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ABSTRACT

To Be or Not to Be... a Scientist?*

Policy makers generally advocate that to remain competitive countries need to train more scientists. Employers regularly complain of qualified scientist shortages blaming the higher wages in other occupations for luring graduates out of scientific occupations. Using a survey of recent British graduates from Higher Education we report that fewer than 50% of science graduates work in a scientific occupation three years after graduation. The wage premium observed for science graduates stems from occupational choice rather than a science degree. Accounting for selection into subject and occupation, the returns to working in a scientific occupation reaches 18% and there is no return to a science degree outside scientific occupations. Finally, scientists working in a scientific occupation are more satisfied with their educational and career choices, which suggests that those not working in these occupations have been pushed out of careers in science.

JEL Classification: I21, J24, J44

Keywords: science, graduate, labour market

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I Introduction

Despite a doubling in the number of graduates since the early Nineties some sectors of the UK economy, especially those related to science and engineering, still report difficulties in the recruitment of graduates (see DIUS (2008) and references therein or ACE (2008) for specific evidence in the construction engineering sector). A shortage of workers in scientific occupations is a recurrent issue and a flurry of reports has thus been commissioned by recent governments to identify the determinants of the supply of science graduates (Roberts, 2002; Lambert, 2003; Royal Society, 2006; Sainsbury, 2007). The concern is that skills shortages reduce investments in R&D and have long-term consequences on productivity (Forth and Mason, 2006; Nickell and Nicolitsas, 2000). This debate is not unique to the UK and a similar angst about the country's readiness for the knowledge economy and competitiveness also exists in the US (Freeman, 2006, Adams, 2009) and Europe (European Commission, 2003).

Indeed, the intake in science subjects has recently grown at a slower pace than in non-scientific ones (11% vs. 15%) (HESA, 2002/2007). Moreover, most of the growth has come from subjects with less intensive scientific requirements[1] and "hard science" has been at most stable[2]. Concomitantly the supply of science in higher education has been reduced by the closures of physics and chemistry departments including some high profile ones (House of Commons, 2005).

[1] Out of the extra 12,600 students graduating from science between 2002 and 2007 half originated from Psychology (+ 2,800), Sport Science (+ 2,600) and forensic science (+1,000). The other science subjects that had a large increase in the number of graduates are health subjects: Medicine (+ 2,000) and Associated to medicine (+6,800).

[2] Roberts (2002) also reports that the number of students in Engineering, Mathematics and Physics declined between 1995 and 2000. A reclassification of degree subjects in Higher Education Statistic Agency (HESA) statistics in 2001 make it problematic to build a longer time series.

Moreover, there is a widespread belief that science graduates are lured to non-scientific occupations like finance which value their numerical skills and offer higher wages. Roberts (2002) calculates that six months after graduations almost half of the new science graduates work outside manufacturing and R&D. Clearly there is a large "wastage"[3] of science graduates in the labour market. As such, the answer to any shortage of scientists may thus be more in increasing the retention of qualified scientists in scientific occupations rather than training more scientists; especially when considering their higher training costs[4] and that due to curriculum choices in secondary schools, the potential for expanding the number of science graduates may be limited (Royal Society, 2006).

Using the Longitudinal Destination of Leavers of Higher Education (LDLHE) survey which pertains to a sample of UK graduates from the 2003 cohort observed in November 2006, we replicate most of the findings from previous studies but in a common framework and after controlling for a large array of confounding factors. We also expand the literature by accounting for selection both into a science degree and into a scientific occupation. We find that on average science graduates employed full time earn 6.5% more than non-science graduates. These estimates increase considerably when accounting for selection into science at university, suggesting negative selection, i.e. students with worse unobservable characteristics graduates from science. However the returns to a science degree drops to 2% -3% when controlling for occupation and should thus be considered an occupational premium.

[3] Throughout the paper we will use wastage in the very specific of science graduates not working in a scientific occupation; these graduates may nonetheless be using their scientific skills, especially those who teach science, and have large public returns. More generally, "the wider societal benefits of having people with a science or math background in areas such as journalism, law, politics, […], and more generally, as citizens , are increasingly well understood" (Royal Society, 2006, p55) but will be ignored here.

[4] The Higher Education Funding Council for England (HEFCE) provides universities with block grants for funding. The formula used to calculate these grants accounts for four categories of subject costs. For an undergraduate full time student the HEFCE notional grant rate in 2008 varies from £5,484 for science (non medical) subjects to £2,709 for non-science subjects.

This conclusion remains when accounting for selections into science subject and scientific occupation. Finally, science graduates, especially when working in a scientific occupation are more satisfied with their occupational and educational choices.

II Literature review

Several studies have documented the large differences in earnings between graduates from different subjects in the UK (see Blundell et al. (2000), Chevalier (2011), Naylor et al. (2002) or Walker and Zhu (2008, 2010) for recent examples). Despite the disparities of data used, the general conclusion is that the wage premium to a science degree reaches 10% compared to humanities. These large differences in the returns to higher education are not specific to Britain, and are reasonably similar in France, Germany and the US (Machin and Puhani (2006), Grogger and Eide (1995)).

However, these studies do not account for selection; i.e. graduates have some unobservable characteristics that make them choose a given subject but are also correlated with earnings. Jointly estimating subject choice (four broad categories) and earning, to account for this selection Bratti and Mancini (2003) find that the returns to subject in the UK become unstable, often jumping from one year to the next by 10 to 30 percentage points, casting doubts on the identifying strategy.

The causality could also be reversed since the human capital model assumes that education decisions are based on the expected future earnings. In the US, Berger (1988) using the NLSY, reports that after accounting for subject selection the present value of future earnings rather than starting salaries affects subject choice positively. Using differences in business cycles to identify the selection effect, Beffy et al.

(2011) estimate that the elasticity of expected wages on subject choice is rather small in France; a 10% increase in expected wages increases participation in a science subject by 2 percentage points. While Arcidiacono (2004) using the National Longitudinal Study of the Class of 1972 estimate a dynamic model of major and college choice and reports that future monetary returns do not drive the major choice.

The second question is assessing why science graduates work in non-scientific occupations. Borghans et al. (2000) report that workers working in fields unrelated to their studies have lower earnings than subject-matched workers. Research on the labour market of scientists is rather limited. An example is Bender and Heywood (2006) who use a survey of U.S. doctoral recipients in science and social sciences to investigate labour market mismatch. They show that science doctorates are 5% to 7% less likely to have a job closely related to their education than economists, resulting in lower job satisfaction and greater turnover. Freeman (2006) points out that in the U.S. the labour market conditions have worsened in science and engineering compared to other occupations thus reducing the supply of science graduates. Roberts (2002) and Sainsbury (2007) also highlight that in the UK part of the supply difficulties originate from teaching quality in secondary and tertiary education as well as inadequacies between curriculum and employers desired skills. None of these papers account for the endogenous selection into occupation.

III Data description

This study relies on the LDLHE, a survey which was conducted in November 2006 amongst a random sample of higher education leavers[5] who typically graduated between June and July 2003. The sampled population contains leavers from higher

[5] The survey only includes individuals who were UK domiciled prior to attaining higher education.

education who responded to a questionnaire administered by the Higher Education Statistic Agency (HESA) six months after graduation: Destination of Leavers of Higher Education (DLHE). The response rate in the DHLE reaches 75%. A sample of 55,900 of these original respondents is contacted three years after graduation by HESA to take part in the LDLHE; 24,823 responded to either a postal, phone or online questionnaires. Tipping and Taylor (2007) provide evidence in favour of the representativeness of the survey. Accounting for item non-response on the earnings question leaves us with 19,979 observations. We then select first degree holders only, aged 18 to 25 on graduation, non-special entry students and who are currently observed in employment. This leads to a sample of 9,296 observations (See Table A1 for details on the sample selection). Science degrees are defined using the official Science, Technology, Engineering and Mathematics (STEM) breakdown.

To describe the labour market decisions of graduates, we define scientific occupations using the 5-digit SOC2000 codes. In the first panel of Table 1, we report the proportion of graduates in different occupation by STEM status. Just under half of science graduates are found to work in a scientific occupation[6] A career that is often thought to compete for science graduates is finance where the analytical skills of science graduates are in high demand. Overall, 5% of graduates work in finance. This proportion is 4% for science graduates[7]. Thus the financial sector is unlikely to be an important factor to the general shortage of graduates in scientific occupations. Science graduates are also in high demand in teaching which accounts for 10% of science graduates employment three years after graduation. With the exception of graduates from medical studies, the retention of scientific graduates into scientific occupations appears relatively low.

[6] Roberts (2002) using an alternative definition based on industry rather than occupation also finds that under half of the scientific graduates work in a scientific occupation.

[7] However, for math graduates this fraction reaches 20%.

Wage differential could of course explain these choices. The LDLHE reports annual gross pay. We recode 36 observations with an unusually high salary – compared to their occupation average earning - which were due to coding errors (additional zero) and drop 149 individuals who claim to earn less than the national minimum wage (assuming they worked 52 weeks a year). The descriptive statistics are calculated for full time individuals only. The distribution of earnings for science and other graduates in October 2006 is reported in Figure 1. The distribution for scientists lies on the right of the one for non-scientists – even when excluding medics who have significantly higher earnings than other science graduates.

The distribution of earnings for science graduates by occupation is reported in Figure 2. The distribution is narrow, with a mode around £23,000, for teachers since they are mostly employed in the public sector. The distribution of earnings in science occupations has a similar mode but is more dispersed. For scientists working in finance, the distribution of earnings is flatter with a substantial mass between £30,000 and £40,000. The earning distribution in other occupations is to the left of the other three occupations but with very large dispersion. The second panel in Table 1 reports the average annual earnings for full-time workers earning less than £60,000 per year. Science graduates earn more than non-scientists but this wage differential exists only for scientists working in a scientific occupation, hence the earning premium for science graduates may be an occupation premium. Additionally for scientists, the mean earnings in a scientific occupation is comparable to the mean earnings in finance, so the poaching effect of financial occupation is likely to be limited.

IV Econometric strategy

We first replicate previous evidence and estimate the following Ordinary Least Square model of log wages:

$$\ln Y = \beta_0 + \gamma S + \beta_1 X_1 + \varepsilon \qquad (1)$$

Where *lnY* is the log annual wage, *S* is a dummy variable indicating graduation from a scientific subject, so that γ is the estimated return to science. X_1 is a set of control variables observed before entering the labour market. ε is a random component assumed normally distributed.

However, estimates from (1) are potentially biased since selection into subject is not random. We use a Heckman's two-step procedure to account for selection (Heckman, 1979; Lee, 1983). First, we model the selection into a scientific subject (*ScGrad**) and compute the Inverse Mills Ratio (λ) to correct for selection into subject.

$$\begin{cases} ScGrad = \alpha_1 + \beta_1 Z_1 + \gamma_1 X + \varepsilon_1 \\ ScGrad* = 1 \text{ if } ScGrad > 0 \text{ ; } ScGrad* = 0 \text{ otherwise} \\ LnY = \alpha_3 + \tau_3 ScGrad* + \delta_3 \lambda_1 + \gamma_3 X + \varepsilon_3 \end{cases} \qquad (2)$$

$$\text{where } \lambda_1 = \begin{cases} \phi(A)/\Phi(A) \text{ if ScGrad}^* = 1 \\ -\phi(A)/(1-\Phi(A)) \text{ if ScGrad}^* = 0 \end{cases}$$

$$\text{and A = - } (\alpha_1 + \beta_1 Z_1 + \gamma_1 X) / \sigma_{11}^{1/2}$$

where ø and Φ are the probability density function and cumulative density function of the normal distribution respectively. The selection equation is identified by Z_1, a variable explaining subject choice but not directly affecting wages.

As mentioned in the descriptive analysis, the scientific premium seems to be driven by occupational choice rather than having a science degree per se. To test this hypothesis formally, (1) is altered to include dummies for occupation (O_k) and their interaction with subject dummies.

$$\ln Y = \beta_0 + \gamma S + \sum_k \gamma_{2k} O_k + \sum_k \gamma_{3k} (S * O_k) + \beta_1 X_1 + \varepsilon \tag{3}$$

γ_{3k} is thus the additional premium for being a scientists in occupation *k*.

This model assumes that both subject and occupational choices are random, which is a rather strong assumption. Dropping the interaction terms, we could account for selection into occupation and estimate a model similar to (2) replacing the *ScGrad** equation with:

$$\begin{cases} ScOcc = \alpha_2 + \beta_2 Z_2 + \gamma_2 X + \varepsilon_2 \\ ScOcc^* = 1 \text{ if } ScOcc > 0 \text{ ; } ScOcc^* = 0 \text{ otherwise} \\ LnY = \alpha_3 + \tau_3 ScGrad^* + \delta_3 \lambda_2 + \gamma_3 X + \varepsilon_3 \end{cases} \tag{4}$$

where $\lambda_2 = \begin{cases} \phi(B) / \Phi(B) \text{ if ScOcc}^* = 1 \\ -\phi(B) / \left(1 - \Phi(B)\right) \text{ if ScOcc}^* = 0 \end{cases}$

and B = - $\left(\alpha_2 + \beta_2 Z_2 + \gamma_2 X\right) / \sigma_{22}^{1/2}$

Instead, we estimate a double selection model to account for subject and occupational choice. We assume that both selection equations are correlated ($\rho = corr(\varepsilon_1, \varepsilon_2)$) and follow Tunali (1986) double selection model.

$$\begin{cases} ScGrad = \alpha_1 + \beta_1 Z_1 + \gamma_1 X + \varepsilon_1 \\ ScOcc = \alpha_2 + \beta_2 Z_2 + \gamma_2 X + \varepsilon_2 \\ LnY = \alpha_3 + \tau_{31} ScGrad + \tau_{32} ScOcc + \delta_1 \lambda_{11} + \delta_2 \lambda_{12} + \gamma_3 X + \varepsilon_3 \end{cases} \tag{5}$$

The two selection equations are estimated simultaneously using a binomial probit model and the IMR ratios are the following:

$$\begin{cases} \lambda_{11} = \phi(A) * \Phi((B - \rho A) / (\sqrt{1-\rho^2})) / P \text{ if } ScGrad = 1 \text{ \& ScOcc} = 1 \\ \lambda_{11} = -\phi(A) * \Phi(1 - ((B - \rho A) / (\sqrt{1-\rho^2}))) / (1-P) \text{ otherwise} \\ \lambda_{12} = \phi(B) * \Phi((A - \rho B) / (\sqrt{1-\rho^2})) / P \text{ if } ScGrad = 1 \text{ \& } ScOcc = 1 \\ \lambda_{12} = -\phi(B) * \Phi(1 - ((A - \rho B) / (\sqrt{1-\rho^2}))) / (1-P) \text{ otherwise} \end{cases}$$

Where P = prob(ScGrad*=1 & ScOcc*=1)

V results

In Table 2, we report the OLS estimates of a science degree on wages for different specifications. The first column reports the raw wage differential between science and non-science subjects after accounting for local labour market characteristics (postcode level) only. Science graduates are found to earn 12% more than non-science graduates. Adding controls for gender, A-level score and socio-economic characteristics (model (2)) marginally reduces the premium to 10%. Controlling further for pre-university personal characteristics, such as age, ethnicity, disability and living arrangement while at university reduces the science premium to 8%, similar to what has been found in previous studies. Model (4) adds class of degree as well as measures of the institution quality. These variables are potentially endogeneous if science degrees are graded differently from other degrees or if institutions that offer science degrees differ in quality from those that do not. Note also that degree classification is specific from medical degrees (not classified); as such introducing degree classification isolates the effect of medics on the wage premium. This model is thus presented only for completeness and our favourite specification is Model (3).

In Model (5) we examine occupation effect. Scientific, financial and teaching occupations all pay substantial premiums over other occupations, ranging from 14% to 19%. The first question of interest is whether the premium for science degrees remains when controlling for occupation and whether it is observed in all occupations. As such, model (6) controls both for science degree and for occupation. The returns to science degree drop to 3% while the returns to occupation barely change compared to model (5). The last specification includes interaction terms between science degree and occupation to test whether the returns to a science degree differ by occupation. Indeed, science graduates earn more than other graduates in scientific occupations (+9%) and marginally significantly more in other occupations (3%). There is no difference in financial occupations and science degree holder earn significantly less in teaching occupation (8%) which is rather surprising since teachers are paid on a common scale and there is, over this period, a shortage of science teachers and as such science teachers were paid a bonus. These results suggest that most of the returns to science degrees are in fact driven by the occupations that science degree holder choose, and that within occupations, there are little premium to holding a science degree apart from scientific occupations where it leads to a 9% premium.

As alluded to in the previous sections, the estimates of the returns to a science degrees may be biased due to selection effects. We now account for selection using the Heckman two-step strategy described above. The identification of subject choice comes from the fee status variable which proxies financial constraint. For this cohort, tuition fees were set at £1,200 per year but were means tested; one third of students did not pay fees and one third paid full fees. The fee status is correlated with subject choice since science subjects are more costly; the average duration of undergraduate studies is longer than for non-science subjects, and science subjects are more likely to lead to post-graduate studies[8]. Table 3 reports the log wage estimates when accounting for selection; the second panel includes the estimates of the identifying

[8] The duration in years of all courses at English institutions listed on UCAS were 5.2 years in Medicine, 3.5 years in Physics and Engineering, 3.4 years in Math, 3.3 years in IT, 3.2 years in Biology and Architecture, 3.0 years in Nursing, Psychology and Sport Science. For non-science subjects, the average duration was 3.2 years in Arts, 3.1 years in Business, English, Law and Sociology and 3.0 in Education. In the DLHE, science graduates were 1.5 percentage points more likely to have engaged in post-graduate studies than non-science graduates. The difference is significant at the 10% level.

restriction in the first stage equation. In Column 1, we account for selection into a science subject. The exclusion variable, fee status, is statistically significant and of the expected sign. The inverse Mills ratio is negative; i.e. the unobservable characteristics in the subject choice equation are negatively correlated with those from the wage regression. This negative selection means that the OLS estimates were biased downwards, and after correction, the estimates to a science degree increase up to fourfold[9].

The descriptive statistics above suggested that the premium to a science degree may have more to do with occupational choice than with the degree itself. Thus, we now estimate the occupational premium accounting for selection into a scientific occupation. Due to limited availability of identifying variables, we limit ourselves to accounting for selection into a scientific occupation versus any other occupation. These estimates are reported in Column 2 of Table 4. The identification of the occupational choice comes from paternal occupational choice. Having a father in a scientific occupation may affect the preference for and also ease the graduate's access to a scientific occupation. Indeed having a father in a scientific occupation increases the probability of working in a scientific occupation by 5 percentage points. The IMR is again negative, so individuals with worse unobserved characteristics work in scientific occupations. As such, the OLS estimate of the premium to working in a scientific occupation is biased downwards and after accounting for occupational selection the estimate increases by 50% to 0.31 log points.

Obviously, the decisions to study science and to work in a scientific occupation are not independent, the Spearman rho reaches 0.48, and we now account for the dual selection into a science degree and a scientific occupation simultaneously. The

[9] When restricting science to Biology, Physics, Math, Engineering and Architecture only and excluding medics and associated subjects from the analysis the conclusions remain similar, and the premium to doing a science degree reaches 14%, significant at the 5% level.

estimates from the bivariate probit model are reported in the second panel of Table 3 in Column 3. The identifying restrictions become weaker when both equations are estimated simultaneously, and only paternal occupation remains significant at the 10% level. As such, the estimates of the returns to subject and occupation are not significantly different from those obtained in OLS as the selection terms become insignificant. After accounting for selection into subject and occupation, returns to a science degree are thus small at 2% and are dominated by the returns to a scientific occupation[10].

Only 197 observations are observed working in scientific occupations without a scientific degree; while this is gives us confidence in our measure of scientific occupation it makes the identification of the model quite difficult. As a robustness check we exclude these observations and estimate the double selection model again conditioning that being in a scientific occupation can only be observed for science graduates; this is a partial observability model a la Poirier (1980). The estimates are reported in Column (4); the selection equations are then more precisely estimated but the main results are almost identical to those obtained in the model without the restriction.

A second robustness check is provided in Columns 5 and 6 where we restrict the sample to science graduates and estimate a wage regression with OLS and Heckman sample selection respectively. The sample size is halved but the OLS estimate is almost identical to the estimates of the double selection model. When accounting for the non-randomness of occupational choice, we again find evidence of negative selection into scientific occupations and as such the estimate on the returns to scientific occupation, corrected for selection into occupation, is larger than the

[10] The conclusions do not substantially differ when science is defined as Biology, Physics, Math , Architecture and Engineering only and Medics are excluded from the analysis; returns to occupations are then only 10%, highlighting that a large part of the occupational returns are driven by medics.

OLS one, at 0.24 log points. Overall, we have consistently found that returns to a scientific degree are quite small but that returns to scientific occupations are quite large. These high returns are consistent with labour shortages in scientific occupations.

VI Discussion and conclusions

A large fraction of science graduates do not work in scientific occupation while we have estimated that the returns to a scientific education are mostly associated with working in a scientific job. We thus now look briefly at early career development and occupational choice.

Table 4 is the matrix of transitions between occupational choices made six months after graduation and 42 months after graduation for scientific graduates. Six months after graduation, a quarter of scientific graduates are observed not working – mostly still studying. Only 36% of scientific graduates are observed working in a scientific occupation six months after graduation. This proportion increases to 46% three and a half year after graduation with graduates mostly making the transition from not-working and other occupations. For those who started in a graduate occupation, the retention is large at 86% - almost twice as large as for graduates whose first job was in finance. The recruiting difficulties thus appear to get science graduates to start a career in a scientific occupation.

Additionally, we report in Table 5 various measures of early career development and satisfaction. These shed some light on the mechanisms by which graduates choose their occupation. The top panel reports the effect of being a science graduate compared to having studied other subjects, the second panel explores the differences along the occupation divide for scientific graduates and the third focuses on the additional impact of switching between occupations. The first column reports the coefficients of a Tobit model on months of unemployment since graduation. Only 27% of graduates currently employed have experienced some unemployment and conditional on having some unemployment the duration was less than five months, so clearly graduate skills are in demand. The estimated model controls for all pre-university characteristics and degree class and dummies for the quality of the institution attended. Science graduates have experienced just over one month less unemployment- or 25% less than other graduates. Among science graduates, those currently working in a scientific occupation have experienced one month less unemployment than other science graduates which is consistent with the shortage of applicants in these occupations. Indeed the interaction terms between current and first occupation (panel 3) shows that science graduates who have been in scientific jobs throughout have had the lowest unemployment.

Using a similar specification, we model the quality of the labour market match, relying on the definition of over-education provided by Elias and Purcell (2004). This classification is based on the proportions of graduates of different age groups in a given occupation and defines five categories of jobs: traditional, modern, new, niche and non-graduate. We define a dummy variable for not working in a graduate job of any type and estimate a probit model; the marginal effects of which are reported in column 2. Overall, 22% of graduates are not in an occupation that requires graduate skills, which is substantially higher than for the 1999 cohort four years after graduation (17%) (Purcell et al. 2005). Science graduates are 9 percentage points less likely to be over-educated. We cannot estimate this model for science students in different occupation since variation in over-education status would by definition be limited. As expected science graduates are in high demand in the labour market; not only do they spend less time unemployed they are also more likely not to be in a job for which they are over-educated.

We also investigate the reasons for accepting the current job. More specifically we report three non-exhaustive reasons: the job is exactly the job I wanted, this was the only job offer, the job allows to pay off debt. The first reason is a positive choice of the graduate while the other two indicates that the graduate may have been pushed into their current occupation. Only 52% of graduates report being in exactly the job they wanted but this proportion is 4 percentage points higher for science graduates. More interestingly, those working in a scientific occupation are 13 percentage points more likely to answer this question in the affirmative than other scientific graduates.

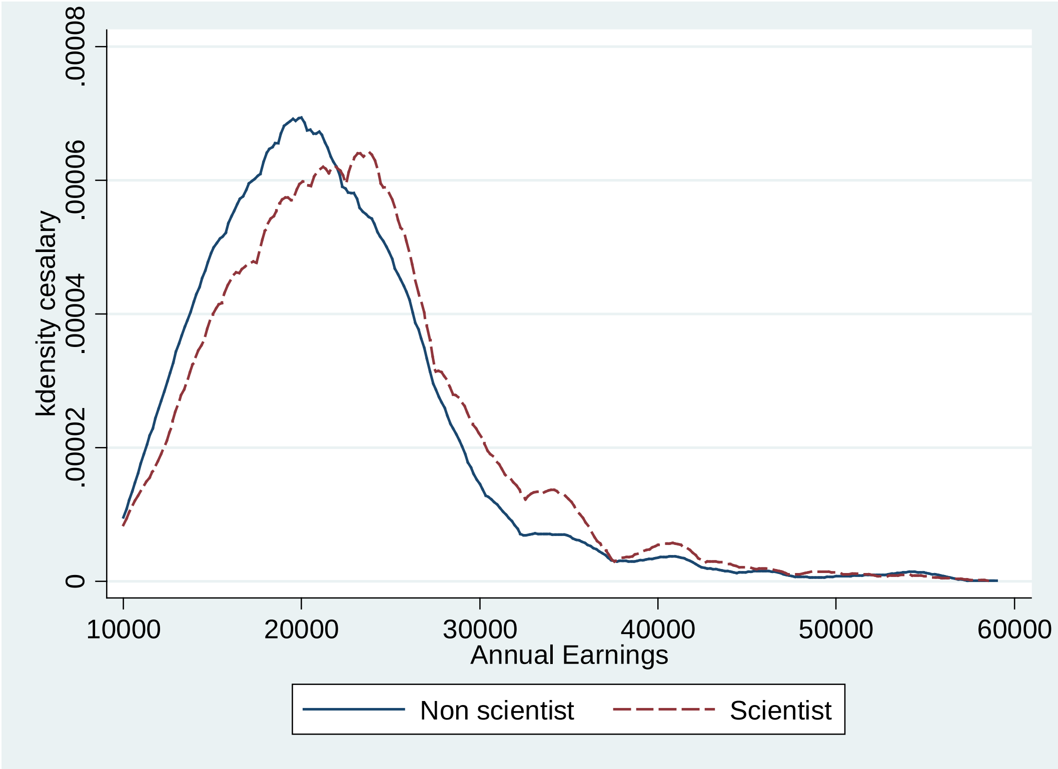
Eighteen percent of graduates report having accepted a job because it was the only offer and there is no difference by subject or occupation. Twenty six percent of graduates report being in their current occupation to pay off their debts, but science graduates are 4 percentage points less likely to have been pushed into such a job. Science graduates who moved away from a scientific occupation do not differ from graduates who never entered such an occupation on any of those three reasons for choosing a job.

Column (6) reports the estimates for the satisfaction of graduates with their career to date. After controlling for current income, there is no variation in satisfaction between science and other graduates. However, amongst science graduates those in scientific occupations are 3 percentage points more satisfied. In the last column, we report estimates of whether graduates would study the same subject again. There is no difference between science graduates and other graduates but there are some clear gaps by occupation for science graduates, similar to those observed for being exactly in their occupation of choice. Overall, science graduates outside science are less satisfied with their choice of studies and their career to date.

While there is a general view that there is a shortage of science graduates, this may be more due to the large number of science graduates not working in scientific occupations rather than a lack of qualified science graduates. Despite higher average returns to a science degree, less than 50% of science graduates work in a scientific occupation three years after graduation. The reasons of this “wastage” at a period of high demand in scientific occupations remain unclear, but scientists working in scientific occupation are more positive about their occupational choice. The sorting between occupations is not random and those not working in a science occupation or finance tend to have lower academic credentials and graduated from less prestigious institutions. However, there is a negative correlation between the unobserved characteristics of science graduates and the wage determinants.

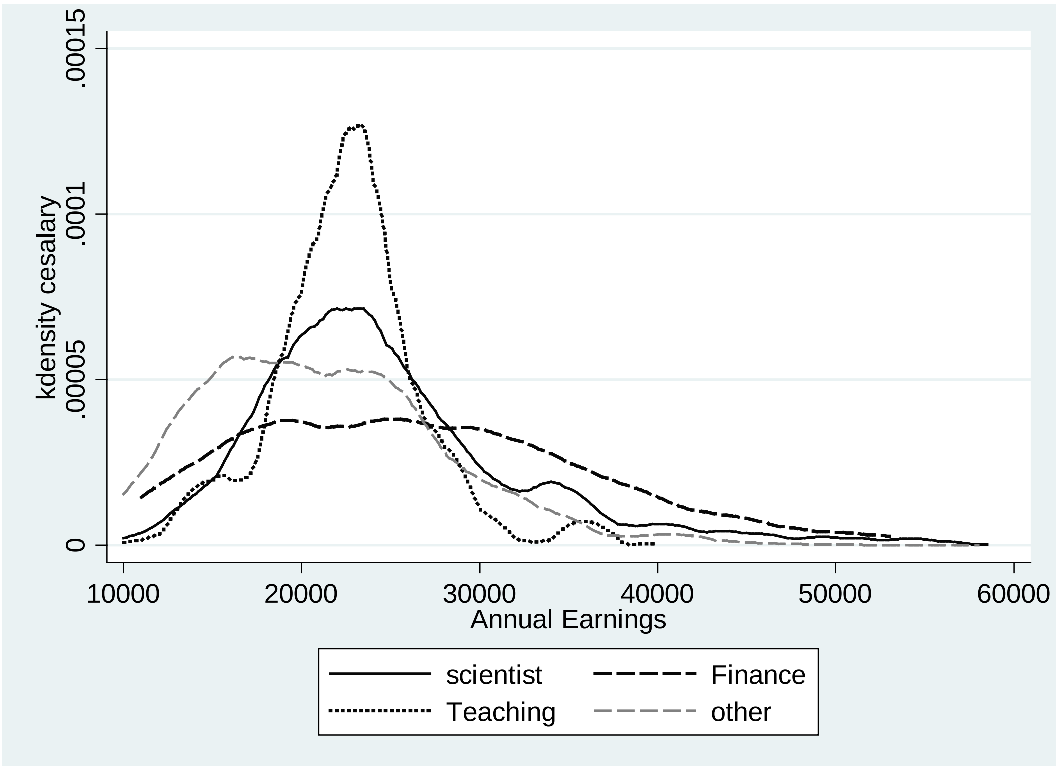
Graduates not working in scientific occupations are less likely to report being in exactly the job they wanted and are less satisfied with career development so far, which could indicate that they have been pushed into non-scientific careers. This may be due to a lack of scientific skills from these graduates or a mis-match between degree programmes and employers’ needs, since they are less likely to report that they would study the same subject again. The lack of appropriate skills of science graduates was indeed the main difficulties in research and development recruiting (Mason, 1999; Lambert, 2003). The large fraction of scientists not working in scientific occupations may thus have more to do with skill mismatch than uncompetitive wages in these occupations.

Figure 1: Distribution of annual earning in October 2006 by Science status – excluding medics



Note: Full time employees only- maximum annual earnings trimmed at £60,000

Figure 2: Distribution of annual earning in October 2006 for science graduates by occupation type



Note: Full time employees only- maximum annual earnings trimmed at £60,000

Table 1: Proportion of graduates working in specific occupational group

	Fraction in occupation		Mean Earning by occupation	
Subject	Non-science	Science	Non science	Science
Scientific occupation	0.05	0.43+	22,856	26,481+
Financial occupation	0.07	0.04+	25,854	26,583
Teaching	0.17	0.11+	22,577	22,038
Other	0.71	0.42+	20,939	21,197
overall	0.51	0.49	21,600	23,757+

Note: Source LDLHE 02/03. Sample restricted to Full time employees with annual salaries lower than £60,000.

+ denotes that the mean is statistically different from the mean for the non-scientific graduates

Science occupations are defined as the following SOC2000 codes: Managers in construction (1122), mining and energy (1123), IT (1136), R&D (1137), Health services (1181), Pharmacy (1182) Healthcare practise (1183), Farm (1211), Natural environment (1212), Chemist (2111), Biologist (2112), Physicists/mathematicians (2113), Engineer (2121. 2122, 2123, 2124. 2125, 2126, 2127, 2128, 2129), IT professional (2131), software professional (2132), medical occupation (2211), other medical professionals (2212), Pharmacist (2213), Optician (2214), Dentist (2215), Veterinarian (2216), Scientific researcher (2321), statisticians (24234), Actuaries (24235), Architects (24310), Technician (3111, 3112, 3113, 3114, 3115, 3119, 3121), draughtsperson (3122), building inspector (3123), IT technician (3131), Nurse (3211), Midwife (3212), Paramedic (3213), other medical associate professional (3214,3215, 3216, 3217,3218, 3221, 3222, 3223, 32290, 32291, 32292, 32293).

Financial occupations are defined as: Financial institution manager (1151), Chartered and certified accountant (2421), Management accountant (2422), Management consultants, actuaries, economists and statisticians (2423), finance and investment analyst (3534), taxation expert (3535), financial and accounting technicians (3537).

Teaching professionals are defined as all occupation in the group teaching professionals (231)

Science includes: Medicine, Subject allied to Medicine, Biological Science, Veterinary/Agriculture related subjects, Physical science, Mathematical and Computer science, Engineering/Technologies, Architecture and mixed science subjects.

Table 2: OLS estimates on the effect of a science degree and scientific occupation on (log) annual earnings

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
STEM	0.117	0.098	0.081	0.065		0.029	0.033
	[8.635]	[7.593]	[6.571]	[5.283]		[2.210]	[1.849]
scientific occupation					0.192	0.177	0.096
					[16.47]	[13.835]	[2.695]
STEM * scien. Occ.							0.090
							[2.163]
financial occupation					0.137	0.139	0.158
					[6.243]	[6.215]	[5.823]
STEM * Fin. Occ.							-0.059
							[1.127]
Teaching					0.158	0.159	0.183
					[9.818]	[9.764]	[8.336]
STEM * Teaching							-0.080
							[2.103]
Gender, A level, Parental SOC		yes	yes	yes	yes	yes	yes
Ethnicity, age, disability, school type and living arrangement			yes	yes	yes	yes	yes
Degree class, institution quality				yes			
Constant	9.911	9.872	9.793	9.857	9.782	9.771	9.823
	[1009.927]	[445.732]	[181.516]	[171.279]	[219.231]	[219.289]	[198.530]
Observations	8280	8280	8280	8280	8280	8280	8280
R-squared	0.146	0.195	0.242	0.272	0.287	0.274	0.277

Note: The analysis is conducted on the weighted sample and controls for current location (postcode) were also included in all specifications. t-statistics, adjusting for clustering at the institution level are reported in brackets.

Table 3: Estimates on the effect of subject and occupation on (log) annual earnings accounting for selection

	All graduates			Exclude non-scientists in scientific occupation		Science graduates only	
	Log Earnings	Log Earnings	Log Earnings	Log Earnings	Log Earnings	Log Earning	Log Earning
Science degree	0.329		0.023	0.023	0.022		
	[5.170]		[1.880]	[1.893]	[1.880]		
Scientific occupation		0.310	0.181	0.181	0.177	0.179	0.244
		[14.97]	[12.77]	[12.76]	[12.43]	[12.57]	[7.491]
λ subject	-0.140		-0.066		-0.198		
	[3.452]		[0.813]		[1.709]		
λ occupation		-0.071	0.015		0.134		-0.042
		[6.050]	[0.241]		[0.798]		[2.234]
Selection equation Subject:							
Fee Status	-0.153		-0.039		-0.433		
	[5.461]		[1.500]		[-2.902]		
Occupation							
Parental occupation		0.170	0.086		0.381		0.104
		[2.894]	[1.666]		[1.726]		[1.352]
$\rho(\varepsilon_s,\varepsilon_o)$			0.762		0.572		
Observations	8280	8280	8280	8103	8103	4303	4303

Note: t-statistics, adjusting for clustering at the institution level are reported in brackets. For the double selection model the t-statistics are obtained from bootstrapping (500 replications).
The specification also includes controls for postcode of current work place, A-levels score (quadratic), a dummy for missing A-levels score, a dummy for female, and a set of dummy for parental social class, dummies for ethnicity, age on graduation, living arrangement while in HE, disability status, type of previous institution attended.
The selection model excluding non scientists in scientific occupation is estimated with a partial observability binomial probit model since by construction only scientists can be observed in scientific occupations.

Table 4: Occupational choice of science graduates 6 months and 3 years after graduation.

		Occupation: 3 years after graduation					
		Scientific	Finance	Teaching	Other	Total	Obs.
Occupation: 6 months after graduation	Scientific	[86%] (67%) 1,313	[2%] (17%) 30	[1%] (3%) 16	[11%] (11%) 169	(36%)	1,528
	Finance	[10%] (0%) 6	[47%] (17%) 29	[6%] (1%) 4	[37%] (1%) 23	(1%)	62
	Teaching	[3%] (0%) 8	[0%] (1%) 1	[86%] (39%) 224	[11%] (2%) 29	(6%)	262
	Other	[21%] (15%) 293	[4%] (33%) 58	[9%] (23%) 130	[66%] (58%) 925	(33%)	1,406
	Not working	[33%] (18%) 347	[5%] (22%) 56	[19%] (35%) 200	[42%] (24%) 442	(24%)	1,045
	Total	[46%]	[4%]	[13%]	[37%]		
	Observation	1,967	174	574	1,588		4,303

Note: In each cell the percentage in brackets pertains to the row percentage, the percentage in parentheses reports the column's percentage, the last row is the number of observations in the cell.
The calculations are based on science graduates only (*science 1*).

Table 5: Early career outcomes

	Month of unemployment	Not graduate job	Exactly job I wanted.	Only job offer	Job to pay off debts	Career satisfaction	Would study same subject? ordered logit
	Tobit	Probit	Probit	Probit	Probit	Probit	
Science definition 1 – all graduates							
Science	-1.242	-0.087	0.041	-0.012	-0.037	0.012	0.004
	[5.95]	[10.08]	[3.83]	[1.49]	[4.00]	[1.57]	[0.11]
Ln income	--	--	--	--	--	0.286	0.843
						[24.48]	[12.96]
Science graduates only							
Scientific occupation	-1.433 [4.33]	---	0.129 [8.42]	0.003 [0.29]	0.004 [0.35]	0.034 [3.25]	0.390 [6.34]
Ln income	--	--	--	--	--	0.229	0.832
						[14.88]	[8.87]
Science graduates only							
Scientific occ. at 6 month	-1.043 [1.47]	0.037 [2.24]	0.042 [1.23]	-0.020 [0.78]	0.019 [0.66]	0.003 [0.14]	0.136 [0.98]
Scientific occ. now	1.329 [3.33]	-0.182 [12.6]	0.080 [3.79]	0.033 [2.13]	0.032 [1.79]	0.033 [2.35]	0.261 [3.10]
Scien. Occ at 6 month * scien. Occ now	-4.788 [5.53]	-0.102 [4.65]	0.046 [1.13]	-0.032 [1.06]	-0.059 [1.76]	0.0003 [0.01]	0.108 [0.66]
Ln income						0.228	0.785
						[14.62]	[8.23]

Note: p statistics are reported in parentheses. Nbr of observations are 9376 in regression not including income and 8280 if income is included. The second panel is based on 4851 observations (4303 when income is included) who are classified as science degree.
The specification also includes controls for gender, A-level score (quadratic), parental social class, disability status, ethnicity, age, type of school attended, accommodation type, degree class and institution quality (quartile).
Over-education is defined using Elias and Purcell (2004) which defines 5 categories of graduate jobs 1 Traditional occupation (20%), 2 Modern occupation (17%), 3 New occupation (19%), 4 Niche occupation (22%), 5 Non-graduate job (22%).
Exactly job I wanted is a dichotomous variable reporting the reason for accepting the current job. It is coded as 0 if answer no (48%) and 1 for yes (52%)
Only job offer is a dichotomous variable reporting the reason for accepting the current job. It is coded as 0 if answer no (82%) and 1 if yes (18%)
Job pay off debts is a dichotomous variable reporting the reason for accepting the current job. It is coded as 0 if answer no (74%) and 1 if yes (26%)
Career satisfaction is coded as 1 satisfied (85%), 0 dissatisfied (15%).
Would study the same subject include 4 categories: 1 very likely different (16%), 2 likely different (19%), 3 not likely different (26%), 4 not likely at all different (39%).

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Appendix:

Table A1: Sample Selection:

Selection criteria	Number of observations
Original sample	19,979
First degree only	11,866
Age on graduation [19,25]	9,850
Not special entry student	9,738
Employed FT or PT	9,296