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Growing Within-Graduate Wage Inequality and the Role of Subject of Degree

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Abstract

This paper provides a supply and demand analysis for the changes in subject of degree, focussing specifically on the UK but also finding similar descriptive patterns in subject choices for the US. The paper makes a unique contribution to the literature by estimating subject-specific implied relative demand shifts. We find that Maths/Computer graduates are the least substitutable in production, but also that Medical Related, Physical Sciences, and Combined graduates are perfect substitutes in production, relative to non-graduates. Almost 40 percent of the total demand shift for graduates between 1994 and 2011 was for those with STEM degree subjects, with the largest of these being for Maths/Computing degrees which are male dominated. We also find relatively large shifts for Education, Law, Other Social Sciences, Management/Business and Medical degrees. Most of the increase in demand for graduates between 1994 and 2011 was in subjects that are relatively concentrated into a few occupations. Overall, the demand for all graduates has increased at least to the same extent as the large increase in supply, with no sign of declining graduate wage differentials.

Keywords: Degree subjects; returns to education; supply and demand shifts

JEL Codes: J24; J31

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1. Introduction

Large increases in Higher Education participation have produced increased numbers of graduates in the labour markets of advanced countries. This in turn has produced numerous research studies into the effect of such an increase on labour market outcomes (see for example Elias and Purcell, 2004; McIntosh, 2006; O'Leary and Sloane, 2005; Walker and Zhu, 2008 in the UK, and Card and Lemieux, 2001; Katz and Murphy, 1992; Topel, 1997 in the US). In terms of the mean wage differential between graduates and non-graduates, there is little evidence that this has been greatly affected by the increased number of graduates in the market.

Simple focus on the mean, however, can miss much variation around the mean. Indeed there is much variation in wages *within* education categories. It has been argued that much of the overall increase in wage inequality has been due to an increase in this residual inequality within education groups, for example by Juhn *et al.* (1993), Katz and Autor (1999) and Lemieux (2006) in the US or Gosling *et al.* (2000) in the UK.

There are various characteristics by which graduates could be differentiated, in order to examine within-graduate wage inequality. For example, one area of study could be variation in university quality attended (for example see Hussain *et al.,* 2009). In this paper we focus on the distribution of graduates by subject of degree. A small number of studies in the economics literature have also considered subject choice. In the UK, for example, O'Leary and Sloane (2005) consider subject of degree in their analysis of changing returns over time. Walker and Zhu (2011) calculate a full net rate of return to investments in different degree subjects, allowing for the increase in fees introduced in the UK from 2012. Chevalier (2011) demonstrates the variation in graduate wages by subject, but shows there is still more variation in wages within subjects than between. Machin and Puhani (2003) consider subject of degree in both the UK and Germany and find that in both countries, wages vary by subject, and furthermore that differences in subject choices between men and women explain a small part of the gender wage gap. Finally, in the US, Altonji *et al.* (2012) consider wage differentials to subject majors, within the context of a theoretical model which takes account of subject choice.

This paper begins by documenting US and UK employment shares and wage differentials by subject of degree, but then also explores changes over time for the UK. The paper goes beyond mere documentation however, by using this information to make a unique contribution to the existing empirical literature. First, we estimate compositionally adjusted relative graduate wages and use labour supply changes to impute implied demand shifts for UK university graduates by subject of degree. Second, we examine the occupational concentration of graduates by subject of degree in the UK (and US) to identify whether graduates of different subjects are employed in different occupations.

To preview our results, we find evidence that graduates with different subjects are employed in different jobs and should therefore not be treated as perfect substitutes in production. Relative to non-graduates, we find that Maths/Computer graduates are the least substitutable in production. Medical Related, Physical Science, and Combined graduates are perfect substitutes in production relative to non-graduates. We find that almost 40 percent of the total demand shift for graduates (relative to non-graduates) between 1994 and 2011 was for those with STEM degree subjects, with the largest of these being for Maths/Computing degrees which are male dominated. We also find relatively large shifts for Education, Law, Other Social Sciences, Management/Business and Medical degrees. Most of the increase in demand for graduates between 1994 and 2011 was in subjects that are relatively concentrated into a few occupations. These are Maths/Computing, Education, Law and Medical degrees which explain 48 percent of the total demand shifts for graduates. Overall, the demand for all graduates has increased at least to the same extent as the large increase in supply, with no sign of declining graduate wage differentials.

The paper is organised as follows. The next section of the paper sets the scene in terms of documenting employment shares and wage differentials by broad education categories, over time in the UK and the US. Section 3 compares graduate employment shares and wage differentials for the UK and US by subject of degree. Section 4 describes the changes over time in UK graduate employment shares and wage differentials. The key analyses are undertaken in Section 5 where we estimate demand shifts for each degree subject. In section 6 we look at the occupational composition of subjects. The final section concludes.

2. Background

Before we look at the changing pattern of subjects, we begin by documenting the overall changing pattern of graduate labour supply and wages in the UK and US. We focus on recent trends (between 1994 and 2011) because this is the period of analysis for subjects that will follow later in the paper. For the UK we use the Labour Force Survey (LFS) throughout the paper. The LFS in the UK is a quarterly survey of households which provides us with an annual series.[1] In order to compare these to the US we draw upon the March Current Population Survey (CPS). Our samples are restricted to those aged 23-60, thus focussing on individuals of working age who are also beyond the normal age by which a degree is usually obtained. UK education qualifications are classified according to the US groupings of educational achievement.[2] Note that the 'college plus' group contains both undergraduates and postgraduates. This is due to the fact that the data sets only provide information on the subject of the first degree and so when subject is considered subsequently it is not possible to look at graduates and postgraduates separately.[3]

Table 1 supports what we already know about the increase in the supply of educated labour in both countries. In the US, for males, there has been a slowdown in the rate of increase. The recent changes have been quite moderate compared to the larger increases that occurred in the 1980s and 1990s.[4] Nevertheless there has still been a statistically significant 3 percentage point rise in the proportion obtaining a degree between 1994 and 2010. For women, the increase in this proportion has been much larger at 10.5 percentage points. The offsetting declining proportion is mostly in terms of declining numbers leaving education after completing high school, rather than large declines in the other two educational categories.

In the UK, the increase in the educational attainment between 1994 and 2011 has been much larger than for the US, with women again seeing the biggest increase. In this case, the largest compensatory fall in the UK has been in terms of the proportion of individuals acquiring no qualifications, the equivalent of high school drop-outs in the US.

Alongside the increase in the number of college graduates, Table 2 shows that there have also been increases in graduate wage differentials.[5] These compositionally adjusted wage differentials are estimated relative to high school graduates in the US, and relative to those with 2+ A levels in the UK. The figures show an increase in the size of the graduate wage differential for both genders in both countries. The largest increase in the graduate pay differential, of 0.131 log percentage points, has been for males in the US, the group who have experienced the smallest change in employment share. US women and UK men saw similar changes in the graduate employment share, and have also experienced similar changes in the graduate wage differential, of 0.067 and 0.054 log percentage points respectively. The graduates who have experienced the largest increase in employment share, namely UK women, have seen the smallest change in the graduate wage differential, a statistically insignificant 0.029 log percentage points.[6]

The rising supply of graduate labour, accompanied by rising graduate wage differentials, are well-documented facts in both countries and these have been shown to be an important driver of the growth in wage inequality. In addition, Figure 1 shows the growth in the 90-10 ratio for all male and female graduates in the US and Great Britain, running from 1963 to 2010 in the US and (because of requiring a consistent education variable) from 1977 to 2010 in Great Britain using the General Household Survey (1977 to 1992) and Labour Force Survey (1993 to 2010). The Figure shows significant long run rises in within-graduate wage inequality. The aim of this paper therefore is to look at the demand and supply of subjects in order to say something about the role that subjects might have played in explaining these increases in within-graduate wage inequality.

3. The Employment Shares and Earnings by Subject of degree in the US and UK.

In this section we describe the change in the supply and wages of graduates by subjects. For the UK we again draw upon the LFS but for the US it is necessary to find another data source since the CPS does not contain information on subject major. We therefore turn to the 2010 American Community Survey (ACS). The ACS is a one percent sample of the US population based on the US population Census and is available annually since 2000. However, the ACS only started to collect information on subject major from 2009. This section of the paper therefore compares the ACS 2010 cross section to the 2010/11 LFS.[7]

Employment Shares by Graduation Cohort

We use the ACS and LFS cross sections to say something about the evolution of subject choice over time. Figure 2 plots the employment shares of US men and women by graduation cohort and subject major.[8] Figure 3 does the same thing for the UK. We present these separately for STEM subjects (Science, Technology, Engineering and Maths) and Non-STEM subjects. Following Walker and Zhu (2011) we define STEM subjects as Medical, Medical Related (including Nurses), Biology/Agricultural Science, Physical Science, Maths/Computing and Engineering/Technology, whilst we define non-STEM subjects as

Law, Economics, Management/Business, Other Social Sciences, Arts/Humanities, Education and Combined subjects.

Figures 2 and 3 are capturing the flows into the 2010 stock of graduates. They clearly show some similarities across the two countries in terms of both the flows by subject and in terms of gender specificities.[9] Amongst the STEM subjects, most have relatively constant employment shares across graduation cohorts, despite the increased overall Higher Education participation amongst younger cohorts. Exceptions include maths and computing degrees being more popular amongst more recent cohorts until the 2000 cohort, and biological/agricultural degrees increasing their employment share amongst younger women in both countries. There is also evidence to suggest that amongst the youngest graduate cohorts who have graduated since 2000, there have been falling employment shares in a number of STEM subjects, such as engineering/technology and maths/computing amongst men in both countries, and for medical-related for women in both countries. Thus there is little evidence of rising employment shares of STEM subjects amongst recent graduates (with the exception of biological/agricultural degrees for women), and indeed evidence of falling employment shares amongst the most recent graduates.

Turning to non-STEM subjects, it is clear that most of the growth in the supply of graduates amongst recent cohorts has been found in such subjects. Amongst US men, there is limited growth in any subject major, reflecting the small overall change in employment share of graduates. Amongst US women, however, there was a growing share of graduates with Management/Business degrees amongst those who attended college in the 1970s and 1980s, while the biggest increase in employment share amongst younger cohorts has been in Arts and Humanities degrees. In the UK, the increase in the employment share of recent graduates cohorts is most noticeable for the same two subjects, in this case for both men and women, and only until the 2000 cohort for Management/Business degrees. Note that amongst female graduates in both countries, there has also been a decline in the employment shares of those with education degrees. This reflects the growing range of graduate occupations for women, where previously being a teacher would have been a likely source of graduate employment.

Wage Payoffs to Subjects

We now turn to the wage payoffs from degree subjects. Table 3 compares relative graduate wage differentials by subject for the US and the UK. These estimates are composition adjusted and are relative to having a degree in education.[10] The payoff from an economics degree is the largest in the US (0.524 and 0.461 log percentage points for men and women respectively) and is very similar to that found by Altonji *et al.* (2012) of 0.517 for men and 0.400 for women from the 2009 ACS.[11] In the UK returns are largest for Medical degrees. Aside from Medical degrees, the wage payoffs are generally lower in the UK than in the US, relative to having an education degree. However, the ranking is similar. The top four paying degrees in the US, for both men and women, are Medical, Economics, Engineering/Technology, and Maths/Computing. For UK men, the top four paying degrees feature three of the same four subjects, the only exception being Law instead of Maths/Computing, while for UK women Law also comes into the top four ranked subjects, in this case in place of Engineering/Technology.

4. The Change in the Employment Shares and Earnings by Subject of Degree in the UK.

For the UK, we can also look at the change in the stock of graduates and the change in graduate wage differentials over time by subject. We can compare these to the cross sectional analysis in the previous section. We can only do this for the period 1994-2011 since the first full LFS survey year with subject information was in 1994.

Evolution of Employment Shares by Subject

Table 4 reports the change in the composition of graduate employment shares by subject using the LFS cross sections for 1994, 2000, 2005 and 2011. Table 4 is therefore capturing changes in the stock of graduates by subject. Note that these are mostly consistent with the findings from using the 2010/11 cohort flows (from Figures 3a and 3b) for those who graduated between 1994 and 2010. Women holding Arts/Humanities degrees are an exception since the increase in employment share over this period is larger for the flow of more recent female graduates in the 2010/11 LFS than the increase in the annual stock count over all ages in the 1994-2011 LFS. Also Figures 3a and 3b suggest that the flow of combined degrees has remained fairly flat over time, while Table 3 shows a fall in the relative stock between 1994 and 2011.

Table 4 shows that the composition of UK graduates has changed over the period, but also that there are gender differences in this composition. For men and women, the employment shares for Management/Business, Medical Related and Biological/Agricultural Science have all increased, with the largest being for Management/Business (0.067 and 0.064 for men and women respectively) and Medical Related for women (0.088).[12] Employment shares for Arts/Humanities and Maths/Computing have also increased, but only for men (0.056 and 0.040 points respectively). Combined degrees have fallen the most for men and women (-0.121 and -0.189), whereas for men the proportion of workers with Engineering degrees has also fallen by -0.039 points.

The gender compositional effects in Table 4 support those found in Altonji *et al.* (2012) who find important gender differences in the US composition of subject majors. Following Altonji *et al.* (2012) Figure 4 plots the relative female share of graduates by year of graduation and subject using the 2010/11 LFS and the 2010 ACS. In both countries some subjects have remained male dominated, in particular Maths/Computing, Engineering/Technology and Economics. For both countries, the subjects with the highest proportions of women are Medical Related and Education, consistent with the female domination of the nursing and teaching professions. The subjects where the share of women has increased are Medical and Physical Science degrees amongst the STEM subjects, and Management/Business amongst the non-STEM subjects. This supports the findings in Table 4 for the UK. But Figure 4 additionally shows that this is also the case in the US, except for a reversal of the upward trend in the share of women amongst UK medical graduates over the most recent 5 years.

Change in Wage Payoffs to Subjects Over Time

It is clear from the evidence we've looked at so far that the gender composition of subjects has changed. Consequently it is important to compositionally adjust wage differentials to take account of the large increase in female labour supply. Figure 5 therefore plots UK composition adjusted relative wage differentials of graduates, relative to 2+ A-levels, by subject of degree, for the period 1994 to 2011.[13] Again we present these separately for STEM and Non-STEM degrees. Figure 5 shows that these wage differentials are relatively flat over time. Only differentials for Engineering/Technology, Economics and Combined degrees have significantly increased over time, with log point increases (standard errors) of 0.112 (0.034), 0.113 (0.059) and 0.072 (0.032) respectively.[14] Medical degrees provide a much larger payoff relative to all other degree subjects and this is consistent over time. Notice also the relative wage payoffs to Arts/Humanities are very small.

Given the large increases in the supply of graduates, discussed above, it might have been expected that graduate wage differentials would be falling over time. The fact that the employment shares of some subjects (like Management/Business and Maths/Computing for men and Medical Related for women) have increased, whilst at the same time graduate wage payoffs have remained relatively flat (and have increased for Engineering/Technology, Economics and Combined degrees), suggests that the demand may have shifted in favour of some subjects relative to others. It is to these demand shifts that the paper now turns.

5. Changes in the Demand and Supply of Subjects

In order to compare the change in demand for subjects, we use data from the LFS 1994 to 2011 to estimate relative demand shifts, drawing upon the Katz and Murphy (1992) canonical model of relative supply and demand:

$$\log\left(\frac{\mathrm{W}_{1t}}{\mathrm{W}_{2t}}\right)=\frac{1}{\sigma}\left[D_t-\log\left(\frac{\mathrm{E}_{1t}}{\mathrm{E}_{2t}}\right)\right] \tag{1}$$

where, in the original paper, W_{1t}/W_{2t} is the relative wage between college graduates and high school graduates and E_{1t}/E_{2t} is the relative supply of college graduate workers relative to all non-graduates workers at time t, measured using total hours of work. The denominator in the relative wage measure is an alternative wage for college graduates, should they have chosen not to go to college. In the US papers this is high school graduates but for UK this alternative wage is workers with two or more A-levels. The relative labour supply measure should contain all workers that are competing in the labour market for jobs, taking account of productivity differences within the numerator and the denominator using efficiency weights, typically based on wages averaged over the full sample. The elasticity of substitution between graduate and non-graduate workers is therefore σ.

Equation (1) is based on the inverse demand function derived directly from the CES production function.[15] D_t captures the relative demand shifts for graduates (often assumed to be driven by technical change) that explain changes in the relative wage over and above shifts in relative supply, whilst σ is the elasticity of substitution between the two types of workers, (see Katz and Murphy, 1992).

Using equation (1), demand shifts can be calculated as:

$$D_t = \log\left(\frac{E_{1t}}{E_{2t}}\right) + \sigma \log\left(\frac{W_{1t}}{W_{2t}}\right) \quad (2)$$

Of more interest to us, however, is using equation (2) to get some idea about subject specific demand shifts. The main issue to consider is how we introduce subject specific substitutability between graduates into the CES production function in order to use the Katz and Murphy model. Our approach is to estimate

$$\log\left(\frac{W_{it}}{W_{2t}}\right) = f(t) + \gamma_i \log\left(\frac{E_{it}}{E_{2t}}\right) + \varepsilon_t \quad (3)$$

separately for each subject i using seemingly unrelated estimation, where $\gamma_i = -1/\sigma_i$ and f(t) is measured using time trends, whilst $\log(W_{it}/W_{2t})$ is the relative log wage differential of graduates with subject i relative to 2 plus A-levels and $\log(E_{it}/E_{2t})$ is the log relative supply of graduates with subject i. For robustness purposes we use two measures of relative labour supply.[16] The first includes non-graduates in the denominator and excludes all other graduates. This assumes that other graduates (with subject $j \neq i$) are total imperfect substitutes for all other workers. We prefer this approach because it assumes that graduates of different subjects are on average employed in different jobs, which is consistent with our findings in the next section. Our second approach includes all other workers in the denominator (graduates with subject $j \neq i$ and non-graduates), where these are efficiency weighted.[17] This assumes perfect substitutability between other graduates and non-graduates in the production process and that productivity differences are captured only by constant efficiency weights.[18]

If γ_i is not statistically different from zero in equation (3) for any subject i this implies that σ_i is equal to infinity and that these graduates are perfect substitutes in production for non-graduates, so that changes in their relative supply are of no significance in explaining changes in their relative wages.

Using the estimates of γ_i from equation (3) one can calculate subject specific demand D_{it} using:

$$D_{it} = \log\left(\frac{E_{it}}{E_{2t}}\right) + \sigma_i \log\left(\frac{W_{it}}{W_{2t}}\right) \tag{4}$$

This assumes that employer demand at time t for graduates with subject i depends on the graduates available $\log(E_{it}/E_{2t})$ and their relative wage $\log(W_{it}/W_{2t})$ discounted by their relative substitutability (σ_i). Since we have two measures of relative supply, we also have two measures of relative demand. The first is the demand for graduates with subject i relative to non-graduates and the second is relative to all other workers. For both measures, if relative wages, $\log(W_{it}/W_{2t})$, go up and labour supply $\log(E_{it}/E_{2t})$ remains constant, then relative demand must have increased. If relative prices go up and labour supply remains constant but the responsiveness of relative demand to price increases is lower (labour demand is more inelastic), then relative demand will have gone up by less. One important factor that determines the elasticity of labour demand is the substitutability of factors of production, in this case the substitutability of subject-specific graduate and non-graduate labour.

Demand and Supply Estimates

We now report the estimates for equation (3) but before we do so, we discuss our measures for relative wages and relative supply. Figure 6 contains compositional adjusted wage differentials $\log(W_{it}/W_{2t})$ similar to those in Figure 5 except now we focus on workers aged 26-45. Since our parameters are estimated separately for thirteen subjects, we focus on this younger age cohort in order to maximise the proportion of graduates we have in our sample. Again these are presented separately for STEM and non-STEM graduates. Figure 6 shows there is more subject variation in the relative wages of these younger workers and especially so for STEM graduates, with younger Medical Related graduates doing much better, on average than for the full sample.[19] The time variation is largely the same for the younger cohort compared to the sample as a whole.

Figure 7 provides the relative supply plots $\log(E_{it}/E_{2t})$ where E_{2t} contains just non-graduates, again for a sample of workers aged 26-45. Following Autor *et al*. (2008) these are measured using hours of work rather than employment shares.[20] It is clear that the relative supply of graduates has increased across all single honours subjects, but also that some have increased more rapidly than others. Relative to non-graduates, Medical Related, Management/Business and Arts/Humanities have increased the most, with Physical Science, Medical, Engineering/Technology and Economics graduates increasing the least and Combined degrees declining in relative supply.

Our key estimates from equation (3) are provided in Table 5. These are relative to non-graduates. Table A2 in the Appendix provides the estimates relative to all other graduates, which are very similar. The first column reports the estimated parameters ($\hat{\gamma}_i$) with corresponding standard errors, whilst the second column contains the estimated elasticitities of substitution ($\hat{\sigma}_i$). Overall, the estimated elasticities are mostly as one might expect, with an overall estimated elasticity of substitution of 4.85. This is broadly supportive of that found for a similar age group in the existing literature.[21] Maths/Computing graduates demonstrate the smallest elasticities of substitution (4.01), with Medical Related, Physical Sciences and Combined degrees being perfect substitutes in production relative to other workers. Education, Management/Business and Other Social Sciences are around the average (4.77 - 5.75), whilst Medical, Biology, Engineering/Technology, Law, Arts/Humanities and Economics are more substitutable (7.89 – 10.95) relative to non-graduates.[22]

The final two columns provide the trend coefficients and these show that over and above subject specific changes in relative supply, relative wages have increased linearly on an annual basis for Medical, Law, Management/Business and Combined degrees whilst they have increased non-linearly for Maths/Computing and Education degrees. However, Equation (1) suggests that strictly speaking we should proxy demand shifts using Equation (4).[23]

Implied Relative Demand Shifts

To compare our subject specific relative demand shifts calculated using equation (4) we compute the change in relative demand D_{it} between 1994 and 2011. We do not estimate relative demand shifts for Medical Related, Physical and Combined degrees, since their estimated infinite elasticities of substitution imply that the Katz and Murphy model is not appropriate in their case. We calculate the relative demand shifts from equation (4) and then Figure 8 reports the subject shares of the total relative demand shift. Panel (a) provides our preferred demand shift shares. These are relative to non-graduates (calculated from the estimated elasticities of substitution in Table 5). Panel (b) provides demand shift shares relative to all other workers (using the estimated elasticities of substitution in Table A2). We focus our discussion on panel (a) since this uses our preferred relative labour supply measure. Panel (b) provides slightly larger subject differences in implied demand shifts but provides very similar conclusions in terms of the subject rankings. Table A1 in the Appendix provides relative demand shifts assuming a Cobb-Douglas production function and assumes therefore that $\sigma = 1$ for all subjects. This also provides qualitatively similar results.

In panel (a) of Figure 8, the largest relative demand shift over this period has been for Maths/Computing (15 percent). After this, it is Education (14 percent), Law (13 percent), Other Social Sciences (12 percent), Management/Business (10 percent) and Medical (9 percent). In terms of the gender mix of these subjects, Figure 4b showed that Maths/Computing degrees are male dominated, whereas Education and Law are female dominated. The other subjects are fairly equally mixed on gender composition.

We find much smaller shifts for Biology (7 percent), Arts/Humanities (7 percent), Engineering (6 percent) and Economics (6 percent). These subjects had negative trend parameters in Table 5, and in the case of the last two, demonstrated the smallest relative supply shifts in Figure 7. Given that Economics and Engineering graduates have also displayed significantly increasing wage differentials over the period, we might conjecture that their supply has been constrained in some way.

Figure 9 takes the demand shifts from Figure 8 and aggregates these to broad subject groups so we can compare these to Figure 10 which contains information collected directly from employers on their degree subject preferences.[24] The latter are taken from a sample of employers surveyed in a CBI (2011) report. We can see that the relative demand for STEM subjects has increased the most which is in line with the CBI data. Panel (a) in Figure 9 shows that 38 percent of the total relative demand shift for graduates has been for STEM subjects. Panel (a) also shows that LEM (Law, Economics and Management/Business degrees) explain around 33 percent and OSSAH (Other Social Science, Arts/Humanities and Education) explain 29 percent.

6. Are Graduates of Different Subjects Employed in Different Jobs?

In the previous section we found that graduates in different subjects differ in their substitutability for non-graduates, with Maths and Computing graduates being the least substitutable. We also found that relative demand shifts differed across graduates in different subjects. However our main estimates are based on the assumption that graduates of different subjects are total imperfect substitutes for each other in production and that they are therefore employed in different jobs. In this section we look at the occupational specificity of graduates by subject to support that assumption. Table 6 reports the occupation concentration indices for our UK sample aged 23-45. These measure the proportion of all graduates in each subject who work in the three most popular occupations, as well as listing these top three occupations. We do this separately by gender.

As expected, the subjects that lead to the traditional graduate professions have a more concentrated selection of jobs, for example degrees in Medicine, Education, Medical Related and Law. With the exception of Law these subjects typically lead to public sector jobs. The least concentrated are, not surprisingly, Other Social Sciences, Arts/Humanities and Combined Degrees, which are much less likely to lead to a specific profession.

Overall there is clear evidence that different subjects do lead to different occupations and therefore that subject specific graduates, as we have defined them in this paper, should not be treated as perfect substitutes in production. Table A3 in the appendix uses the 2010 ACS to show that similar patterns exist in the United States, even though the results are not strictly comparable across the two counties, because their occupational classifications differ.

Table 6 also shows that the largest demand shifts found in the previous section are in subjects that are concentrated in a small number of occupations namely Maths/Computing, Education, Law and Medicine. Relative demand has increased but to a lesser extent for subjects that are relatively widely dispersed across a number of occupations, such as Other Social Sciences and Management/Business. Hence the largest increase in the relative demand for UK graduates seems to have been concentrated in a relatively small proportion of occupations (for example teachers, software/ICT professionals, solicitors/lawyers and doctors).

7. Concluding Comments

The main aim of this paper was to use wage differentials and relative supply changes to examine the change in the demand for degrees in different subject areas. Data limitations prevent any time series US analysis but for the UK we find that Maths/Computing graduates are the least substitutable in production compared to non-graduates. We find that Medical Related, Physical Sciences and Combined graduates are perfect substitutes for non-graduates in production. Consequently, we cannot estimate their demand shifts using the canonical Katz and Murphy model and therefore one further avenue for research would be to estimate models that do not impose a constant elasticity of substitution over time.

We find that almost 40 percent of the total demand shift for UK graduates has been for those with STEM degree subjects. Amongst more narrowly defined subjects, we find the largest demand shifts were for Maths/Computing which is male dominated, although Education and Law were not far behind. Education is consistently female dominated and Law has become female dominated relatively recently. We also find that these subjects are not very widely dispersed across occupations. Maths/Computing, Education, Law and Medical degrees explain 48 percent of the total demand shifts for graduates and these are all relatively concentrated into a small percentage of occupations. Demand has shifted relatively equally for Management/Business and Other Social Science subjects and these are more widely dispersed across a range of occupations.

The paper also shows that for the US and UK, the growth in the supply of graduates has not been even across all subjects. The largest increases in the supply of UK graduates have been in non-STEM subjects such as Business/Management, and Arts and Humanities. Amongst the STEM subjects, the biggest changes have been in Maths/Computing amongst male graduates and Medical Related amongst female graduates, with some suggestion that the former may be falling again amongst the youngest cohorts. In terms of the best-paying subjects, in the US these are the STEM subjects of Medical, Engineering/Technology and Maths/Computing, plus arguably the most technical/mathematical of the non-STEM subjects, Economics. In the UK, the same subjects also receive the highest wage differentials, with the exception of Law replacing Maths/Computing for men, and replacing Engineering/Technology for women. The time series element of the UK data revealed that the only subjects to have seen an increase in their relative wage differentials since 1994 are Engineering/Technology, Economics and Combined Degrees. Changes in the relative returns to different subjects have not therefore been the main cause of rising within-graduate wage inequality.

Overall, therefore, demand for UK graduates has increased at least to the same extent as the large increase in supply, with no sign of declining wage differentials for any subjects. Thus the extra graduates produced by the increase in Higher Education participation have largely been absorbed by the labour market, both in total and within subjects. Looking to the future, the fact that most of the largest changes in supply and demand have been in subjects that are used in a relatively narrow range of occupations may be a cause of concern. So, while the labour market has absorbed the extra Education, Law and Medical degrees produced so far, through the growth in the professions, and the extra Maths/Computing degrees, through the development of technology, it is not obvious that it will continue to do so when such degrees are only used in a narrow range of jobs.

Two of the smallest supply increases have been for Economics and Engineering, and the results suggest a shortage of graduates in these two areas, since these are the only two subjects for which the wage differential has increased over the period studied, implying an excess demand for graduates in these fields. Nevertheless, the implied change in demand for these two subjects is still smaller than that for all other subjects, where the larger increases in supply have been matched by similar-sized increases in demand. It may be that the UK economy does not need many additional engineers and economists, and the small supply increases have been just about sufficient. Such a conclusion would however seem to be in conflict with anecdotal evidence that it is just these sorts of technical, numerate graduates that firms increasingly want, particularly in the case of Engineering. An alternative interpretation of the results would be that subject specific demand has largely followed supply. Perhaps it is the relatively small number of economics and engineering university places available that has constrained the supply of graduates in these subjects. Alternatively, there may be a lack of demand from students to pursue these subjects because of their perceived difficulty.

The ‘demand follows supply’ theory therefore suggests that professional services may have grown because UK universities have produced such graduates, while the lack of supply in technical graduates such as engineers means sectors of the economy which might have demanded such graduates have not expanded. As suggested above, it is doubtful whether such a situation can continue indefinitely, with there surely being a limit to the expansion of professional services, and so to the number of job opportunities available to new graduates there.

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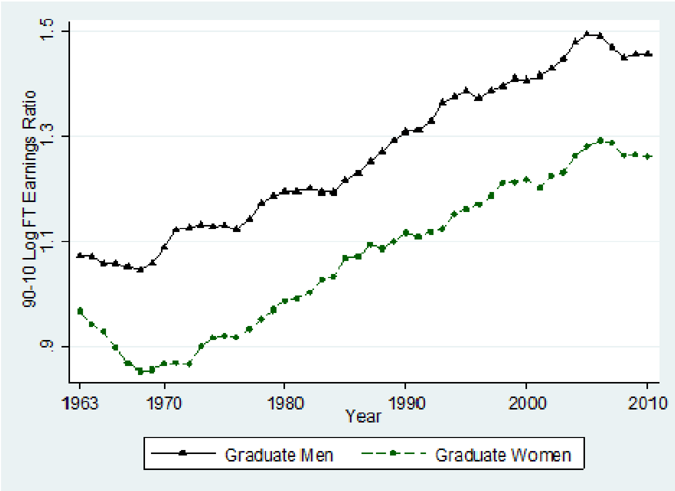
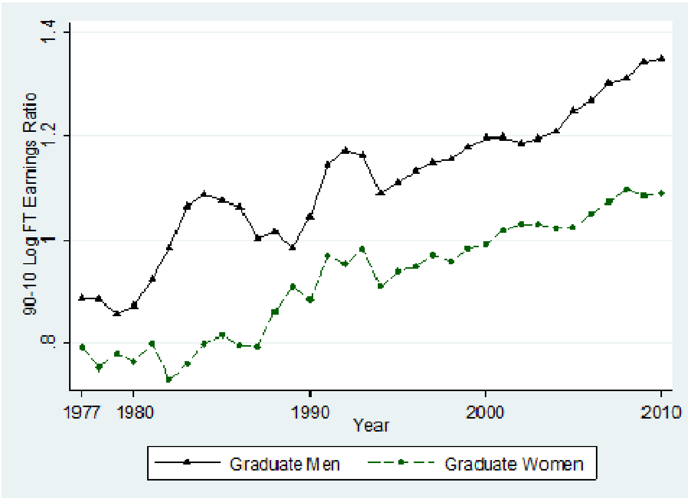
Figure 1: Trends in 90-10 Wage Ratio For Graduates

United States, 1963 to 2010



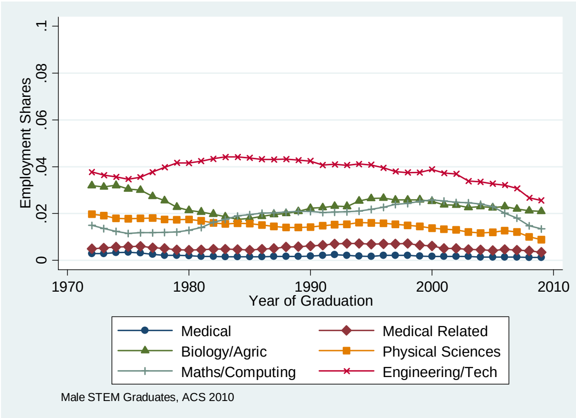
Great Britain, 1977 to 2010



Source: Lindley and Machin (2011). US 90-10 Log(Earnings) ratios from March Current Population Surveys for income years 1963 to 2010. Weekly earnings for full-time full-year workers. GB 90-10 Log(Earnings) ratios from 1977 to 2010 from splicing together the General Household Survey (1977-1992) to the Labour Force Survey (1993 to 2010). Weekly earnings for full-time workers (those working 30 or more hours).

Fig 2a Employment Shares by Graduation Cohorts for Men, US.

a. STEM Graduates



b. Non-STEM Graduates

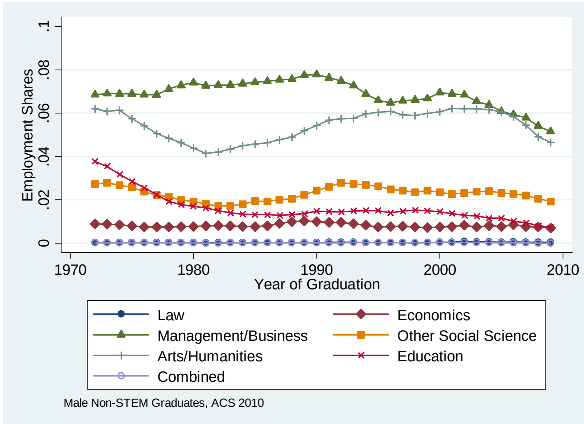
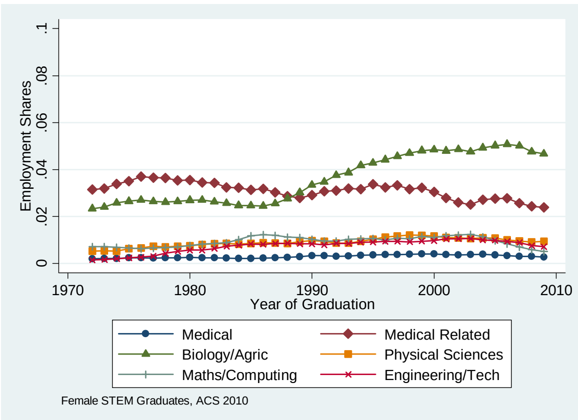
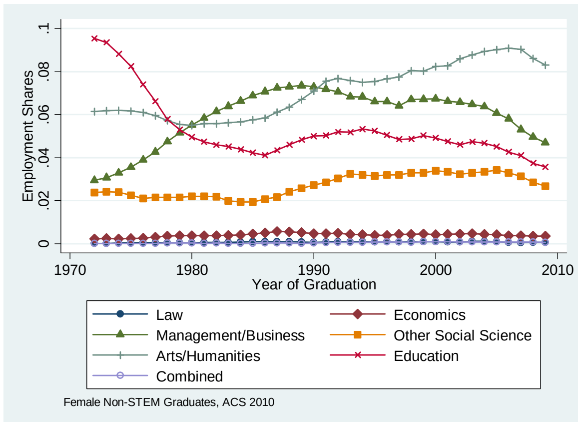


Fig 2b Employment Shares by Graduation Cohorts for Women, US.

a. STEM Graduates



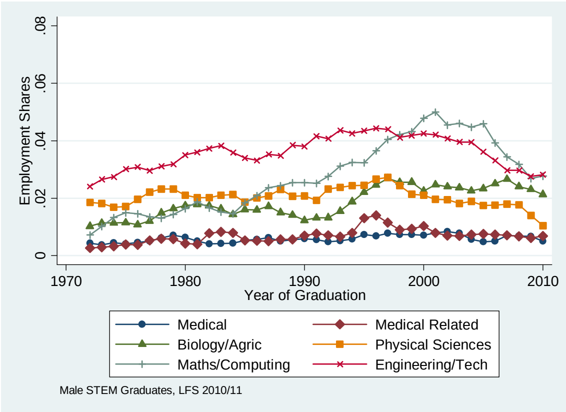
b. Non-STEM Graduates



Notes: Assuming graduation at age 22.

Fig 3a Employment Shares by Graduation Cohorts for Men, UK.

a. STEM Graduates



b. Non-STEM Graduates

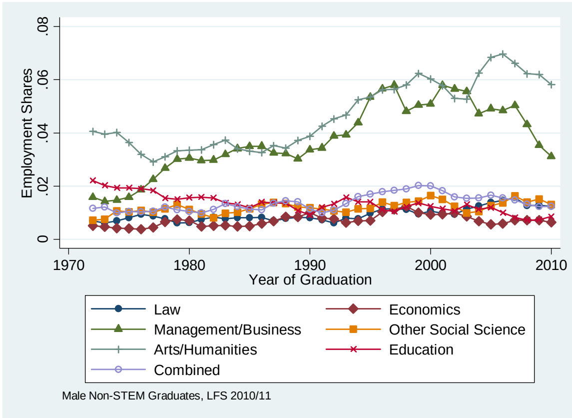
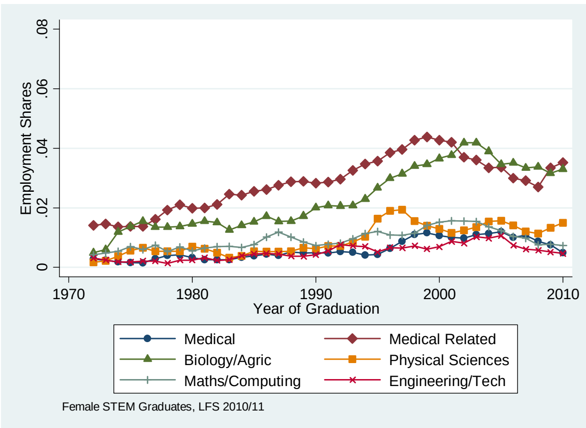
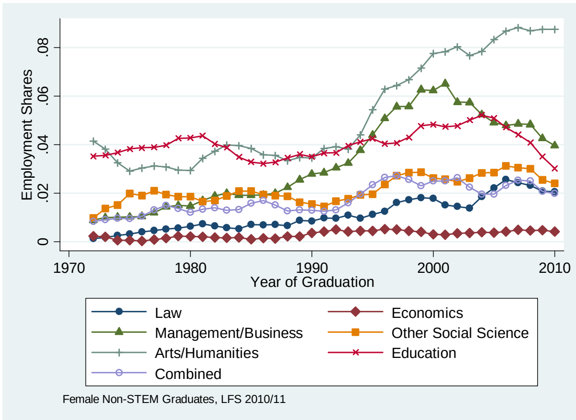


Fig 3b Employment Shares by Graduation Cohorts for Women, UK.

a. STEM Graduates



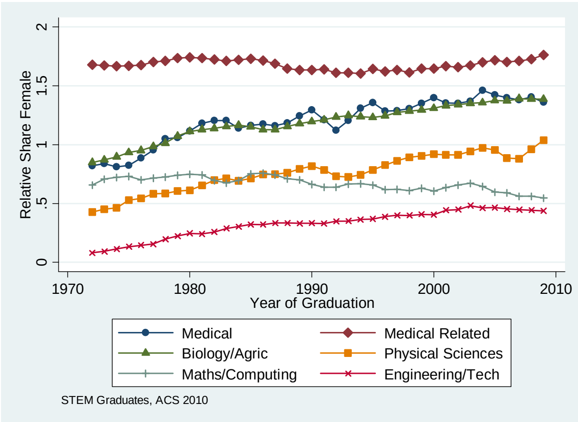
b. Non-STEM Graduates



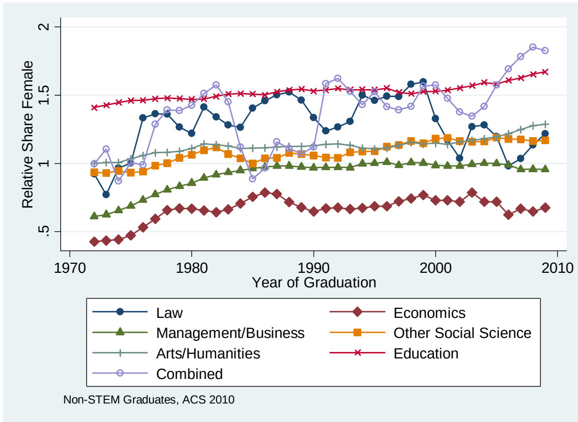
Notes: Assuming graduation at age 22.

Fig 4a Relative Share Female by Subject of Degree and Graduation Cohort, US

a. STEM Graduates



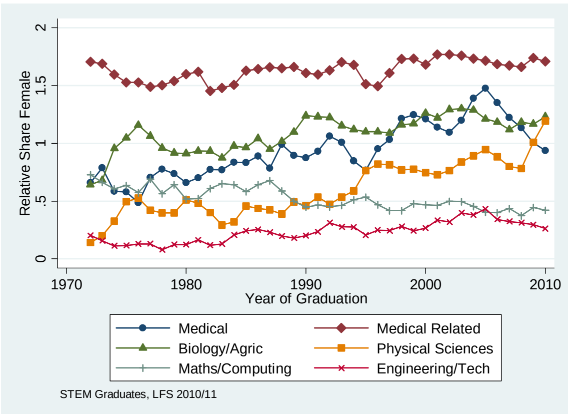
b. Non-STEM Graduates



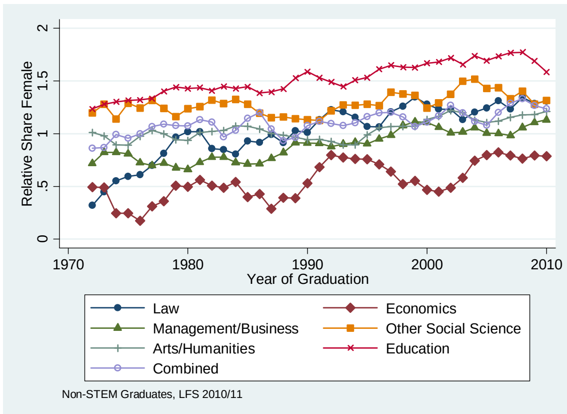
Notes: Assuming graduation at age 22.

Fig 4b Relative Share Female by Subject of Degree and Graduation Cohort, UK

a. STEM Graduates



b. Non-STEM Graduates



Notes: Assuming graduation at age 22.

Figure 5 Relative Wages for Graduates Age 23-60 by Subject of Degree, $\log(W_{it}/W_{2t})$.

a. STEM Graduates b. Non-STEM Graduates

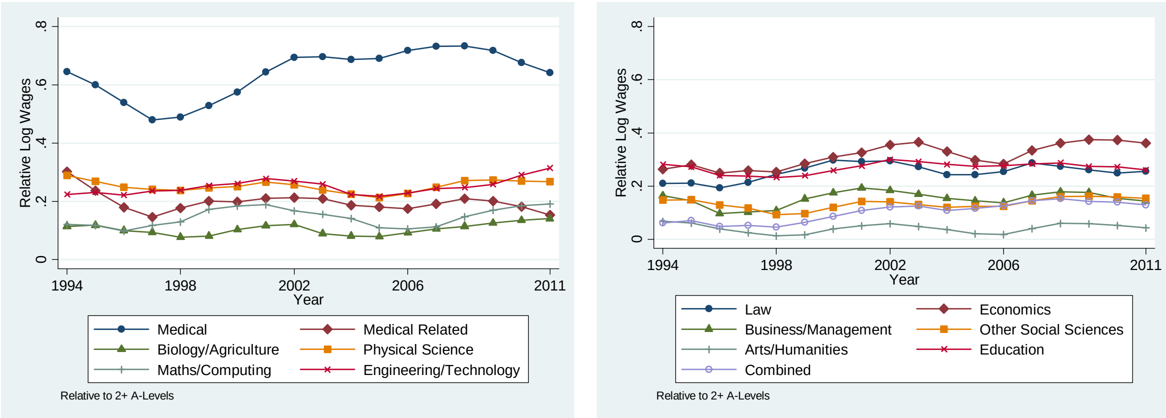


Figure 6 Relative Wages for Graduates Age 23-45 by Subject of Degree, $\log(W_{it}/W_{2t})$.

a. STEM Graduates b. Non-STEM Graduates

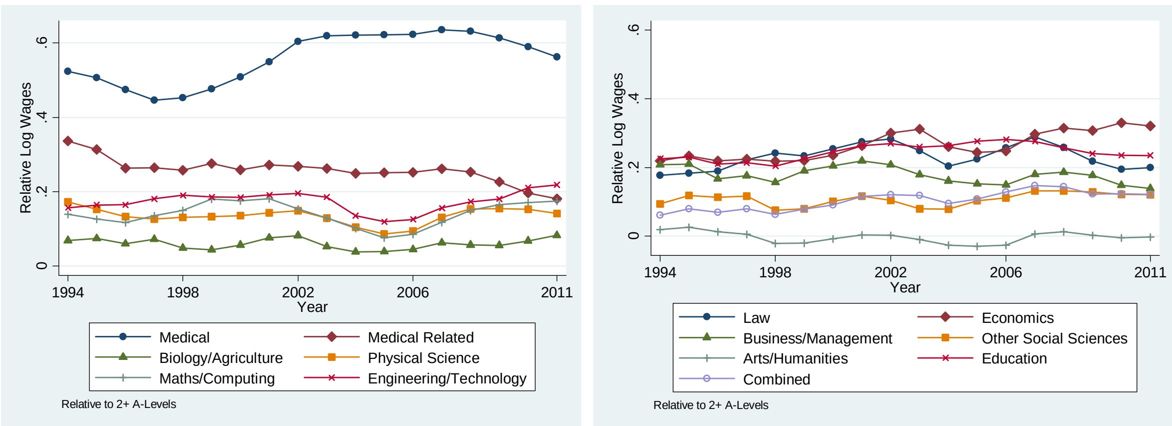


Figure 7 Relative Supply of Graduates Age 23-45 by Subject of Degree, $\log(E_{it}/E_{2t})$.

a. STEM Graduates

b. Non-STEM Graduates

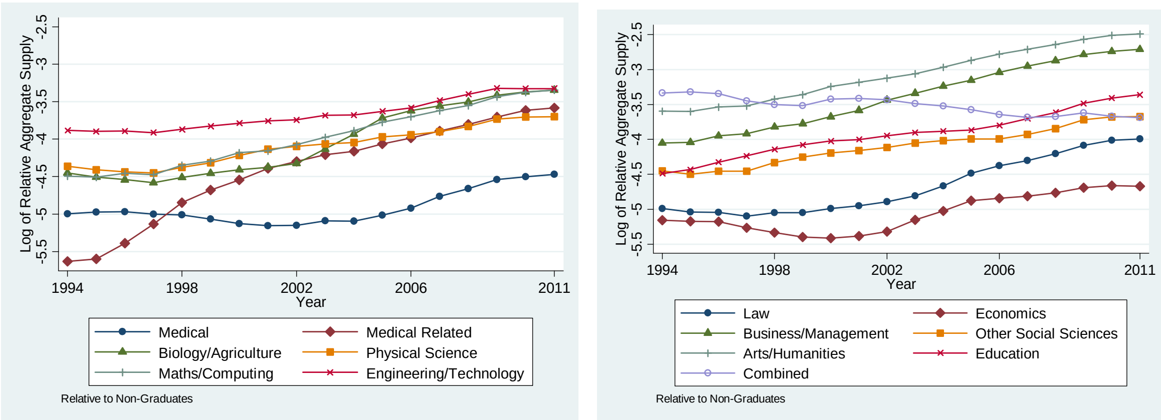
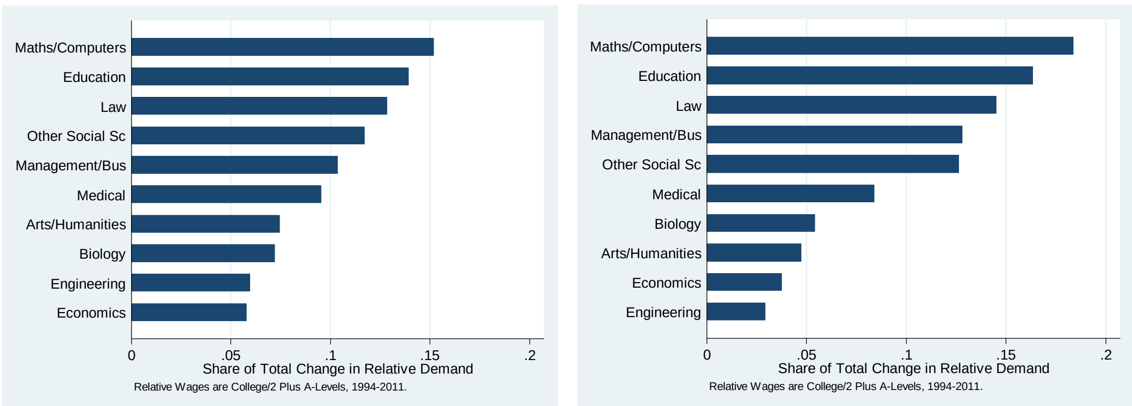


Figure 8 Implied UK Relative Demand Shifts by Subject of Degree, 1994-2011.

a. Relative to Non-Graduates.

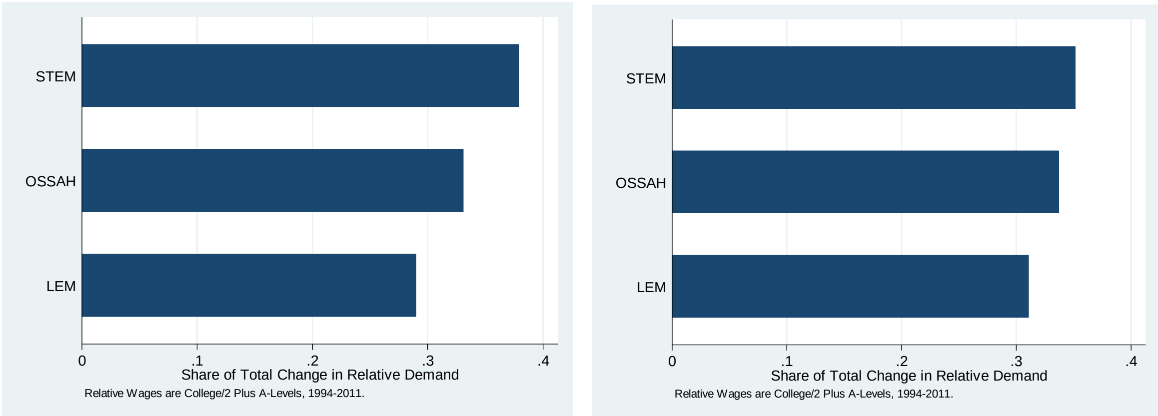
b. Relative to All Other Workers.



Notes: Using subject specific relative labour supply. In Panel (a) the denominator (E_{2t}) of relative supply $\log(E_{it}/E_{2t})$ contains only non-graduates, where the elasticities of substitution are from Table 5. In Panel (b) the denominator contains all workers, where the elasticities of substitution are from Table A2. All relative labour supply composites are efficiency weighted using relative wages averaged over the full time period.

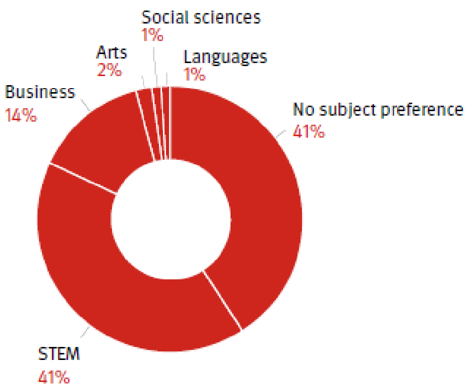
Figure 9 Broad Subject Implied UK Relative Demand Shifts by Broad Subject, 1994-2011.

a. Relative to Non-Graduates. b. Relative to All Other Workers.



Notes: Using subject specific relative labour supply. In Panel (a) the denominator (E_{2t}) of relative supply $\log(E_{it}/E_{2t})$ contains only non-graduates, where the elasticities of substitution are from Table 5. In Panel (b) the denominator contains all workers, where the elasticities of substitution are from Table A2. All relative labour supply composites are efficiency weighted using relative wages averaged over the full time period. STEM consists of Medical, Biology, Maths/Computing and Engineering/Technology. LEM consists of Law, Economics and Management/Business. OSSAH consists of Other Social Sciences, Arts/Humanities and Education.

Figure 10 Degree Subjects Preferred by UK Employers



Source: The CBI Education and Skills Survey, 2011.

Table 1. Change in Employment Shares by Education Group and Gender, 1994-2011

a. United States

	1994	2000	2005	2010	2010-1994
Men					
High School Dropout	0.103	0.092	0.096	0.091	-0.012* (0.002)
High School Graduate	0.332	0.325	0.319	0.316	-0.016* (0.003)
Some College	0.264	0.268	0.262	0.260	-0.040 (0.003)
College Plus	0.300	0.314	0.322	0.332	0.032* (0.003)
N	31493	27940	43723	38235	
Women					
High School Dropout	0.075	0.071	0.061	0.056	-0.019* (0.002)
High School Graduate	0.340	0.309	0.280	0.255	-0.085* (0.004)
Some College	0.310	0.307	0.313	0.311	0.001 (0.004)
College Plus	0.273	0.313	0.345	0.378	0.105* (0.004)
N	28781	25568	40540	35994	

b. United Kingdom

	1994	2000	2005	2011	2011-1994
Men					
High School Dropout	0.131	0.097	0.085	0.059	-0.072* (0.001)
Less than 2 A Levels	0.544	0.549	0.527	0.527	-0.017* (0.002)
2 Plus A Levels	0.039	0.045	0.047	0.051	0.012* (0.001)
Some College	0.139	0.139	0.133	0.110	-0.029* (0.002)
College Plus	0.147	0.169	0.207	0.252	0.105* (0.002)
N	94311	90364	79192	60376	
Women					
High School Dropout	0.216	0.135	0.096	0.057	-0.159* (0.002)
Less than 2 A Levels	0.464	0.503	0.500	0.503	0.039* (0.002)
2 Plus A Levels	0.033	0.041	0.043	0.045	0.012* (0.001)
Some College	0.182	0.178	0.168	0.139	-0.043* (0.002)
College Plus	0.104	0.142	0.191	0.255	0.151* (0.002)
N	93000	90049	82117	65295	

Notes: Source for the US is the Current Population Survey for people in the US. Source for the United Kingdom is the 1994-2011 Labour Force Surveys. Employment shares are defined for people in work age 23 to 60.

Table 2. Change in Log Weekly Wage Differentials by Education Group and Gender, 1994-2011

United States	1994	2000	2005	2010	2010-1994
			Men		
High School Dropout	-0.309* (0.013)	-0.354* (0.015)	-0.318* (0.012)	-0.344* (0.014)	-0.035** (0.020)
Some College	0.159* (0.010)	0.178* (0.010)	0.206* (0.008)	0.203* (0.009)	0.044* (0.013)
College Graduate	0.490* (0.009)	0.560* (0.010)	0.616* (0.008)	0621* (0.009)	0.131* (0.012)
N	20516	17755	27824	22951	
			Women		
High School Dropout	-0.314* (0.017)	-0.346* (0.018)	-0.340* (0.016)	-0.384* (0.019)	-0.070* (0.025)
Some College	0.203* (0.009)	0.206* (0.010)	0.218* (0.009)	0.214* (0.010)	0.011 (0.013)
College Graduate	0.565* (0.009)	0.596* (0.010)	0.608* (0.008)	0.632* (0.009)	0.067* (0.013)
N	15788	14007	21958	19208	

United Kingdom	1994	2000	2005	2011	2011-1994
			Men		
High School Dropout	-0.492*(0.021)	-0.503*(0.016)	-0.503*(0.017)	-0.482*(0.022)	0.010 (0.032)
Less than 2 A Levels	-0.205*(0.018)	-0.215*(0.014)	-0.238*(0.014)	-0.194*(0.016)	0.011 (0.077)
Some College	-0.195*(0.020)	-0.183*(0.015)	-0.207*(0.016)	-0.229*(0.019)	-0.034 (0.029)
College Graduate	0.173*(0.020)	0.191*(0.014)	0.167*(0.015)	0.227*(0.017)	0.054** (0.028)
N	14534	26103	21584	16403	
			Women		
High School Dropout	-0.474*(0.025)	-0.463*(0.018)	-0.517*(0.020)	-0.496*(0.027)	-0.022 (0.032)
Less than 2 A Levels	-0.224*(0.022)	-0.216*(0.016)	-0.270*(0.016)	-0.241*(0.019)	-0.017 (0.033)
Some College	-0.021* (0.024)	-0.008(0.017)	0.063*(0.017)	-0.051*(0.021)	0.030 (0.030)
College Graduate	0.277*(0.025)	0.268*(0.016)	0.242*(0.017)	0.306*(0.019)	0.029 (0.035)
N	7399	15647	14265	11098	

Notes: For the UK sources are the 1994-2011 Labour Force Surveys. Source is the Current Population Survey for people in the US. Log weekly wages are deflated using the Retail Price Index and are bottom coded. These are for full time employees age 23 to 60. For the UK differentials are relative to 2 Plus A Levels, whereas in the US the default group is High School Graduates. Standard errors are in parentheses.

Table 3. Log Weekly Wage Differentials of College Graduates by Subject and Gender in 2010.

	Men		Women	
	US 2010	UK 2010/11	US 2010	UK 2010/11
STEM Subjects				
Medical	0.497*	0.599*	0.386*	0.443*
	(0.029)	(0.039)	(0.022)	(0.035)
Medical Related	0.382*	0.085*	0.273*	0.024
	(0.020)	(0.038)	(0.009)	(0.019)
Biological/Agricultural	0.359*	0.071*	0.189*	0.024
Sciences	(0.012)	(0.029)	(0.008)	(0.021)
Physical Sciences	0.322*	0.105*	0.257*	0.052*
	(0.013)	(0.027)	(0.013)	(0.027)
Maths/Computer Science	0.390*	0.171*	0.310*	0.156*
	(0.014)	(0.027)	(0.014)	(0.029)
Engineering/Technology	0.424*	0.199*	0.372*	0.095*
	(0.011)	(0.025)	(0.015)	(0.039)
Non-STEM Subjects				
Law	0.291*	0.261*	0.128*	0.164*
	(0.087)	(0.035)	(0.056)	(0.027)
Economics	0.524*	0.292*	0.461*	0.183*
	(0.017)	(0.036)	(0.020)	(0.048)
Management/Business	0.358*	0.189*	0.246*	0.045*
	(0.011)	(0.025)	(0.009)	(0.018)
Other Social Sciences	0.280*	0.031	0.156*	-0.023
	(0.013)	(0.031)	(0.009)	(0.022)
Arts/Humanities	0.095*	-0.023	0.107*	-0.086*
	(0.011)	(0.025)	(0.007)	(0.017)
Combined Degrees	0.161	0.078*	0.040	0.014
	(0.122)	(0.030)	(0.068)	(0.014)
N	53445	8776	50549	7087

Notes: Source for United States 2010 American Community Survey. Source for the United Kingdom is Labour Force Surveys. Log weekly wages for US full time graduate employees who worked 50-52 weeks per year and are top and bottom coded. Log weekly wages for UK full time graduate employees are bottom coded. Differentials are relative to having a degree subject in education since the wage differentials over time in the UK are relatively flat (see Figure 3), rather than combined degrees as these are defined quite differently across the two countries (in the US they are general education degrees, whereas in the UK they are degrees with more than one subject).

Table 4. Change in UK Employment Shares of College Graduates by Subject of Degree and Gender, 1994-2011

	1994	2000	2005	2011	2011-1994
Men					
STEM Subjects					
Medical	0.029	0.027	0.020	0.023	-0.006* (0.002)
Medical Related	0.013	0.024	0.028	0.029	0.016* (0.002)
Biological/Agricultural Sciences	0.060	0.054	0.067	0.075	0.015* (0.003)
Physical Sciences	0.097	0.089	0.092	0.079	-0.018* (0.003)
Maths/Computer Science	0.071	0.085	0.098	0.111	0.040* (0.004)
Engineering/Technology	0.174	0.161	0.142	0.135	-0.039* (0.004)
Non-STEM Subjects					
Law	0.035	0.024	0.035	0.037	0.002 (0.002)
Economics	0.040	0.026	0.032	0.028	-0.012* (0.002)
Management/Business	0.086	0.107	0.133	0.153	0.067* (0.004)
Other Social Sciences	0.052	0.056	0.052	0.048	-0.004** (0.003)
Arts/Humanities	0.129	0.157	0.169	0.185	0.056* (0.005)
Education	0.045	0.063	0.048	0.049	0.004 (0.003)
Combined Degrees	0.169	0.125	0.082	0.048	-0.121* (0.003)
N	13614	14707	15831	14526	
Women					
STEM Subjects					
Medical	0.023	0.021	0.019	0.023	0 (0.002)
Medical Related	0.028	0.076	0.090	0.116	0.088* (0.004)
Biological/Agricultural Sciences	0.073	0.056	0.096	0.088	0.015* (0.004)
Physical Sciences	0.046	0.037	0.038	0.034	-0.012* (0.003)
Maths/Computer Science	0.038	0.034	0.035	0.037	-0.001* (0.003)
Engineering/Technology	0.014	0.015	0.016	0.019	0.005* (0.002)
Non-STEM Subjects					
Law	0.032	0.028	0.035	0.043	0.011* (0.003)
Economics	0.014	0.012	0.012	0.011	-0.003* (0.001)
Management/Business	0.062	0.081	0.113	0.126	0.064* (0.004)
Other Social Sciences	0.086	0.101	0.078	0.082	-0.004 (0.004)
Arts/Humanities	0.209	0.210	0.209	0.201	-0.008 (0.006)
Education	0.120	0.162	0.142	0.155	0.035* (0.005)
Combined Degrees	0.254	0.166	0.115	0.065	-0.189* (0.004)
N	9463	12352	15143	16095	

Notes: Source for the United Kingdom is the 1994-2011 Labour Force Surveys. Employment shares are defined for graduates in work age 23 to 60.

Table 5. Katz-Murphy Demand and Supply Model, 1994-2011

$$\log\left(\frac{W_{it}}{W_{2t}}\right) = f(t) + \gamma_i \log\left(\frac{E_{it}}{E_{2t}}\right) + \varepsilon_t$$

	$\hat{\gamma}_i$	$\hat{\sigma}_i$	Trend	Trend Sq
STEM Subjects				
Medical	-0.091* (0.043)	10.95	0.013* (0.003)	-
Medical Related	-0.004 (0.026)	∞	-0.005 (0.003)	-
Biological/Agricultural Sciences	-0.105* (0.022)	9.52	-0.009* (0.004)	0.001* (0.0002)
Physical Sciences	-0.005 (0.040)	∞	-0.013* (0.005)	0.001* (0.0003)
Maths/Computer Science	-0.249* (0.053)	4.01	0.008 (0.007)	0.001* (0.0003)
Engineering/Technology	-0.127* (0.054)	7.89	-0.009 (0.007)	0.001* (0.0003)
Non-STEM Subjects				
Law	-0.112* (0.053)	8.89	0.009* (0.004)	-
Economics	-0.089* (0.028)	11.22	-0.006 (0.007)	0.001* (0.0003)
Management/Business	0.183* (0.041)	5.47	0.013* (0.006)	-
Other Social Sciences	0.174* (0.054)	5.75	0.002 (0.005)	-
Arts/Humanities	-0.102* (0.044)	9.78	-0.005* (0.004)	0.001* (0.0001)
Education	-0.210* (0.025)	4.77	0.024* (0.003)	-0.0004* (0.0001)
Combined Degrees	0.001 (0.022)	∞	0.045* (0.001)	-
All Subjects[a]	-0.206* (0.069)	4.85	0.004 (0.004)	0.001* (0.0002)
N	18			

Notes: **a** This is the estimate of γ derived from $\log(W_{1t}/W_{2t}) = t + t^2 + \gamma \log(E_{1t}/E_{2t}) + \varepsilon_t$
Estimated on a sample of working men and women age 23-45. Where E_{2t} contains non-graduates only.

Table 6. The Proportion in the 3 Most Frequent UK Jobs by Subject and Gender

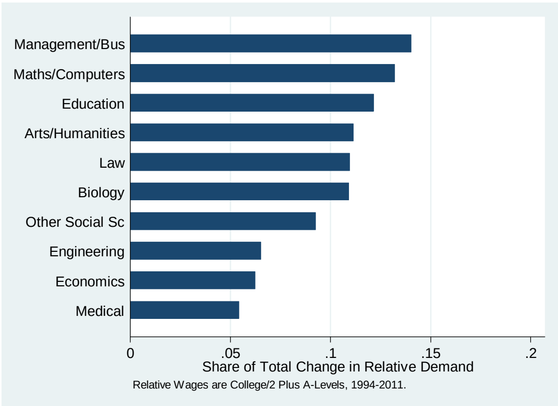
	Prop	Top Three Jobs
Men		
Medical	89.73	Medical Practitioners, Dental Practitioners, Bio Scientists & Biochemists
Medical Related	38.06	Pharmacists & Pharmacologists, Nurses, Medical Practitioners
Biological/Agric. Sciences	19.35	Bio Scientists & Biochemists, Marketing & Sales Managers, Secondary Teachers
Physical Sciences	17.26	Software Professionals, Physicists Geologists & Meteorologists, Chemists
Maths/Computer Science	48.27	Software Professionals, ICT Managers, IT Strategy and Planning Professionals
Engineering/Technology	21.16	Production Works & Maintenance Managers, Design & Development Engineers, Mechanical Engineers
Law	44.09	Solicitors Lawyers Judges & Coroners, Legal Associate Professionals, Police Officers
Economics	25.39	Management Consultants Actuaries Economists & Statisticians, Financial Managers, Financial & Investment Analysts and Advisers
Management/Business	20.81	Marketing & Sales Managers, Financial Managers, Chartered & Certified Accountants
Other Social Sciences	14.96	Social Workers, HE Teachers, General Office Assistants & Clerks
Arts/Humanities	13.04	Secondary Teachers, Architects, Graphic Designers
Education	70.58	Secondary Teachers, Primary Teachers, FE Teachers
Combined Degrees	15.55	Marketing & Sales Managers, Secondary Teachers, Medical Practitioners
Women		
Medical	80.81	Medical Practitioners, Dental Practitioners, Nurses
Medical Related	47.02	Nurses, Physiotherapists, Occupational Therapists
Biological/Agric. Sciences	20.79	Bio Scientists & Biochemists, Secondary Teachers, Psychologists
Physical Sciences	14.39	Secondary Teachers, Physicists Geologists & Meteorologists, Bio Scientists & Biochemists
Maths/Computer Science	28.01	Secondary Teachers, Software Professionals, Primary Teachers
Engineering/Technology	12.45	Civil Engineers, Production Works & Maintenance Managers, Management Consultants Actuaries Economists & Statisticians
Law	43.21	Solicitors Lawyers Judges & Coroners, Legal Associate Professionals, General Office Assistants & Clerks
Economics	22.45	Management Consultants Actuaries Economists & Statisticians, Accounts/Wages Clerks & Bookkeepers, Financial Institution Managers
Management/Business	17.45	Marketing & Sales Managers, Chartered & Certified Accountants, Marketing Associate Professionals
Other Social Sciences	20.47	Social Workers, Secondary Teachers, Housing & Welfare Officers
Arts/Humanities	18.99	Secondary Teachers, Primary Teachers, Marketing & Sales Managers
Education	75.68	Primary Teachers, Secondary Teachers, Educational Assistants
Combined Degrees	22.68	Primary Teachers, Secondary Teachers, Marketing & Sales Managers

Notes: Using the LFS 2010/11 for 354 occupations. The sample consists of workers age 23-45.

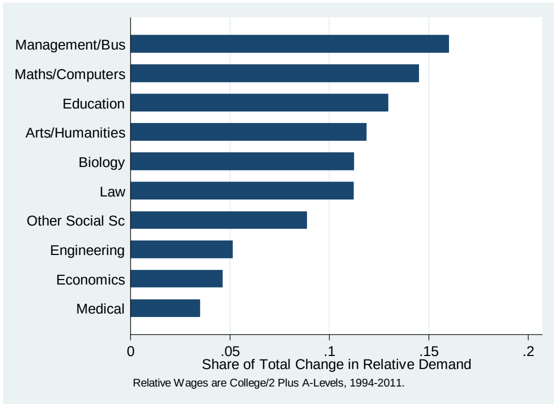
Appendix.

Figure A1 UK Relative Demand Shifts using σ = 1, 1994-2011.

a. Relative to Non-Graduates.



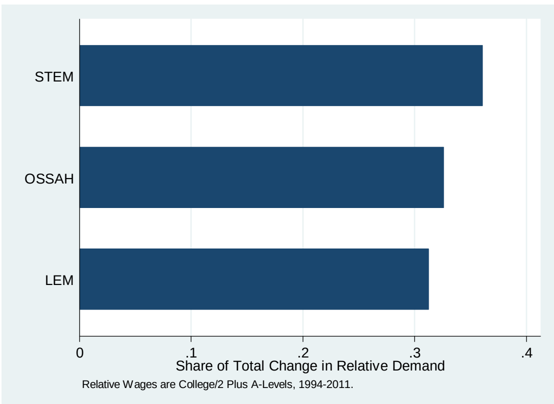
b. Relative to All Other Workers.



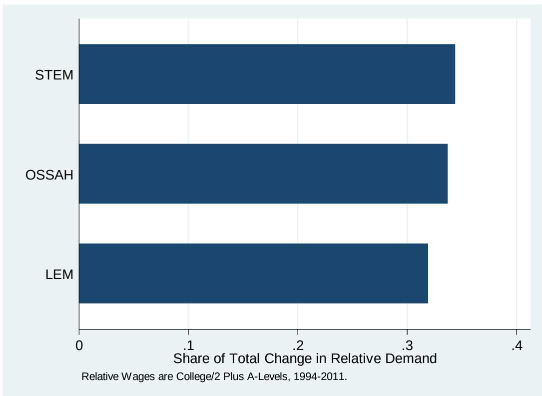
Notes: Using subject specific relative labour supply. In Panel (a) the denominator (E_{2t}) of relative supply $\log(E_{it}/E_{2t})$ contains only non-graduates. In Panel (b) the denominator contains all workers. All relative labour supply composites are efficiency weighted using relative wages averaged over the full time period.

Figure A2 UK Relative Demand Shifts by Broad Subject using σ = 1, 1994-2011.

a. Relative to Non-Graduates.



b. Relative to All Other Workers.



Notes: Using subject specific relative labour supply. In Panel (a) the denominator (E_{2t}) of relative supply $\log(E_{it}/E_{2t})$ contains only non-graduates. In Panel (b) the denominator contains all workers. All relative labour supply composites are efficiency weighted using relative wages averaged over the full time period. STEM consists of Medical, Biology, Maths/Computing and Engineering/Technology. LEM consists of Law, Economics and Management/Business. OSSAH consists of Other Social Sciences, Arts/Humanities and Education.

Table A1 Employment shares of College Graduates by Subject Major and Gender in 2010.

	Men		Women	
	US 2010	UK 2010/11	US 2010	UK 2010/11
STEM				
Medical	0.007	0.023	0.009	0.023
Medical Related	0.019	0.027	0.099	0.110
Biological/Agricultural Sciences	0.082	0.072	0.113	0.090
Physical Sciences	0.053	0.079	0.028	0.035
Maths/Computer Science	0.066	0.111	0.030	0.036
Engineering/Technology	0.135	0.141	0.023	0.019
Non-STEM				
Law	0.001	0.036	0.002	0.043
Economics	0.029	0.028	0.013	0.014
Management/Business	0.242	0.151	0.189	0.127
Other Social Sciences	0.079	0.046	0.085	0.083
Arts/Humanities	0.189	0.182	0.224	0.199
Education	0.056	0.050	0.167	0.155
Combined Degrees	0.001	0.053	0.001	0.067
N	219508	30909	257457	33582

Notes: Source for United States 2010 American Community Survey. Source for the United Kingdom is the 2010-2011 Labour Force Surveys. Employment shares are defined for college graduates in work age 23 to 60.

Table A2. Katz-Murphy Demand and Supply Model, 1994-2011

$$\log\left(\frac{W_{it}}{W_{2t}}\right) = f(t) + \gamma_i \log\left(\frac{E_{it}}{E_{2t}}\right) + \varepsilon_t$$

	$\hat{\gamma}_i$	$\hat{\sigma}_i$	Trend	Trend Sq
STEM Subjects				
Medical	-0.113* (0.045)	8.85	0.011* (0.002)	-
Medical Related	0.003 (0.025)	∞	-0.006* (0.003)	-
Biological/Agricultural Sciences	-0.097* (0.021)	10.32	-0.009* (0.004)	0.001* (0.0002)
Physical Sciences	0.012 (0.043)	∞	-0.013* (0.005)	0.001* (0.0003)
Maths/Computer Science	-0.286* (0.059)	3.49	0.009 (0.007)	0.0004* (0.0003)
Engineering/Technology	-0.085 (0.066)	11.72	-0.010 (0.007)	0.001* (0.0003)
Non-STEM Subjects				
Law	-0.131* (0.059)	7.60	0.009* (0.004)	-
Economics	-0.089* (0.029)	11.38	-0.006 (0.007)	0.001* (0.0003)
Management/Business	-0.207* (0.044)	4.83	0.016* (0.006)	-
Other Social Sciences	-0.197* (0.058)	5.07	0.003 (0.005)	-
Arts/Humanities	-0.082* (0.049)	12.21	-0.006* (0.005)	0.001* (0.0001)
Education	-0.207* (0.026)	4.83	0.023* (0.003)	-0.0004* (0.0001)
Combined Degrees	0.019 (0.022)	∞	0.005* (0.001)	-
All Subjects[a]	-0.206* (0.069)	4.85	0.004 (0.004)	0.001* (0.0002)
N	18			

Notes: **a** This is the estimate of γ derived from $\log(W_{1t}/W_{2t}) = t + t^2 + \gamma \log(E_{1t}/E_{2t}) + \varepsilon_t$ where E_{2t} contains non-graduates. Estimated on a sample of working men and women age 23-45. Where E_{2t} for the subject specific samples contains other graduates and non-graduates. These are efficiency weighted using relative wages averaged over the full time period.

Table A3. The Proportion in the 3 Most Frequent US Jobs by Subject and Gender

	Prop	Top Three Jobs
Men		
Medical	45.48	Pharmacists, Physicians, Physical Therapists
Medical Related	39.06	Nurses, Physical Therapists, Physicians
Biological/Agric. Sciences	22.35	Physicians, Managers & Admin, HE Instructors
Physical Sciences	20.45	Managers & Admin, HE Instructors, Physicians
Maths/Computer Science	54.42	Computer Software Developers, Computer Analysts, Managers & Admin
Engineering/Technology	32.41	Managers & Admin, Computer Software Developers, General Engineers
Law	29.01	Lawyers, Managers & Admin, Legal Assistants
Economics	21.48	Managers & Admin, Financial Specialists, Accountants & Auditors
Management/Business	25.87	Accountants & Auditors, Managers & Admin, Salespersons
Other Social Sciences	25.01	Police, Detectives and PIs, Lawyers, Managers & Admin
Arts/Humanities	14.23	Managers & Admin, Primary Teachers, Lawyers
Education	54.75	Primary Teachers, Secondary Teachers, Managers in Education
Combined Degrees	24.32	Primary Teachers, Managers in Education, Secondary Teachers
Women		
Medical	42.62	Pharmacists, Physical Therapists, Nurses
Medical Related	52.94	Nurses, Speech Therapists, Physical Therapists
Biological/Agric. Sciences	16.40	Primary Teachers, Physicians, Social Workers
Physical Sciences	23.87	HE Instructors, Managers & Admin, Primary Teachers
Maths/Computer Science	34.25	Computer Software Developers, Computer Analysts, Managers & Admin
Engineering/Technology	27.55	Managers & Admin, Computer Software Developers, General Engineers
Law	40.73	Legal Assistants, Lawyers, Secretaries
Economics	19.88	Accountants & Auditors, Managers & Admin, Lawyers
Management/Business	27.35	Accountants & Auditors, Managers & Admin, Secretaries
Other Social Sciences	21.83	Social Workers, Lawyers, Primary Teachers
Arts/Humanities	19.05	Primary Teachers, Managers & Admin, Secretaries
Education	60.39	Primary Teachers, Secondary Teachers, Nursery Teachers
Combined Degrees	43.73	Primary Teachers, Teachers NEC, Secretaries

Notes: Using the ACS 2010 for 333 occupations. The sample consists of workers age 23-45.

[1] Each household remains in the sample for five consecutive quarters, before dropping out to be replaced by a new incoming cohort of households. The survey design is therefore of a rolling panel. Around 45,000 households are surveyed in each quarter, with each individual in the participating household included. Data from the LFS quarters were merged to form annual data sets, covering the period 1994 to 2011. Each year has on average around 150,000 observations. For further information see Office for National Statistics (2011).

[2] In particular, individuals with a first or higher degree are classified as 'college plus', individuals with a Higher Education qualification below first degree level are classified as 'some college' and individuals with any other qualifications are classified as 'high school graduate'. Individuals with no qualifications at all are labelled as 'high school drop-outs'. In the UK, the 'high school graduate' group is sub-divided into those with and without two or more A levels, since the former provide the natural comparison group when estimating wage differentials between graduates and non-graduates.

[3] For an analysis of the returns to specifically postgraduate study, see Lindley and Machin (2011).

[4] See Acemoglu and Autor (2010) as well as Card and Lemieux (2001) who document the earlier rise in attainment for males in the US.

[5] These are estimated from log weekly wage equations estimated separately by year and gender, whilst conditioning on race, region of residence and a quadratic in age using a sample of full time workers aged between 23 and 60.

[6] See also Lindley and Machin (2012) who find similar patterns for women. When Lindley and Machin (2012) look at a younger 26-35 age group they find a fall over time in the undergraduate differential (standard error) of -0.035 (0.025) for men and -0.037 (0.029) for women. Also O'Leary and Sloane (2005) report a falling wage differential to an undergraduate degree for younger women.

[7] We pool together the 2010 and 2011 LFS in order to maximise sample sizes since we disaggregate here by subject, gender and year of graduation (which is effectively age).

[8] Following Altonji *et al.* (2012) it is assumed that these graduates obtained their degree at age 22.

[9] The stocks of employment shares for the two countries are provided in Table A1 in the appendix. These are remarkably similar across the two countries for most subjects. Combined degrees are an exception because in the US these are general degrees which are less common. Also there are fewer medical and law graduates and more Management/Business graduates in the 2010 ACS than in the 2010/11 LFS.

[10] Again we estimate log weekly wage equations separately by gender including controls for race, region of residence, age and age squared for a sample of full time graduates aged between 23 and 60.

[11] Of course our combinations of degree subjects are subject to within group variances. By disaggregating the Engineering and Mathematics degrees Altonji *et al.* (2012) find much higher wage returns to some specific subjects, for example 0.715 log points for Engineering Mechanics and Physics, as well as 0.722 log points for Pure Mathematics and Computer Science. These fall substantially however once occupational dummies are included. Small sample sizes and changes in the questions prevent further disaggregation for the UK and consequently our aim is to combine US individual degree programmes so that they are roughly comparable across the two countries.

[12] This result reflects the gradual change in nursing towards being a graduate occupation, to be compulsory for new nurses from 2013.

[13] These are estimated using separate log wage equations for our 13 education/subject groups and two age bands by gender. Sample sizes restrict estimating using more age bands than two. Controls include race, region of residence and age.

[14] This table of results is available from the authors on request.

[15] The starting point in this approach is a Constant Elasticity of Substitution production function where output in period t (Y_t) is produced by two education groups (E_{1t} and E_{2t}) with associated technical efficiency parameters (θ_{1t} and θ_{2t}) as follows: $Y_t = (\theta_{1t}E_{1t}^{\rho} + \theta_{2t}E_{2t}^{\rho})^{1/\rho}$ where $\rho = 1 - 1/\sigma_E$, and σ_E is the elasticity of substitution between the two education groups.

[16] We considered adopting a similar testing approach to Ottaviano and Peri (2012) by estimating the elasticity of substitution between two groups of graduates with subject i and j to test whether they should be grouped together. However, since we have 13 subjects this still leaves us with the same problem of how we treat the graduates with one of the other 11 subjects. We would still have to make some assumption about the substitutability of these graduates in the production process relative to those with subject i or j during this estimation process.

[17] All education groups, including non-graduates, are efficiency weighted using average relative wages over the full 18 year period.

[18] Of course we could assume that graduates of different subjects are perfect substitutes for each other by including all graduates in the numerator and efficiency weighting to account for differences in their relative productivity, with just non-graduates in the denominator. If we do this we find a statistically significant estimate of γ_i only for Law graduates (-5.04e+07 with a standard error of 1.61e+07). This implies that all graduates (except Law graduates) are perfect substitutes in production for non-graduates. However, this approach assumes that all graduates (regardless of their subject) are employed in the same jobs, so we consider this to be a non-credible relative labour supply measure, given our findings in the next section show that this is not the case.

[19] This may suggest a lack of career progression in medical related occupations (typically nursing), or alternatively that individuals are leaving these professions in mid-career for less well-paid jobs.

[20] We follow the procedure used in Lindley and Machin (2011) which is based on the method initially used by Autor *et al.* (2008). We calculate labour supply measures using hours of work for 16 education and subject groups, sex, 18 years and for two age bands 23-35 and 36-45. This provides 1152 cells from which we calculate aggregate quantity and price samples before averaging at the aggregate level. See Lindley and Machin (2011) who carefully document this procedure.

[21] Fortin (2006) presents US state level estimates for age 26-35 workers between 1979 and 2002. Her 2SLS estimates from her Table 3 are in the range of 4.39 to 5.68.

[22] In Table A2 the parameter on Engineering/Technology is only statistically significant at the 20 percent level but we ignore this because the parameter is clearly much larger and more significant compared to Medical Related, Physical Science and Combined degrees for example.

[23] The trend parameters in Equation (3) proxy $(1/\sigma_i)D_{it}$ and not D_{it}.

[24] Panel b in Table A1 in the Appendix provides broad subject relative demand shifts assuming a Cobb-Douglas production function and assumes therefore that $\sigma = 1$ for all subjects. This provides qualitatively similar results.