from Higher Education (DLHE) survey between the 2012/2013 and 2016/2017 academic years to examine whether mobility (1) differs by graduates' socio-demographic background and PhD programme characteristics and (2) is associated with different early labour market outcomes, including a continuation in academic and research positions, 6 months after graduation. The DLHE survey collects information on the activities of graduates from the UK higher education system approximately 6 months after graduation (HESA, 2023). We also briefly explore the DLHE longitudinal survey, which collects information on employment 3.5 years after graduation for cohorts 2010/2011 and 2012/2013, to investigate the association between initial and later mobility. However, as highlighted in earlier research, the small sample size and missing data in longitudinal DLHE pose significant limitations to examining doctoral careers (Hancock, 2021).

The DLHE survey target population includes all students graduating from UK higher education institutions. Our analysis is restricted to doctoral graduates who were British nationals domiciled in the UK when they started their PhD programmes. We excluded non-UK PhD graduates because their motivations to be internationally mobile may differ from UK PhD graduates, such as returning to their home country. We also excluded UK doctoral graduates who were unemployed, taking time out in order to travel, or doing something

Table 1 Region of employment for UK-domiciled doctoral graduates six months after graduation

Region of employment	Number of cases	Percentage[a]
Central and East Asia	140	0.5
Europe (excluding the UK)	900	3.2
Latin America and the Caribbean	35	0.1
Middle East and North Africa	85	0.3
North America	740	2.6
Oceania	170	0.6
South Asia	25	0.1
Southeast Asia	75	0.3
Sub-Saharan Africa	65	0.2
UK (including UK islands and British overseas territories)	26,300	92.2
Total	28,535	100.0

[a]Percentages were not displayed to zero decimal places according to the HESA Standard Rounding Methodology to display greater precision

else (e.g. retired, looking after home or family) ($N=165$). Consequently, our analysis is focused on UK doctoral graduates who secured employment 6 months after graduation ($N=28{,}535$[1]). The DHLE response rates for graduates domiciled in the UK were over 78% for all the academic years that were analysed.[2] Even though the response rates for graduates with UK domicile are generally high, they can vary depending on the higher education (HE) provider and the amount of resources committed to different stages of the survey. It is therefore important to note that survey attrition selection bias was not factored into our analysis. Graduates who were internationally mobile may have been less inclined than those who remained in the UK to respond to the survey.[3] These caveats should be considered when interpreting the findings.

The data presentation follows the HESA Standard Rounding Methodology to reduce the risk of identifying individual survey respondents. Furthermore, we adhere to HESA guidelines by using the provided survey weight in order to establish a representative sample of the population.

Variables

To measure international mobility 6 months after PhD graduation, we assessed the variable for country of employment. Table 1 presents the number of cases and percentage for the region of employment 6 months after graduation. Since most UK-domiciled doctoral graduates enter the national labour market (92.2%), we subsequently focus on the binary of employment within/out of the UK.

[1] Weighted using the full person equivalent (FPE).

[2] Response rates for UK-domiciled graduate by academic year: 80% in 2012/13, 80.2% in 2013/2014 and 2014/2015, 79.5 in 2015/2016 and 78.8% in 2016/2017.

[3] HESA does not publish the characteristics of non-respondents of the DLHE survey.

We examined variables for doctoral graduates' socio-demographic background and degree characteristics to understand who moved abroad after graduation. To measure socio-demographic background, we used graduates' gender, ethnicity and age at the end of the PhD programme. To capture degree characteristics, we used field of doctoral study—arts and humanities; biological sciences; medical sciences; science, technology, engineering and mathematics (STEM) and social sciences—and the prestige of the doctoral higher education institution (Boliver, 2015; Wakeling & Savage, 2015)—Oxbridge, Other Golden Triangle, Other Russell Group, pre-1992 and post-1992. The categorisation of university prestige should be understood as reflecting hierarchies of prestige that are present in both empirical data and public discourse. It is subjective, performative and has tangible significance for the distribution of resources and influence.

The DLHE survey does not contain information on graduate ability or motivation. To approximate this, we considered: the primary source of PhD fees and mode of qualification (full-time or part-time). On the source of PhD fees, we assume that students granted funding for their PhD underwent a selection process which factored in their prior academic attainment and trajectory. Funding source—European or Overseas, UK research council or UK employer—might also affect the motivation to move abroad after graduation (e.g. to establish an international network, increase competitiveness in the international labour market). Studies have shown that PhD funding is associated with higher research productivity and visibility (Horta et al., 2016). Previous research has also identified differences between full-time and part-time PhD students in the UK (Clegg, 2004). While full-time students often have an aspiration to become academics or researchers, part-time students are frequently mature professionals 'in a reflexive enquiry into their own work-based practice' (Clegg, 2004, p. 155). Mode of study may thus be associated with differing inclinations for post-doctoral mobility. We included the variable for the academic year of entry to the PhD programme to control for any differences in cohorts.

To examine early labour market outcomes, we used logged salary, the UK Standard Occupation Classification (SOC) and Standard Industrial Classification (SIC), type of contract and the indicator for graduates employed in a postdoctoral position. The variable for logged salary comprises graduates' annual salary to the nearest thousand pounds (£) before tax. For comparability purposes, we only examined the salary differences for full-time working graduates. The UK SOC and SIC respectively classify occupations based on the required skill level and content; and industries by the type of activity they undertake. We created an indicator variable for managerial and professional occupations using the UK SOC and an indicator variable for employment in higher education and research using the UK SIC. Using the variable for the type of contract, we created an indicator variable for graduates in permanent or open-ended contracts.

Statistical approach

We applied two different statistical methods to answer our research questions. First, we examined the association between mobility beyond the UK and graduates' socio-demographic background and degree characteristics using the following logistic regression model:

$$P_i = \left(X_i = 1 | Z_i\right),$$

where P represents the probability of being international mobile ($X = 1$) 6 months after graduation for graduate i conditioned on covariates, Z. The findings section refers to the

average marginal effects (AME) to report the logistic regression results. The AMEs represent the percentage point difference in the predicted probability between each covariate's categories and its reference group. Negative AMEs indicate a smaller average or lower probability, while positive AMEs indicate a higher average or probability when compared to the reference groups.

Second, following Jacob et al. (2019), we estimate the relationship between mobility and early labour market outcomes using IPWRA. The doubly robust estimation of IPWRA means that the estimator remains consistent (i.e. gives unbiased estimates) as long as either the model for the probability of being internationally mobile or the model for the labour market outcome is correctly specified. The weighting step adjusts for differences in the probability of being internationally mobile across different groups, while the regression adjustment controls for confounding variables, leading to a more accurate effect on labour market outcomes.

The socio-demographic background and degree characteristics of doctoral graduates simultaneously influence their likelihood of pursuing international mobility and their early career outcomes. Therefore, using the logistic regression above, we first estimated the effect of doctoral graduates' socio-demographic background and degree characteristics on the probability of being mobile. Second, we run two regression models—linear for continuous and logistic for binary outcomes—to predict a particular labour market outcome for (1) graduates who were mobile ($X_i = 1$) and (2) graduates who were not mobile ($X_i = 0$) 6 months after graduation. Each model was weighted respectively by the inverse probability of moving beyond the UK 6 months after graduation and the inverse probability of staying in the UK 6 months after graduation:

$$Y_{i1} = \frac{\alpha_1 + \beta_1 Z_i + e_i}{P_i\left(X_i = 1 \middle| Z_i\right)}$$

$$Y_{i0} = \frac{\alpha_0 + \beta_0 Z_i + e_i}{\left[1 - P_i\left(X_i = 1 \middle| Z_i\right)\right]}$$

The difference in the early labour market outcomes of mobile and non-mobile PhD graduates—average treatment effect—is estimated by subtracting the weighted mean of mobile and non-mobile doctoral graduates. Although we employ a causal effect approach to account for the influence of covariates on the likelihood of being mobile and achieving early labour market outcomes, we acknowledge a directionality challenge. This is because, for example, while mobility could influence the type of employment agreement that PhD graduates secure, the type of agreement could also impact their likelihood of being mobile. As such, we focus solely on the correlation between mobility and early labour market outcomes when interpreting the findings.

Finally, we investigate the correlation between the mobility of graduates 6 months and 3.5 years after graduation through the DLHE longitudinal survey. As a result of the aforementioned data constraints, we chose to conduct solely bivariate analysis.

Findings

Who are the doctoral graduates who are mobile six months after graduation?

Figure 1 shows the AMEs of the logistic regression model on the probability of being mobile 6 months after graduation for UK-domiciled doctoral graduates. Although the

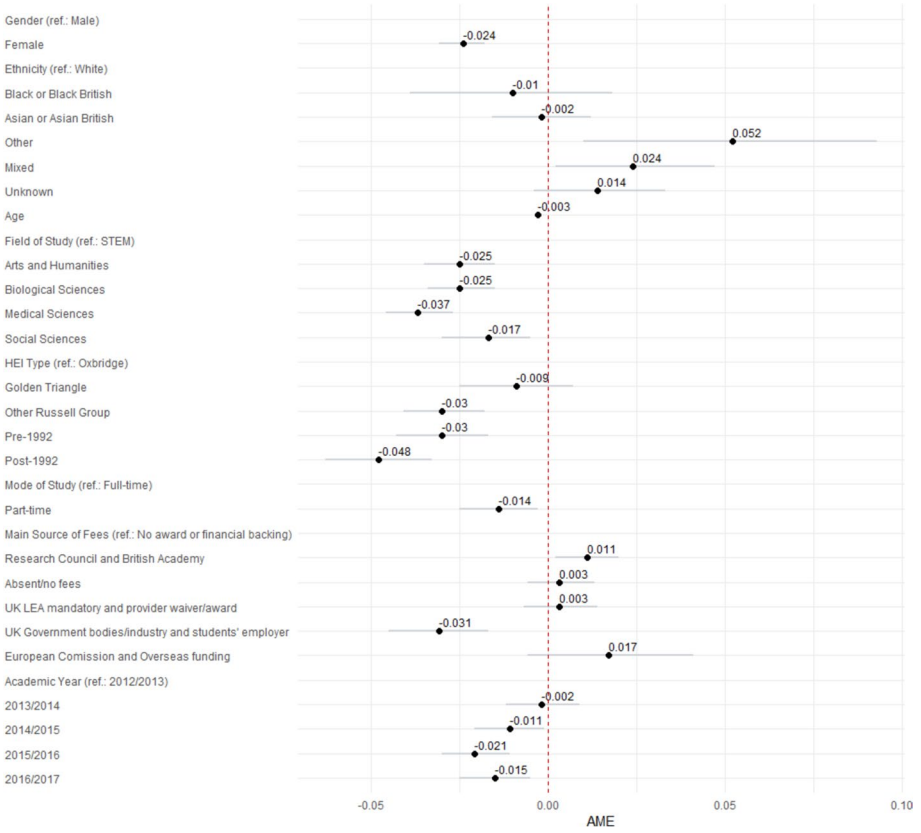

Fig. 1 AMEs of the logistic regression model on the probability of being mobile 6 months after graduation for UK-domiciled doctoral graduates

majority of the coefficients for the association between socio-demographic background, PhD programme characteristics and the likelihood of international mobility among doctoral graduates are statistically significant (see Appendix A for the logistic regression model coefficients).[4]

Female doctoral graduates were less likely to be mobile compared to male doctoral graduates by about a 2.4% point difference. The negative impact of gender on post-PhD mobility aligns with increasing research on gender disparities in academic mobility, which can be explained by traditional family patterns and gender roles (e.g. Leemman, 2010; Morley et al., 2018). Moreover, we found no statistically significant association between international mobility and ethnicity among doctoral graduates who declared White, Black or Black British, Asian or Asian British or with unknown ethnicity. Other and mixed-ethnicity doctoral graduates were more likely to be mobile compared to graduates who declared being White (5.2% and 2.4% point difference, respectively). While there is

[4] We examined interaction terms between gender and field of study and field of study and higher education type. They were not statistically significant and, for that reason, were not included in the final model.

increasing number of studies exploring the lack of academic representation from minority backgrounds, little is known about the relationship between ethnicity and mobility among academics. Therefore, future studies should focus on exploring this relationship. Older graduates were less likely to be mobile. A 1-year increase in age was associated with a 0.3% point difference decrease in the probability of being mobile.

Doctoral graduates from all other fields of study were less likely to be mobile compared to STEM fields of study (between − 1.7% for social science and − 3.7% for medical science). PhD graduates from other Russell Group, pre-1992 and post-1992 higher education institutions are less likely to be mobile when compared to Oxbridge PhD graduates. The difference in the percentage point difference probability is higher for post-1992 graduates, 4.8% compared to Oxbridge. Graduates of the Universities of Cambridge and Oxford have strong labour market outcomes in the UK relative to other groups of graduates (Sutton Trust, 2009). It is unlikely that Oxbridge doctoral graduates leave the UK out of necessity. Rather it is plausible that international mobility is a choice made by Oxbridge doctoral graduates, facilitated by the far reaching reputation of their institutions and leveraging international connections made while studying there (Tholen et al., 2013). Research in the USA similarly indicates that the place of graduation significantly impacts future career prospects (Smith-Doerr, 2006).

Part-time doctoral graduates were less likely to move abroad after graduation when compared to full-time graduates (1.4% point difference). The main source of PhD programme fees had a mixed association with the probability of international mobility after doctoral graduation. We found no statistically significant difference in the probability of moving abroad for doctoral graduates who had no fees (absent and UK LEA mandatory and provider waiver) or had European Commission and Overseas funding compared to self-funded graduates. Doctoral graduates funded by the UK Research Councils or British Academy were more likely to move abroad when compared to graduates who were self-funded by a 1.1% point difference. Graduates funded by the UK government or an employer were less likely (by − 3.1%) to be mobile. We found a negative association between mobility and the academic year of entry into the PhD programme across the last three academic years. Since the EU was the primary destination of mobile UK PhD graduates, post-Brexit migration sentiment and policy change may explain the decrease in mobility.

Examining the DLHE longitudinal survey ($n = 1855$), we found a strong association ($r = 0.6$) between international mobility 6 months after graduation and international mobility 3.5 years later. As can be seen in Fig. 2, some 58% of the PhD graduates who were internationally mobile at 6 months were employed outside of the UK 3.5 years after PhD graduation.

What are the labour market outcomes for international mobile doctoral graduates?

Figure 3 shows the percentage change in the early labour market outcome for internationally mobile PhD graduates compared to the outcome mean for PhD graduates who stayed

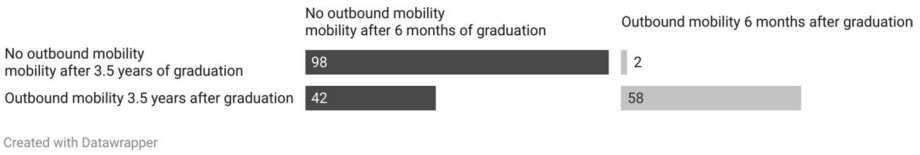

Fig. 2 Association between mobility 6 months and mobility 3.5 years after graduation

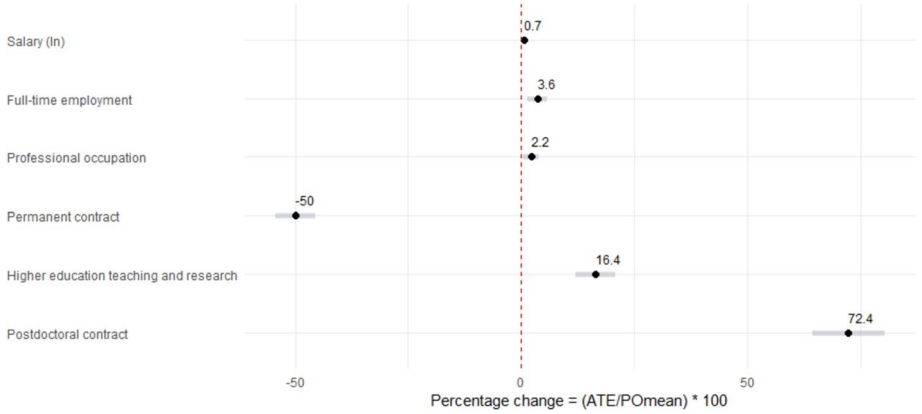

Fig. 3 Percentage change in the early labour market outcome for PhD graduates who moved abroad compared to the outcome mean for PhD graduates who stayed in the UK with the 95% confidence interval

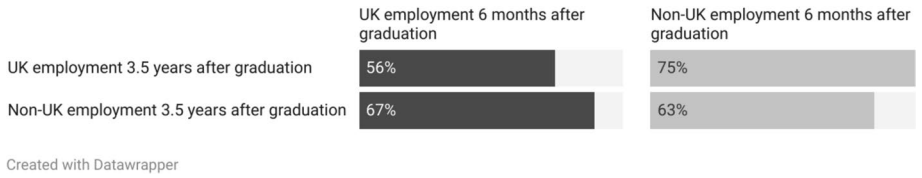

Fig. 4 Percentage of PhD graduates in academic employment by location and time of employment

in the UK (with a 95% confidence interval). Appendix B presents the estimated average treatment effect (ATE) and the estimated outcome means (POmean) (mobile vs. non-mobile graduate) for all early labour market outcomes.

International mobility 6 months after the PhD graduation has a small association with salary for graduates who were in full-time employment.[5] Internationally mobile graduates had, on average, a 0.7% higher salary than those who stayed in the UK. However, because we do not adjust for the relative cost of living in the country of destination, we cannot draw conclusions on the extent to which the higher salary is an advantage. Mobile graduates were more likely to be employed full-time and in a professional occupation (a percentage change of 3.6% and 2.2%, respectively, compared to graduates who stayed in the UK). International mobility 6 months after graduation may also be associated with continuing in an academic job. In our models, being mobile is associated with a 16.4% increase in higher education teaching and research employment and a 72.4% increase in employment on a postdoctoral contract compared to non-mobile graduates. We found a negative relationship between permanent contracts and mobility, with a percentage change of − 50%. Nevertheless, this association can be explained by the high number of mobile graduates employed on postdoctoral contracts.

Considering employment 3.5 years after graduation, we find a further association between international mobility and academic trajectories (see Fig. 4). Doctoral graduates

[5] Graduates in part-time employment were excluded from the analysis due to comparability reasons.

who remained continuously in the UK reported the lowest rate of academic employment (56%) compared to those who were mobile during their early career. Doctoral graduates who were mobile 6 months after graduation and were back in the UK 3.5 years later were most likely to be in an academic job (75%). Those who became or remained mobile at the time of the follow-up survey also reported higher rates of academic employment (67% and 63%, respectively). However, this association should be considered with caution as it is based on the small sample size in longitudinal DLHE.

Concluding discussion

Researching the international mobility of doctoral graduates is a complex undertaking, with geopolitical, economic and asymmetrical power differences intersecting with demographic characteristics, fields of study and higher education institutions to shape individual trajectories. This article has explored whether the mobility of UK-domiciled PhD graduates differs by socio-demographic background and PhD programme characteristics, and if mobility is associated with different labour market outcomes, including a continuation in academic and research positions.

The logistic regression model used to investigate differences in the probability of international mobility among UK doctoral graduates suggests that individual socio-demographic background and PhD programme characteristics have a statistically significant effect on international mobility 6 months after graduation. Although the magnitude of this effect is small, it emphasises the need for a nuanced characterisation of the factors that influence international doctoral mobility. We did not include a correction for multiple comparisons in the logistic regression model, which could increase the likelihood of type I errors. Given the number of associations tested on the same dataset, our findings should be considered exploratory rather than confirmatory. Future research may benefit from applying appropriate corrections to validate these associations.

Institutional and disciplinary stratification are significant factors in the international mobility patterns of UK doctoral graduates. International mobility is significantly higher among Oxbridge and STEM doctoral graduates, even though they possess relatively privileged access to skilled employment in the UK (de Vries, 2014). The IPWRA reveals intriguing labour market outcomes for internationally mobile doctoral graduates. The small positive association between international mobility and PhD graduates' salary soon after graduation is consistent with the literature on student mobility (Netz & Cordua, 2021). International mobility after the PhD is highly associated with the probability of securing an academic and research role or a postdoctoral contract 6 months after graduation. Our findings are congruent with existing research on scientific careers which identifies a 'mover's advantage'; likely explained by mobile researchers joining environments that are better resourced, provide opportunities for interaction with high-performing colleagues, and which in turn heighten productivity (Holding et al., 2024). Our dataset does not enable us to investigate the influence of mobility on academic productivity or alignment to research institutions. Subsequent research should concentrate on understanding the distinct knowledge advantages that mobile individuals may possess in a new environment (Hoisl, 2007), as well as the supportive role that mobility could play in facilitating better alignment between researchers' skills and institutional expertise (the match between employee and employer) (Fernadez-Zubieta, Geuna & Lawson, 2013).

Since the DLHE dataset imparts little about individual decision-making, interpreting doctoral mobility patterns is not without challenge. On the basis of our analysis, we tentatively suggest that the higher rates of international mobility among Oxbridge PhD and STEM graduates may reflect decision-making informed by an overcrowded and precarious academic labour market, the high esteem of these degrees in the international educational market, and an anticipated positional advantage for future career progression.

In this context, international mobility can be framed as a human capital investment that enables self-advancement amid the intense competition for academic and research employment. Our observations of the association between international mobility and academic employment at 3.5 years would suggest that these assumptions are borne out. The norms of the knowledge economy and global science provide a framework in which institutions logically favour doctoral graduates with international experience. For the same reason, international mobility may also act as a positive signal of productive capability, particularly in relation to the traits sought and rewarded by global science: intercultural competence, an international network, collaborative working (Marginson, 2022). If international experience remains a relatively exclusive experience among UK-domiciled doctoral graduates, its potential for creating distinction in the academic labour market—and the conceptual insights afforded by human capital and signalling theory, will persist.

Future scholarship in this area should prioritise the collection of qualitative data from mobile doctoral graduates to further understand how individual agency, decision-making and epistemic culture influence career choices and investments in human capital. There is a need for additional longitudinal data to understand if the early international mobility enhancements we detected affect labour market outcomes and career pathways in the longer term; and to disentangle selection effects in estimating the advantages of mobility (Holding et al., 2024). The case for richer data on doctoral career pathways is articulated elsewhere (Hancock et al., 2019). Whether international mobility persists, and continues to be associated with different types of doctoral graduates and career trajectories, cannot be answered by existing datasets on doctoral graduates in the UK.

Our insights are germane to a variety of stakeholders concerned with continuing doctoral expansion and its connection to research, innovation and the wider economy. The outcomes observed in our dataset will better inform prospective and current PhD students, and those supporting them, of likely career outcomes following the doctorate and the possible advantages of mobility. Our findings also prompt reflection on why certain types of doctoral graduates are more mobile than others. Universities and research funders should relate these observations to ongoing initiatives to ensure equity across academic and research careers. The combined effects of Brexit and changing international relations have cast uncertainty over the global positioning of UK higher education. Internationally mobile doctoral graduates may be a minority in the UK system, but they are an elite group. The UK higher education landscape—currently beset with insecure finances, precarious employment, limited postdoctoral training opportunities and an apparent retreat from the global scientific community—may be perceived by home and overseas researchers alike as an unattractive place to forge an academic career (Marini, 2024). The UK government's decision in late 2023 to rejoin Horizon Europe, the largest international research collaboration scheme in the world indicates a renewed commitment to supporting researcher mobility and transnational knowledge diffusion. Such actions may prove to be critical to attract and retain doctoral graduates and safeguard the standing of the UK in global science.

Appendix A

Table 2 Coefficients, standard errors (S.E.) and confidence interval (C.I.) for the logistic regression model on the probability of being mobile 6 months after graduation for UK-domiciled doctoral graduates (weighted using FPE)

	Estimates		S.E	95% C.I		Odds ratio
Sex (ref.: male)						
Female	−0.35	**	(0.05)	−0.44	−0.25	0.71
Ethnicity (ref.: White)						
Black or Black British	−0.15		(0.23)	−0.61	0.30	0.86
Asian or Asian British	−0.03		(0.10)	−0.23	0.17	0.97
Other	0.59	**	(0.20)	0.20	0.97	1.80
Mixed	0.30	*	(0.13)	0.05	0.56	1.36
Unknown	0.19		(0.12)	−0.04	0.42	1,21
Age	−0.04	**	(0.00)	−0.04	−0.03	0.97
Field of study (ref.: STEM)						
Arts and humanities	−0.33	**	(0.07)	−0.47	−0.19	0.72
Biological sciences	−0.33	**	(0.07)	−0.47	−0.20	0.72
Medical sciences	−0.53	**	(0.08)	−0.68	−0.38	0.59
Social sciences	−0.22	**	(0.09)	−0.39	−0.06	0.80
HEI type (ref.: Oxbridge)						
Golden Triangle	−0.11		(0.09)	−0.29	0.08	0.90
Other Russell Group	−0.37	**	(0.07)	−0.51	−0.24	0.69
Pre-1992	−0.38	**	(0.08)	−0.54	−0.22	0.68
Post-1992	−0.67	**	(0.11)	−0.89	−0.46	0.51
Mode of study (ref.: full-time)						
Part-time	−0.21	*	(0.09)	−0.39	−0.04	0.81
Main source of fees (ref.: no award or financial backing)						
Research Councils and British Academy	0.15	*	(0.06)	0.03	0.28	1.17
Absent/no fees	0.04		(0.07)	−0.09	0.18	1.05
UK LEA mandatory and provider waiver/award	0.05		(0.08)	−0.10	0.20	1.05
UK government bodies/industry and students' employer	−0.57	**	(0.16)	−0.88	−0.27	0.56
European Commission and Overseas funding	0.20		(0.15)	−0.06	0.52	1.26
Academic year (ref.: 2012/2013)						
2013/2014	−0.02		(0.07)	−0.16	0.11	0.98
2014/2015	−0.15	*	(0.07)	−0.29	−0.01	0.86
2015/2016	−0.29	**	(0.07)	−0.43	−0.15	0.75
2016/2017	−0.20	**	(0.07)	−0.34	−0.06	0.82
Intercept	−0.51	**	(0.16)	−0.82	−0.21	0.60

Number of cases (unweighted): 30,203.

***$p < 0.001$, **$p < 0.01$, *$p < 0.05$.

Appendix B

Table 3 Average treatment effect (ATE) and potential-outcome mean (POmean) for logged salary for full-time employed PhD graduates, estimated using inverse-probability weighted regression adjustment (weighted using FPE)

Treatment-effects estimation	Number of obs (unweighted) = 17,355	
Estimator: IPW regression adjustment		
Outcome model: linear		
Treatment model: logit		
		Coefficient
ATE	Location employment	
	(non-UK vs. UK)	0.08
POmean	Location employment	
	UK	10.42

Table 4 Average treatment effect (ATE) and potential-outcome mean (POmean) for the indicator of full-time employment for PhD graduates, estimated using inverse-probability weighted regression adjustment (weighted using FPE)

Treatment-effects estimation	Number of obs (unweighted) = 30,203	
Estimator: IPW regression adjustment		
Outcome model: logit		
Treatment model: logit		
		Coefficient
ATE	Location employment	
	(non-UK vs. UK)	0.03
POmean	Location employment	
	UK	0.83

Table 5 Average treatment effect (ATE) and potential-outcome mean (POmean) for the indicator of professional occupation for PhD graduates estimated using inverse-probability weighted regression adjustment (weighted using FPE)

Treatment-effects estimation	Number of obs (unweighted) = 30,183	
Estimator: IPW regression adjustment		
Outcome model: logit		
Treatment model: logit		
		Coefficient
ATE	Location employment	
	(non-UK vs. UK)	0.02
POmean	Location employment	
	UK	0.89

Table 6 Average treatment effect (ATE) and potential-outcome mean (POmean) for the indicator of permanent contract for PhD graduates estimated using inverse-probability weighted regression adjustment (weighted using FPE)

Treatment-effects estimation	Number of obs (unweighted) = 30,203	
Estimator: IPW regression adjustment		
Outcome model: logit		
Treatment model: logit		
		Coefficient
ATE	Location employment (non-UK vs. UK)	−0.25
POmean	Location employment UK	0.50

Table 7 Average treatment effect (ATE) and potential-outcome mean (POmean) for the indicator of higher education teaching and research employment for PhD graduates estimated using inverse-probability weighted regression adjustment (weighted using FPE)

Treatment-effects estimation	Number of obs (unweighted) = 30,203	
Estimator: IPW regression adjustment		
Outcome model: logit		
Treatment model: logit		
		Coefficient
ATE	Location employment (non-UK vs. UK)	0.09
POmean	Location employment UK	0.55

Table 8 Average treatment effect (ATE) and potential-outcome mean (POmean) for the indicator of postdoctoral contract for PhD graduates estimated using inverse-probability weighted regression adjustment (weighted using FPE)

Treatment-effects estimation	Number of obs (unweighted) = 29,683	
Estimator: IPW regression adjustment		
Outcome model: logit		
Treatment model: logit		
		Coefficient
ATE	Location employment (non-UK vs. UK)	0.21
POmean	Location employment UK	0.29

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Data availability Access to the data is restricted due to copyright and licensing agreements. The data was delivered as a tailored dataset via Jisc Services Limited on behalf of HESA.

Declarations

Competing interests The authors have no competing interests to declare that are relevant to the content of the article.

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