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Does intersectoral labour mobility pay for academics?

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Abstract Labour mobility plays a significant role in the diffusion of knowledge and economic growth. In this study, we examined academics' incentives for mobility among university, private sector and government jobs. Using register data on doctoral degree holders in Finland, we found that moving from academia to the private sector is related to higher subsequent earnings, particularly among young academics and in hard sciences. However, frequent mobility across sectors was related to lower subsequent earnings.

Keywords Mobility · Academics · Triple helix · Academia · Private sector · Public sector · Wage · Earnings

Introduction

Universities play a central role in producing new knowledge and diffusing it into society, for example, through student education, research articles and joint projects with private sector firms. In addition to these three pathways, labour mobility among organizations, sectors and regions may have a significant effect on the knowledge diffusion process (Aslesen et al. 2008; Hommen and Doloreux 2003; Power and Lundmark 2004; Hoisl 2007; Lenzi 2009). Recent studies have proposed that this also applies to academics. According to Ejsing et al. (2011) and Herrera et al. (2010), the mobility of academics from the public to the private sector may have a considerable effect on private sector firm productivity. Academics may have knowledge that is complementary to the existing knowledge base of the firm, which may be particularly advantageous for innovation (Herrera et al. 2010). Similarly, academics' ability to formulate, structure and solve complex problems is highly valued in the commercial sector (Zellner 2003).

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Although there is evidence that academics' intersectoral mobility may contribute to better firm performance and, thus, to economic growth (e.g., Ejsing et al. 2011; Herrera et al. 2010), the incentives, particularly the pecuniary incentives, for academics to leave academia have received limited attention. The literature also typically concentrates on the mobility of specific groups of scientists, such as research and development (R&D) researchers, between universities and industry (see e.g., Herrera et al. 2010; Zellner 2003; Zucker et al. 2002; Crespi et al. 2007). What has also been ignored to a large extent is the role that the government sector plays in academic mobility.

Our paper augments this literature by providing evidence on academic mobility in Finland. In this study, we define academics as doctoral degree holders who worked in the university sector or in state research institutions (university for short) in Finland in the year 2000. We follow these individuals' labour mobility between 2000 and 2005 and examine whether their mobility was associated with their subsequent earnings during the period 2006–2010. This study contributes to the previous literature in three major ways. First, we shed light on the incentives of academics to leave academia. If intersectoral mobility is associated with subsequent earnings, it could indicate that either financial incentives and penalties or that ability-based selection are associated with mobility. Second, we focus on mobility among three sectors of the economy, i.e., academia, the private sector and government. The so-called triple helix concept emphasizes that the interaction among these three sectors is a key element for knowledge creation and diffusion (Etzkowitz and Leydesdorff 1995). Thus, our paper augments the previous literature, which concentrates on the mobility between academia and the private sector, by also acknowledging government as the third sector of the economy. Third, our data are from a total sample of Ph.D.s who worked in the university sector in the year 2000. Our paper therefore extends the previous literature which is based on highly selected groups of top scientists and patent holders.

This paper is organized as follows. "Labour mobility, knowledge transfer and academics' incentives for mobility" section presents the analytical framework. "Academic career system in Finland" section describes the academic career system in Finland. " Data and results" section presents the data and results, and the final section concludes.

Labour mobility, knowledge transfer and academics' incentives for mobility

Knowledge transfer and firm productivity

Previous empirical research has shown that labour mobility may play a significant role in firm productivity by facilitating the transfer of knowledge between firms (Almeida and Kogut 1999; Rosenkopf and Almeida 2003; Song et al. 2003). Much of the previous literature emphasizes the benefits of labour mobility on innovation activity and performance, although the transfer of knowledge may not always be straightforward (Cohen and Levinthal 1990; Katz and Allen 1982; Kessler et al. 2000; Maliranta et al. 2009). Labour mobility may also reduce firms' incentives for R&D investments because there is a threat that an employee may depart and transfer the knowledge embodied in people to another firm (Castillo et al. 2016; Kim and Marschke 2005; Møen 2007).

Universities and state research institutes also play a key role in knowledge production and diffusion. The main channels for knowledge diffusion include (1) training students; (2) developing scientific articles; (3) professional networking; (4) consulting; (5) joint industry-academia research and development (R&D) projects; and (6) board work in private sector companies (see e.g., Cohen et al. 2002). However, the transferability of new knowledge via the aforementioned methods may be limited because of the tacit nature of such knowledge. Therefore, labour mobility is considered an important way of transferring knowledge among universities, the public sector and private sector companies (Fritsch and Krabel 2012; Kim and Marschke 2005). Through job mobility, university employees transfer tacit and explicitly codified knowledge and university networks to other economic sectors (Nonaka 1994; Nonaka and Takeuchi 1995; Garavelli et al. 2002).

Empirical studies have suggested that the mobility of academics may have a significant effect on firm productivity, which even exceeds the effects achieved by private sector labour mobility (Ejsing et al. 2011). For example, Herrera et al. (2010) found that researchers from the public R&D system increased firms' innovation efforts and performance, and according to Agrawal (2006), engaging an academic inventor during the development phase of a new product increased the likelihood of its successful commercialization. Supporting the view that academics may have a significant impact on firms' innovation potential, Czarnitzki et al. (2008) and Zucker and Darby (1998) found that the knowledge produced by research institutions was more likely to lead to radical innovations than was the knowledge produced in the private sector. In summary, based on the previous empirical research, academics' sectoral mobility may play a significant role in innovation activity and performance.

Although there is evidence that academics may promote firm productivity and growth, the convertibility of academics' knowledge between sectors may not be straightforward. Academics may not be used to private sector working habits, and their professional networks may be biased and consist primarily of other academics (Ejsing et al. 2011). In contrast, knowledge that is relevant in private sector operations may not be easily converted into high-quality academic research. Therefore, the transferability of human capital between different sectors of economy may be modest. However, when academic knowledge is easily commercializable, the transmission of academic human capital into the private sector is facilitated better, which may influence academics' labour mobility and subsequent earnings (Fritsch and Krabel 2012; Zellner 2003).

Individual incentives for academics' sectoral mobility

Although there is evidence that the academics' intersectoral mobility may contribute to better firm performance and, thus, to economic growth, there is much less evidence about whether intersectoral mobility benefits the academics. Academics have made extensive investments in their academic human capital in the early stages of their career, and they later seek returns on these investments (Bercovitz and Feldmann 2006). Whether the economic return in terms of earnings is maximized by staying in academia or by moving between sectors is unclear theoretically. It has been argued (Ejsing et al. 2011) that university researchers could augment their scientific and technical human capital, including professional networks, by moving between academia and the private sector (see also Azoulay et al. 2017). Based on this view, academics' sectoral mobility could result in more versatile human capital, which may also translate into higher earnings. However, the possibility of receiving economic gains from intersectoral mobility depends on the transferability of human capital across academia, the private sector and government. In the short run, mobile academics may also be willing to accept lower wages if they are anticipating higher wages in the future (Maliranta et al. 2009).

The preference for an academic career may also affect academics' intersectoral mobility. Careers in academia may provide recognition for discoveries and substantial discretion in choosing research projects (Aghion et al. 2008; Stern 2004). These factors may reduce academics' willingness to switch from academia to private sector or government occupations. Moreover, based on the findings of Stern (2004), in many cases, academics seem to have academic aspirations insofar as they are willing to face a compensating wage differential to participate in science. The possibility of receiving recognition for discoveries may therefore cause an ability-based selection across sectors if more talented individuals, who are more likely to receive recognition, are also more prone to choose an academic career. Similarly, discretion over one's work may cause selection, as those who value autonomy may be more prone to stay in academia.

Sectoral mobility may also be associated with migration or commuting, which creates both push and pull factors for academics' intersectoral mobility. At the end of an employment contract, an academic may be forced to migrate or commute if (s)he desires to continue in an academic career. However, if an academic is not willing to migrate or commute because of the costs involved, (s)he might be forced to switch sectors. Indirect financial effects include removal and travelling expenses. Migration may further involve "psychic" costs, which are related to the loss of familiar surroundings and friends in the case of migration (Sjaastadt 1962) or increased symptoms of stress associated with commuting (e.g., Costal et al. 1988; Kluger 1998; Stutzer and Frey 2004). Migration may also induce non-monetary returns in the form of amenities, such as mild weather, or a supply of cultural events (Chen and Rosenthal 2008). Earlier research has further emphasized the role of a couple's co-location problem in the migration decision. In this framework, the migration decision is based on family net gain. Thus, the family decides to migrate only if the sum of the benefits of migrating outweighs the costs of migrating taken over all family members (see e.g., Compton and Pollak 2007). For example, top scientists' (particularly women's) willingness to move may decrease when their children are of high school age because the loss of their children's social networks reduces the family's net gains associated with migration (Azoulay et al. 2017; Shauman and Xie 1996).

Academic career system in Finland

The number of doctorate-level degrees has risen rapidly in Finland over the past 25 years. For example, in 2009, the number of doctorate degrees was three times higher than it was at the beginning of the early 1990s (Official Statistics of Finland 2009). In 2009, approximately 58% of doctoral degrees were awarded in natural sciences, technology and medicine. Despite the rapid increase in the number of doctorate holders compared to the rest of the population, their unemployment rates have remained low (2% in 2007), and their employment rates have remained high (80% in 2007) (Ministry of Education and Culture 2010).

According to Pietilä (2015), the previous literature has identified four stages in the Finnish academic career path. During the first stage, doctoral students work on their doctoral thesis, typically on a fixed-term contract. After obtaining a doctoral degree, they can apply for vacant post-doctoral positions, which are also typically for a fixed term. There are no requirements to change institutions after obtaining a doctoral degree. However, the scarcity of post-doctoral positions and graduates' willingness to change institutions may induce labour mobility among recent doctoral graduates. The third-stage positions (e.g., lecturer) are typically permanent positions and are based on an open call for applications. The fourth stage includes professors and research directors. These positions are typically permanent, and there is usually an open call for recruitment. In an exceptional case, an invitation for a professorship is also possible. A significant share of academic employment is fixed-term, and possibilities for advancement within the university are usually based on vacancies.

Most doctoral degree graduates continue working in the public sector after graduation,[1] and most of them are employed at universities or public research institutions. In 2007, 37.8% of doctoral degree holders worked in the university sector, and 8.6% worked in public-sector research institutions. The university sector in Finland consists of universities and Universities of Applied Sciences (UAS), which are funded primarily through the state budget. In 2005 (the midpoint of our inspection period), there were 20 universities that employed 14,950 university staff members (excluding Ph.D. students) who worked in research and teaching positions. The network of UAS was launched after a trial period in 1996, and in 2005, there were 29 UAS located across Finland, employing approximately 5960 teachers, 7.4% of whom had a doctoral degree (Ministry of Education 2006). State research institutes, such as the National Institute for Health and Welfare and the Technical Research Centre of Finland (VTT), constitute a significant part of the publicly funded research efforts in Finland. These state research institutes, which mainly employ researchers with doctoral degrees, contribute substantially to Finland’s research and innovation system. In addition to universities and state research institutes, another major public-sector employer is the health care system, which employed 19.8% of doctorate holders in 2007. Most of them were medical doctorates who worked for municipalities (local governments) that are responsible for providing healthcare to their residents.

Based on the mobility patterns of academics during 2006–2007, doctorate holders who left academia typically switched to health care or public administration (Ministry of Education and Culture 2010). In 1999, approximately 15% of doctorate holders worked in the private sector (Husso 2002 cited in Tohtoreiden työllistyminen and sijoittuminen ja tarve 2003). Since the 2000s, the share of doctorate holders in private-sector work tasks has increased. In 2007, the private sector employed approximately one-quarter of doctorate holders (Ministry of Education and Culture 2010). The most common private-sector employment was among technical scientists (33% in the year 1999), whereas among the humanities, private-sector employment was only 6% (Tohtoreiden työllistyminen and sijoittuminen ja tarve 2003). In the private sector, the most significant employers in 2007 were the business services and information technology industries (Ministry of Education and Culture 2010).

Data and results

To examine the mobility of doctoral degree holders, we used register data on the total Finnish population under 70 years of age provided by Statistics Finland. Our individual-level data came from several administrative registers, such as Longitudinal Population Census (LPC) data, which includes annual information on background characteristics such

[1] The average age of obtaining a Ph.D. degree is relatively high in Finland. For example, the average age of those who obtained their Ph.D. degree in 2000 was 32.4 (Tohtoreiden työllistyminen and sijoittuminen ja tarve 2003). In our sample, the mean age of obtaining a Ph.D. was 35 (median 34), which is in line with the aforementioned statistics.

as age and gender, starting from 1987. The LPC was linked to the Longitudinal Employment Statistics File using unique personal identifiers. This register dataset contains annual information on the work experience and earnings of all individuals in Finland between 1987 and 2012. Employment Statistics records an individual's main employment relationship during the last week of each year. This information originates from the state-run pension registers that cover all legal employment contracts. The information on the highest completed degree was based on the Statistics Finland's Register of Completed Education and Degrees, which was also linked to data by using unique identifiers. The use of rich longitudinal register data for all residents of Finland allowed us to avoid potential problems related to sample selection and measurement error resulting from self-reported information.

In this study, we concentrated on doctoral degree holders who worked in the university sector (including universities and government research institutions) in Finland in the year 2000. These data include doctorate holders at different stages of their career, including professors and recent doctoral graduates.[2] These individuals' intersectoral labour market mobility was examined between 2000 and 2005. Based on this information, the doctoral degree holders were divided into four groups: (1) Stayers = worked in the university sector during the whole period of 2000–2005; (2) Dual university-private (dual UP) workers = worked both in the university and private sector during the period of 2000–2005; (3) Dual university-government (dual UG) workers = worked both in the university and government sector during the period 2000–2005; and (4) Triple helix (UPG and UGP) workers = worked in all three sectors during 2000–2005. Government sector workers include Ph.D.s who worked in a state- or municipality-owned organisation but were not employed in teaching or research positions. This includes, for example, administrative positions at municipalities and ministries as well as health care professions at hospitals and health centres. In the baseline models, the subjects may have changed sectors several times. For example, an individual who first worked in the university sector, then changed to the private sector and finally returned to the university sector, is defined as a dual UP worker. As a robustness check, we further examined how the frequency of intersectoral mobility affects the results.

The variable means and standard deviations are shown in Table 1. The results are summarized separately for stayers, dual UP workers, dual UG workers and triple helix workers. Most doctorate holders in our sample ($N = 5012$) stayed in the university sector during the period 2000–2005. The most typical intersectoral mobility was between the university sector and government (dual UG mobility, $N = 1144$). The number of dual UP workers was 598, and the number of triple helix workers was 192. Those who stayed in the university sector during the whole period of 2000–2005 were typically older individuals with higher earnings. Sectoral mobility between universities and the private sector was more frequent in engineering, whereas mobility that involved the government sector (either dual UG or triple helix) was more typical in education and medicine and in the Helsinki region, where the capital of Finland is located. The results concerning mobility to the government sector are reasonable, given that the government sector is the main provider of education and health care in Finland and that many government occupations are located in the Helsinki area. Intersectoral mobility, particularly UG and triple helix mobility, was less frequent in science and among non-Finnish-speaking individuals. The results thus suggest that language may create barriers for labour mobility among non-Finnish speakers, for

[2] We do not observe the doctorate holders' exact titles or positions in the data. However, we are able to control for their career age (time since doctorate degree in 2000) and earnings in 2000, which serve as proxies for the career stage.

Table 1 Descriptive statistics

	(1) All	(2) Stayers	(3) Dual: University private	(4) Dual: University government	(5) Triple helix	(6) Kruskal–Wallis/Chi squared
Log earnings 2006–2010	10.646 (1.093)	10.729 (0.694)	10.467 (1.580)	10.398 (1.823)	10.514 (1.564)	1.296
Career age in 2005 (mean, SD)	8.796 (7.887)	9.237 (7.734)	6.478 (7.908)	8.351 (8.317)	7.141 (7.558)	144.530***
Age in 2005 (mean, SD)	49.111 (8.475)	49.756 (8.047)	45.295 (9.526)	48.632 (9.020)	47.029 (8.947)	166.124***
Log earnings in 2000 (mean, SD)	10.579 (0.480)	10.602 (0.418)	10.491 (0.569)	10.539 (0.627)	10.486 (0.616)	47.010***
Women (share)	0.326 (0.469)	0.306 (0.461)	0.313 (0.464)	0.406 (0.491)	0.411 (0.493)	48.533***
Field of education in 2005 (share, SD)						
Engineering	0.208 (0.406)	0.220 (0.414)	0.286 (0.452)	0.120 (0.325)	0.177 (0.383)	81.466***
Education	0.051 (0.220)	0.049 (0.216)	0.035 (0.184)	0.059 (0.235)	0.099 (0.299)	13.909***
Humanities and arts	0.122 (0.328)	0.127 (0.333)	0.110 (0.314)	0.111 (0.314)	0.109 (0.313)	3.433
Social sciences, business and law	0.172 (0.377)	0.169 (0.375)	0.176 (0.381)	0.185 (0.389)	0.156 (0.364)	2.174
Science	0.270 (0.444)	0.292 (0.454)	0.211 (0.408)	0.223 (0.416)	0.161 (0.369)	46.808***
Agriculture	0.036 (0.186)	0.038 (0.192)	0.027 (0.162)	0.031 (0.172)	0.031 (0.174)	3.339
Medicine, health and welfare	0.118 (0.322)	0.079 (0.270)	0.145 (0.353)	0.250 (0.433)	0.245 (0.431)	298.803***
Services	0.024 (0.152)	0.026 (0.158)	0.010 (0.100)	0.022 (0.146)	0.021 (0.143)	5.983 (0.112)
Unknown	0.000 (0.021)	0.001 (0.024)	0 (0)	0 (0)	0 (0)	1.158 (0.763)
Marital status in 2005 (share, SD)						
Single	0.145 (0.353)	0.149 (0.356)	0.162 (0.369)	0.129 (0.336)	0.094 (0.292)	8.382**
Married	0.737 (0.440)	0.735 (0.441)	0.744 (0.437)	0.730 (0.444)	0.802 (0.399)	4.748
Divorced	0.107 (0.309)	0.110 (0.313)	0.087 (0.282)	0.110 (0.313)	0.078 (0.269)	4.755
Widow(er)	0.011 (0.103)	0.006 (0.077)	0.007 (0.082)	0.031 (0.172)	0.026 (0.160)	58.725***
Area of residence in 2005 (share, SD)						
Helsinki region	0.428 (0.495)	0.405 (0.491)	0.460 (0.499)	0.494 (0.500)	0.542 (0.500)	43.694***
Other university region	0.454 (0.498)	0.510 (0.500)	0.343 (0.475)	0.294 (0.456)	0.302 (0.460)	228.740***
Other	0.099 (0.299)	0.085 (0.279)	0.124 (0.330)	0.141 (0.348)	0.135 (0.343)	39.627***

Table 1 continued

	(1) All	(2) Stayers	(3) Dual: University private	(4) Dual: University government	(5) Triple helix	(6) Kruskal–Wallis/Chi squared
Language in 2005 (share, SD)						
Finnish	0.900 (0.301)	0.893 (0.309)	0.895 (0.307)	0.919 (0.273)	0.967 (0.174)	17.313***
Swedish	0.074 (0.262)	0.077 (0.267)	0.075 (0.264)	0.068 (0.252)	0.026 (0.160)	7.688*
Other	0.026 (0.161)	0.030 (0.170)	0.030 (0.171)	0.013 (0.114)	0.005 (0.072)	13.911**
N	6946	5012	598	1144	192	

Kruskal–Wallis and Chi squared tests statistics are reported for continuous and dichotomous variables, respectively. Significant at the * 10%, ** 5%, and *** 1% level example, because requirements to speak Finnish reduce mobility or because non-Finnish speaking people prefer work communities where people share the same linguistic background. There are also positions, particularly in the government sector, that require additional licensing if the completed qualification was obtained in a non-EU/ETA member state (e.g., doctors), and there are few positions that are open to only Finnish citizens (e.g., military officer). This may reduce the possibility of foreign non-Finnish-speaking academics switching to the government sector.

Table 1 also presents the Kruskal–Wallis and Chi square test statistics that were used to analyse whether the mobility groups differed in terms of observable background variables. Based on the results, there were significant differences in the background variables between groups. Therefore, to avoid omitted variable bias, we controlled for these characteristics in our subsequent estimations.

To estimate the connection between sectoral mobility and subsequent earnings, we estimated a Mincer-type (1974) wage regression, where the log of average earnings over the period 2006–2010 was regressed on sectoral mobility indicators and other explanatory variables. The additional explanatory variables include age, gender, field of education, region of work, marital status, and mother tongue, which were all measured in the year 2005. Despite the multitude of control variables, there might still be non-observable differences between groups that are not considered by our control variables. We therefore also controlled for earnings in 2000, which may capture these non-observable differences. We also controlled for the career age in the year 2005 (i.e., time since doctorate degree in 2005), the average years of employment and the share of self-employment years over the period 2006–2010. The coefficients of primary interest were the indicator variables for dual UP and UG workers and triple helix mobility, which equalled "1" if the person had switched sectors between 2000 and 2005, as described above.

The OLS results from the earnings regressions are reported in Table 2. The Baseline I model in Column 1 shows significant wage penalties for dual UP, dual UG and triple helix mobility. The magnitude of the wage penalty is relatively high: Compared to university sector stayers, dual and triple helix mobility were associated with approximately 30 percent lower earnings during 2006–2010. Because the mobility coefficients may partly reflect differences in employment, in the Baseline II model (Column 2), we controlled for the average years of employment during 2006–2010. This reduced the estimated mobility coefficients significantly, suggesting that the wage penalties in Column 1 partly reflect differences in employment.

Earlier research suggests that labour mobility patterns may depend on age. For example, Kim and Marschke (2005) found that young scientists are more mobile than their older colleagues are. Therefore, we estimated separate models for individuals who were "young" (under 48 years of age) and those who were "old" (at least 48 years of age) in 2005.[3] Based on the results among young workers, dual UP and triple helix mobility were associated with higher subsequent earnings, whereas among old doctorate holders, intersectoral mobility was related to lower earnings. To assess the potential differences between disciplines, we estimated the model separately for "soft sciences" (education, humanities and arts) and "hard sciences" (science and engineering).[4] The results indicated a negative relationship between earnings and dual UG mobility in the hard sciences, whereas in the soft sciences, both dual UP and dual UG mobility were related to lower earnings. Overall,

[3] The threshold of 48 was chosen because the median age in our baseline sample was 48.

[4] The disciplines of agriculture, social sciences and health were excluded because it was not clear whether these disciplines should be considered "hard" or "soft" sciences.

Table 2 OLS results from earnings regression

	(1) Baseline I	(2) Baseline II	(3) Young	(4) Old	(5) Hard sciences	(6) Soft sciences
Sectoral mobility (reference group: stayers)						
Dual: University private (UP)	−0.334*** (0.065)	−0.027 (0.043)	0.084** (0.032)	−0.210** (0.103)	0.000 (0.062)	−0.204* (0.115)
Dual: University government (UG)	−0.372*** (0.052)	−0.141*** (0.030)	−0.005 (0.028)	−0.295*** (0.053)	−0.208** (0.060)	−0.301*** (0.068)
Triple helix	−0.261** (0.107)	−0.067 (0.072)	0.048** (0.052)	−0.305** (0.145)	−0.019 (0.093)	−0.085 (0.112)
Average employment years 2006–2010		x	x	x	x	x
Test for equality of mobility coefficients (*F*-statistics)						
Dual UP versus dual UG	0.22	4.15**	3.32*	0.49	5.49**	0.44
Dual UP versus triple helix	0.35	0.22	1.22	0.27	0.03	0.55
Dual UG versus triple helix	0.89	0.87	7.61**	0.00	2.85*	2.66
R^2	0.146	0.576	0.539	0.594	0.570	0.616
N	6946	6946	3136	3810	3316	1368

Significant at the * 10%, ** 5%, and *** 1% level. Heteroscedasticity-robust standard errors are reported in parentheses. The dependent variable is the log of average earnings over the period 2006–2010. All models include controls for age, gender, field of education, region of work, marital status, career age and mother tongue, which were measured in the year 2005. All models also control for the log of earnings in the year 2000 and the share of self-employment years over the period 2006–2010. In Column (3), the estimation sample includes individuals who were under 48 years of age in 2005 ("young"). In Column (4), the estimation sample includes individuals who were at least 48 years of age in 2005 ("old"). Hard sciences refers to science and engineering, and soft sciences refers to education, humanities and the arts the wage penalties in the soft sciences seem to be higher compared to those in the hard sciences. We also used the *F*-statistics to test for the equality of mobility coefficients in Table 2. The results in the Baseline II model suggest that working in the government sector gives a higher wage penalty than observed for the UP workers. This applies particularly to young workers and academics in the hard sciences. Additionally, the coefficients for dual UG and triple helix mobility are significantly different among the young and in the hard sciences.

To assess the robustness of the baseline results, we used treatment effects estimation. Treatment methods are intuitively appealing because they aim to model the counterfactual, i.e., what would have happened to the treatment group without the treatment. The drawback is that the method assumes that there is no selection bias based on unobservable characteristics. We estimated a multinomial-logit Inverse Probability Weighting (IPW) model, which jointly considers multiple treatments through multinomial logit and constructs suitable counterfactuals by using probability weights (see e.g., Takeshima et al. 2016).[5] The results are presented in detail in "Appendix 1". The negative coefficients for dual and triple helix mobility are in line with our baseline results in Table 2, suggesting that intersectoral mobility is related to lower subsequent earnings.

The definition of dual and triple helix mobility in Table 2 allowed individuals to change sectors multiple times during the period of 2000–2005. To examine whether the frequency of intersectoral mobility affects our results, we next limited the number of sector changes to 1 (dual UP and dual UG workers) or 2 (triple helix workers). Thus, the analysis included only stayers and doctorate holders who, having changed sectors once, did not return over the period 2000–2005. The results based on these "non-frequent" mobility patterns are tabulated in Table 3. Based on the results in Column (1), dual UP mobility was associated with higher subsequent earnings. Otherwise, the mobility coefficients were statistically insignificant. However, the results seem to differ between subgroups. Among young academics, dual UP, dual UG mobility and triple helix mobility were related to higher earnings, whereas among old academics, the coefficients of both dual UP and dual UG mobility indicated a wage penalty. Mobility from the university sector to the private sector and triple helix mobility were related to higher earnings in the hard sciences. However in the soft sciences, dual UG mobility was related to lower earnings.[6]

Table 4 reports the results based on university sector stayers and individuals with "frequent" intersectoral mobility. An individual's mobility pattern is defined as "frequent" if the person switched sectors multiple times during 2000–2005. For example, a frequent dual UG worker changed sectors at least two times: from the university sector to the government sector and then back to the university sector. In a similar fashion, a triple helix worker switched sectors at least three times during the period 2000–2005. The results in Table 4 suggest that the negative associations between intersectoral mobility and subsequent earnings shown in Table 2 were driven mainly by individuals with frequent intersectoral mobility. The baseline results in Column (1) show a negative association between earnings and dual mobility. The wage penalty for dual UG and dual UP mobility is particularly evident among old academics. Dual UG mobility was also related to lower

[5] We used Stata command teffects in the analysis.

[6] We also divided the triple helix mobility into two subgroups: (1) doctorate holders who moved from the university sector to the private sector and then to the government (UPG triple helix) and (2) doctorate holders who changed from the university sector to government and then to the private sector (UGP triple helix). Both triple helix coefficients were statistically insignificant in the baseline model of Table 3. Thus, the order in which the intersectoral mobility occurred does not seem to matter.

Table 3 OLS results from earnings regression (non-frequent mobility)

	(1) Baseline	(2) Young	(3) Old	(4) Hard sciences	(5) Soft sciences
Sectoral mobility (reference group: stayers)					
Dual: University private (UP)	0.072* (0.039)	0.130*** (0.025)	−0.264* (0.150)	0.156*** (0.031)	−0.155 (0.129)
Dual: University government (UG)	0.027 (0.020)	0.075*** (0.019)	−0.103* (0.053)	0.008 (0.031)	−0.189** (0.077)
Triple helix (UPG or UGP)	−0.054 (0.102)	0.149** (0.050)	−0.321 (0.266)	0.126** (0.050)	−0.064 (0.151)
Test for equality of mobility coefficients (*F*-statistics)					
UP versus UG	1.03	3.25	1.01	12.82***	0.05
UP versus triple helix	1.31	0.13	0.03	0.27	0.21
UG versus triple helix	0.58	2.00	0.63	4.21**	0.57
R^2	0.553	0.532	0.191	0.579	0.214
N	5970	2655	3315	3007	1145

Notes: Non-frequent mobility: sector changes are limited to 1 (dual UP and dual UG workers) or 2 (triple helix workers) during the period 2000–2005. Significant at the * 10%, ** 5%, and *** 1% level. Heteroscedasticity-robust standard errors are reported in parentheses. The dependent variable is the log of average earnings over the period 2006–2010. All models include controls for age, gender, field of education, region of work, marital status, career age and mother tongue, which were measured in the year 2005. All models also control for the log of earnings in year 2000 and the average employment years and the share of self-employment years over the period 2006–2010. In Column (2), the estimation sample includes individuals who were under 48 years of age in 2005 (“young”). In Column (3), the estimation sample includes individuals who were at least 48 years of age in 2005 (“old”). Hard sciences refers to science and engineering, and soft sciences refers to education, humanities and the arts

Table 4 OLS results from earnings regression (frequent mobility)

	(1) Baseline	(2) Young	(3) Old	(4) Hard sciences	(5) Soft sciences
Sectoral mobility (reference group: stayers)					
Dual: University private (UP)	−0.142* (0.079)	0.033 (0.061)	−0.374** (0.161)	−0.265 (0.161)	−0.257 (0.155)
Dual: University government (UG)	−0.286*** (0.051)	−0.074 (0.057)	−0.486*** (0.085)	−0.420*** (0.118)	−0.445*** (0.108)
Triple helix	−0.081 (0.106)	0.132* (0.068)	−0.350 (0.214)	−0.230 (0.220)	−0.101 (126)
Test for equality of mobility coefficients (*F*-statistics)					
UP versus UG	1.92	1.20	0.35	0.52	0.79
UP versus triple helix	0.21	1.02	0.01	0.02	0.59
UG versus triple helix	2.87*	5.87*	0.33	0.54	3.83**
R^2	0.589	0.568	0.603	0.583	0.625
N	5988	2558	3430	2871	1235

Frequent mobility: Dual UG/UP worker has changed sector at least two times (UPU or UGU) and triple helix worker at least three times during the period 2000–2005. Significant at the * 10%, ** 5%, and *** 1% level. Heteroscedasticity-robust standard errors are reported in parentheses. The dependent variable is the log of average earnings over the period 2006–2010. All models include controls for age, gender, field of education, region of work, marital status, career age and mother tongue, which were measured in year 2005. All models also control for the log of earnings in the year 2000 and the average employment years and the share of self-employment years over the period 2006–2010. In Column (2), the estimation sample includes individuals who were under 48 years of age in 2005 ("young"). In Column (3), the estimation sample includes individuals who were at least 48 years of age in 2005 ("old"). Hard sciences refers to science and engineering, and soft sciences refers to education, humanities and the arts subsequent earnings in both the hard and soft sciences. Among young academics, triple helix mobility was related to higher earnings.

The frequency of intersectoral mobility seems to play a major role in our results. Because dual UP and dual UG mobility in Table 3 involve only one mobility event, whereas the triple helix case involves two events, comparing these coefficients may be problematic. Therefore, as a robustness check, we fixed the number of sector changes to two in both dual and triple helix mobility. In the case of dual UG and dual UP workers, this implies that the workers returned to the university sector after working in the government sector or private sector. The results in "Appendix 2" show that this reduces the relative advantage of dual mobility in the baseline model among young individuals and in the hard sciences. This may indicate the importance of the frequency of mobility or selection in the results, as those who returned to the university sector differed from those who stayed in the private or government sectors after the change.

Conclusions

Knowledge plays a significant role in innovation activity and economic growth. One way to promote knowledge diffusion in the economy is labour mobility, which has been linked to increased innovation activity and performance (e.g., Agrawal 2006; Ejsing et al. 2011; Herrera et al. 2010; Castillo et al. 2016). In this study, we focused on the intersectoral mobility of academics, defined as doctoral degree holders who worked at universities or state research institutions in the year 2000. Academics have made extensive investments in their academic human capital. They have typically developed an ability to formulate, structure and solve complex problems and can have a significant effect on innovation activity and performance in private- and government-sector occupations (e.g., Herrera et al. 2010; Czarnitzki et al. 2008; Zucker and Darby 1998; Agrawal 2006; Ejsing et al. 2011). The labour mobility of academics may therefore have a significant effect on economic growth.

Here, we focused on the financial incentives and compared the earnings of mobile doctorate holders with the earnings of those who stayed in the university sector during the period 2000–2005. We found that in certain cases, non-frequent mobility was related to higher earnings. In particular, non-frequent dual university—private (dual UP) mobility, dual university—government (dual UG) mobility and triple helix mobility were related to higher earnings among young academics, and non-frequent dual UP mobility and triple helix mobility were associated with higher earnings in the hard sciences. In the soft sciences, dual UG mobility was related to lower earnings. Frequent mobility was typically associated with lower subsequent earnings. Old academics in particular seemed to be penalized by frequent dual UP and UG mobility.

The differences in results concerning frequent and non-frequent mobility may reflect the possibility that frequent mobility across sectors reduces the ability of academics to acquire sector-specific information, which would be essential for their labour market success. Another possibility is that there were omitted variables, such as differences in ability, which may explain different earnings consequences from infrequent and frequent mobility. Employers may also consider frequent previous job mobility as a negative signal regarding an employee's likelihood to stay in a position, which may weaken a job seeker's future employment prospects (e.g., King et al. 2005). Another notable result was that whereas young academics may benefit from intersectoral mobility, the economic gains may be limited among older academics. It is likely that particularly talented older academics have already reached a high position in the university sector; therefore, their possible gains from intersectoral mobility can be limited. Whether intersectoral mobility is voluntary may also depend on age. Among young academics, there may be individuals who have less interest in an academic career and are thus more willing to change sectors. Older academics, instead, have already made the decision to continue in their academic career and presumably have discovered that the requirements of an academic career provide a good match with their skills and knowledge (Munasinghe and Sigman 2004; Carless 2005). Another possibility is that young academics, who are typically on fixed-term contracts, are forced to look for new opportunities also outside academia.

Based on our results, mobility from the university to the private sector (UP or triple helix mobility) may bring economic gains in the hard sciences, whereas in the soft sciences, the earnings returns from UP mobility are statistically insignificant. While the results may again reflect non-random selection (i.e., omitted variables drive the results), it is also possible that the transferability of academic human capital into private sector purposes is easier in the hard sciences. The absence of economic gains from mobility in the soft sciences could also partly explain the finding of Fritsch and Krabel (2012) that working in the private sector is less interesting to humanities researchers.

Our results suggest that the incentives to leave academia may differ between subgroups. Whether intersectoral mobility should be made more appealing, for example, among older academics or in the soft sciences remains unclear. Policy implications would require further knowledge on the transferability of "soft science" academic human capital across sectors.

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Appendix 1

We estimated a multinomial-logit Inverse Probability Weighting (IPW) model that jointly considers multiple regimes through multinomial logit and constructs suitable counterfactuals through by using probability weights (see, e.g., Takeshima et al. 2016). The explanatory variables in the multinomial logit are the same as those used in the OLS baseline model. Tables 5, 6 and 7 reports the raw and model-adjusted differences in means and the ratios of variances between the treated and untreated groups for each covariate. As Tables 5, 6 and 7 show, the differences in the means before weighting were relatively large. After weighting, the differences in means are typically smaller, and the variance ratios are, in most cases, close to one. The diagnostics indicate that the inverse probability-weighted samples are more comparable across regimes than the unweighted samples. Thus, the diagnostics support the assumption that our model balances covariates. Table 8 presents the estimated average treatment effects on the treated as estimated by multinomial IPW. The negative coefficients are in line with our baseline results in Table 2.

Table 5 The model-adjusted difference in means and ratio of variances between the treated (dual UP) and untreated (stayers) for each covariate

	Standardized differences raw	Standardized differences weighted	Variance ratio raw	Variance ratio weighted
Employment years 2005–2010	−0.193	−0.067	2.074	1.397
Self-employment years 2005–2010	0.343	0.005	32.657	1.236
Log earnings in 2000	−0.221	−0.017	1.853	1.594
Gender (male)				
Female	0.014	0.043	1.013	1.379
Career age in 2005	−0.353	0.042	1.045	1.379
Age in 2005 (below 30)				
Age 30–39	0.475	−0.081	1.816	0.955
Age 40–54	−0.144	0.048	1.007	1.007
Age 55–	−0.306	0.036	0.689	1.065
Field of education in 2005 (engineering)				
Education	−0.071	0.027	0.724	1.152
Humanities and arts	−0.051	0.008	0.887	1.020
Social sciences, business and law	0.018	0.004	1.033	1.007
Science	−0.187	0.029	0.806	1.043
Agriculture	−0.065	0.014	0.707	1.089
Medicine, health and welfare	0.211	0.033	1.706	1.070
Services	−0.119	0.016	0.396	1.177
Area of residence in 2005				
Other university region	−0.342	0.039	0.903	1.028
Other	0.125	0.018	1.390	1.044
Marital status in 2005 (married)				
Single	0.036	0.026	1.073	1.051
Divorced	−0.077	−0.086	0.812	0.794
Widow(er)	0.009	−0.016	1.118	0.794
Language in 2005 (Finnish)				
Swedish	−0.007	−0.019	0.980	0.941
Other	0.003	0.007	1.020	1.042
N	598	1736.4	598	1736.4

Table 6 The model-adjusted difference in means and ratio of variances between the treated (dual UG) and untreated (stayers) for each covariate

	Standardized differences raw	Standardized differences weighted	Variance ratio raw	Variance ratio weighted
Employment years 2005–2010	−0.218	−0.095	2.419	1.635
Self-employment years 2005–2010	0.048	−0.146	1.820	0.482
Log earnings in 2000	−0.119	0.002	2.243	1.509
Gender (male)				
Female	0.209	0.069	1.136	1.058
Career age 2005	−0.111	0.057	1.156	1.243
Age in 2005 (below 30)				
Age 30–39	0.157	−0.112	1.312	0.935
Age 40–54	−0.052	0.052	1.007	1.008
Age 55–	−0.078	0.071	0.931	1.126
Field of education in 2005 (engineering)				
Education	0.041	0.022	1.177	1.124
Humanities and arts	−0.049	−0.009	0.891	0.978
Social sciences, business and law	0.043	−0.012	1.076	0.979
Science	−0.158	0.012	0.839	1.018
Agriculture	−0.042	0.006	0.805	1.040
Medicine, health and welfare	0.473	0.070	2.571	1.150
Services	−0.026	0.053	0.853	1.647
Area of residence in 2005				
Other university region	−0.452	0.001	0.831	1.001
Other	0.175	0.067	1.549	1.161
Marital status in 2005 (married)				
Single	−0.057	0.042	0.888	1.082
Divorced	0.000	−0.082	1.002	0.803
Widow(er)	0.184	−0.013	4.985	0.867
Language in 2005 (Finnish)				
Swedish	−0.034	0.004	0.894	1.013
Other	−0.114	0.001	0.452	0.995
N	1144	1677.6	1144	1677.6

Table 7 The model-adjusted difference in means and ratio of variances between the treated (triple helix) and untreated (stayers) for each covariate

	Standardized differences Raw	Standardized differences weighted	Variance ratio raw	variance ratio weighted
Employment years 2005–2010	−0.147	−0.229	1.626	1.775
Self-employment years 2005–2010	0.295	−0.031	25.976	1.131
Log earnings in 2000	−0.220	−0.120	2.170	1.495
Gender (male)				
Female	0.220	0.117	1.146	1.094
Career age in 2005	−0.275	0.061	0.955	1.090
Age in 2005 (below 30)				
Age 30–39	0.276	−0.076	1.534	0.958
Age 40–54	−0.090	0.115	1.013	1.010
Age 55–	−0.156	−0.059	0.857	0.893
Field of education in 2005 (engineering)				
Education	0.190	0.028	1.912	1.159
Humanities and arts	−0.054	0.111	0.883	1.285
Social sciences, business and law	−0.034	−0.062	0.944	0.892
Science	−0.315	0.052	0.659	1.078
Agriculture	−0.039	−0.007	0.825	0.958
Medicine, health and welfare	0.460	0.027	2.546	1.059
Services	−0.033	0.010	0.817	1.113
Area of residence in 2005				
Other university region	−0.432	0.186	0.848	1.107
Other	0.160	−0.005	1.506	0.988
Marital status in 2005 (married)				
Single	−0.170	0.025	0.673	1.049
Divorced	−0.109	0.041	0.739	1.102
Widow(er)	0.160	−0.012	4.282	0.867
Language in 2005 (Finnish)				
Swedish	−0.232	−0.114	0.358	0.669
Other	−0.187	0.119	0.182	1.766
N	192	1784.4	192	1784.4

Table 8 Multinomial-logit inverse probability weighting results from earnings regression

Compared regimes	Coefficient
University private (UP) versus stayer	−0.139** (0.057)
University government (UG) versus stayer	−0.318*** (0.089)
Triplehelix versus stayer	−0.423** (0.176)
N	6943

Significant at the * 10%, ** 5%, and *** 1% level. Heteroscedasticity-robust standard errors are reported in parentheses. The dependent variable is the log of average earnings over the period 2006–2010. The model includes controls for age, gender, field of education, region of work, marital status, career age, and mother tongue, which were measured in the year 2005. The model also controls for the log of earnings in the year 2000 and the average employment years and the share of self-employment years over the period 2006–2010

Appendix 2

See Table 9.

Table 9 OLS results from earnings regression

	(1) Baseline	(2) Young	(3) Old	(4) Hard sciences	(5) Soft sciences
Sectoral mobility (reference group: stayers)					
Dual: University private (UPU)	0.062 (0.040)	0.086** (0.043)	0.030 (0.073)	0.065 (0.063)	−0.012 (0.067)
Dual: University government (UGU)	0.031 (0.051)	0.001 (0.027)	0.051* (0.030)	0.102*** (0.032)	−0.084* (0.043)
Triple helix (UPG or UGP)	−0.031 (0.103)	0.168*** (0.050)	−0.247 (0.213)	0.123** (0.050)	0.006 (0.156)
Test for equality of mobility coefficients (*F*-statistics)					
UPU versus UGU	0.48	2.89*	0.07	0.29	0.84
UPU versus triple helix	0.71	1.57	1.50	0.53	0.01
UGU versus triple helix	0.34	8.79**	1.89	0.12	0.32
R^2	0.572	0.595	0.579	0.592	0.602
N	5543	2344	3199	2731	1115

The number of sector changes is fixed to two in both dual and triple helix mobility. Significant at the * 10%, ** 5%, and *** 1% level. Heteroscedasticity-robust standard errors are reported in parentheses. The dependent variable is the log of average earnings over the period 2006–2010. All models include controls for age, gender, field of education, region of work, marital status, career age and mother tongue, which were measured in the year 2005. All models also control for the log of earnings in the year 2000 and the average employment years and the share of self-employment years over the period 2006–2010. In Column (2), the estimation sample includes individuals who were under 48 years of age in 2005 ("young"). In Column (3), the estimation sample includes individuals who were at least 48 years of age in 2005 ("old"). Hard sciences refers to science and engineering, and soft sciences refers to education, humanities and the arts

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