To what Degree? - Recovering changes in the UK's graduate skill distribution.

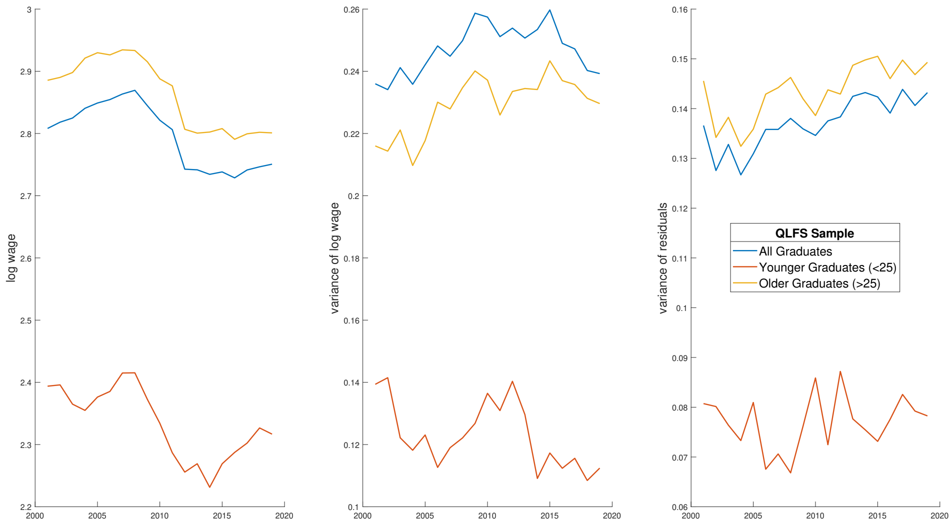
Max Schroeder

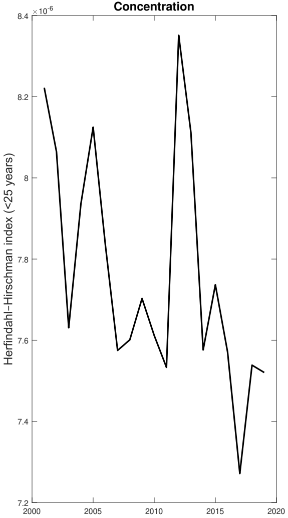
University of Birmingham

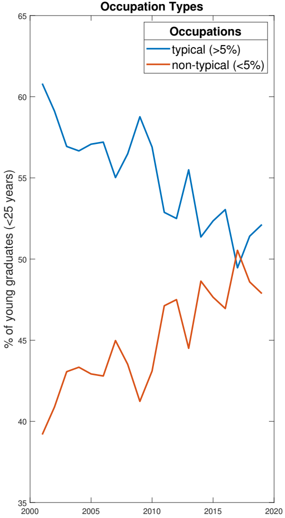
3^{rd} of April 2023

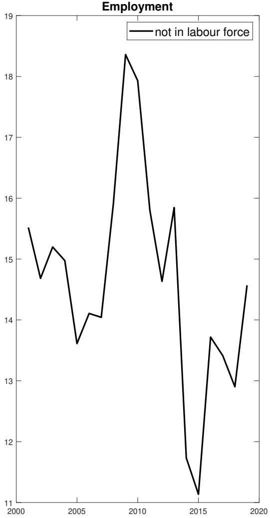
Introduction

- Generally, we believe a university education is beneficial for the individual, providing skills, good jobs and high earnings. But the HE sector is also crucial in determining the supply of high skilled labour allowing the economy to grow and develop.
- As a result, university education has become an increasingly important fixture of the UK education policy. Over the last 50 years, we have seen a massive increase in enrolment rates and a large increase in the number of HEI's.
- Recently, concerns have been raised about the effectiveness of universities in providing the correct skills to their students, leading to debates about inequality, employability, under-employment and cost-effectiveness.


log wage
variance of log wage
variance of residuals
QLFS Sample
All Graduates
Younger Graduates (<25)
Older Graduates (>25)


Concentration
×10^-6
Herfindahl-Hirschman index (<25 years)
8.4
8.2
8
7.8
7.6
7.4
7.2
2000
2005
2010
2015
2020


Occupation Types
Occupations
typical (>5%)
non-typical (<5%)
% of young graduates (<25 years)
65
60
55
50
45
40
35
2000
2005
2010
2015
2020


Employment
not in labour force
19
18
17
16
15
14
13
12
11
2000
2005
2010
2015
2020

- The last 20 years saw huge changes in both the demand for and supply of skills:
    - technological change
    - structural transformation of the labour market
    - higher education expansion
    - school reform
    - demographic change
- If we want to understand changes to the labour market outcomes of graduates, we need to take into account both supply and demand factors.

The qualitative margin

- Recent work suggests that subject of study matters a lot for graduate outcomes (e.g. Altonji et al. (2016), Andrews et al. (2022) and Lovenheim & Smith (2022)).
- Further work suggests that task content is an important driver of differences in labour market outcomes (c.f. Autor et al. (2003), Autor & Handel (2013), Sanders & Taber (2015))
- This suggests we should try and study the *qualitative* dimension of graduate's skills.

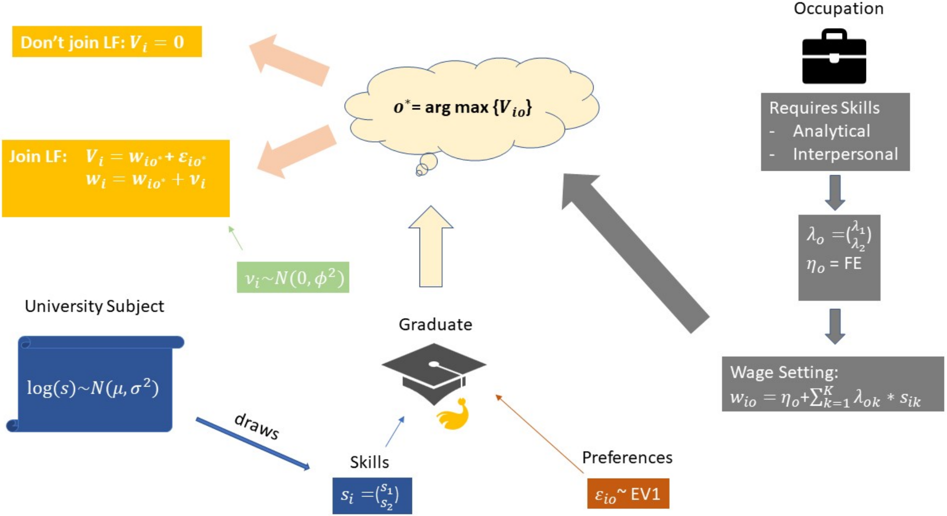
Aim of this paper

- In this paper I develop a model of the labour market for young university graduates. The model features:
    - multidimensional skills
    - skill heterogeneity
    - differences in the return to these skills
    - non-pecuniary preferences
- I estimate the model and use it to decompose the different factors driving changes to the labour market outcomes of young graduates.

The Economic Environment

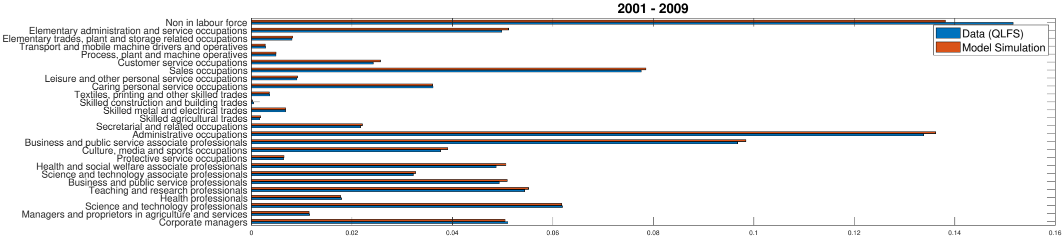
- There is a finite number of *Occupations*, that differ in their demand for a finite number of general skills according to the tasks that are required to produce their output in each case.
- Similarly, workers are heterogeneous with respect to the multidimensional set of skills that they have.
- Workers choose which occupation they want to enter and workers are paid their marginal product ▸ Derivation

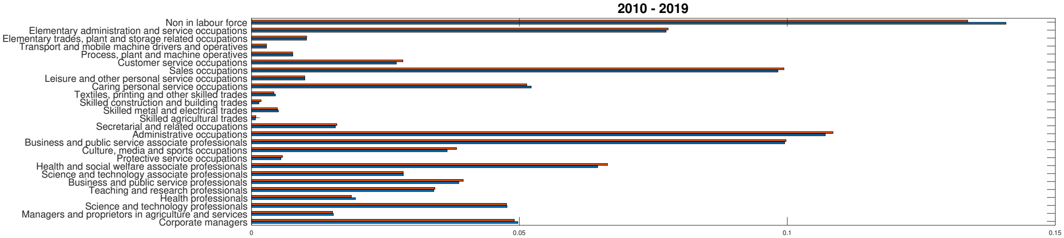
A picture says more than e^6.90775527898 words



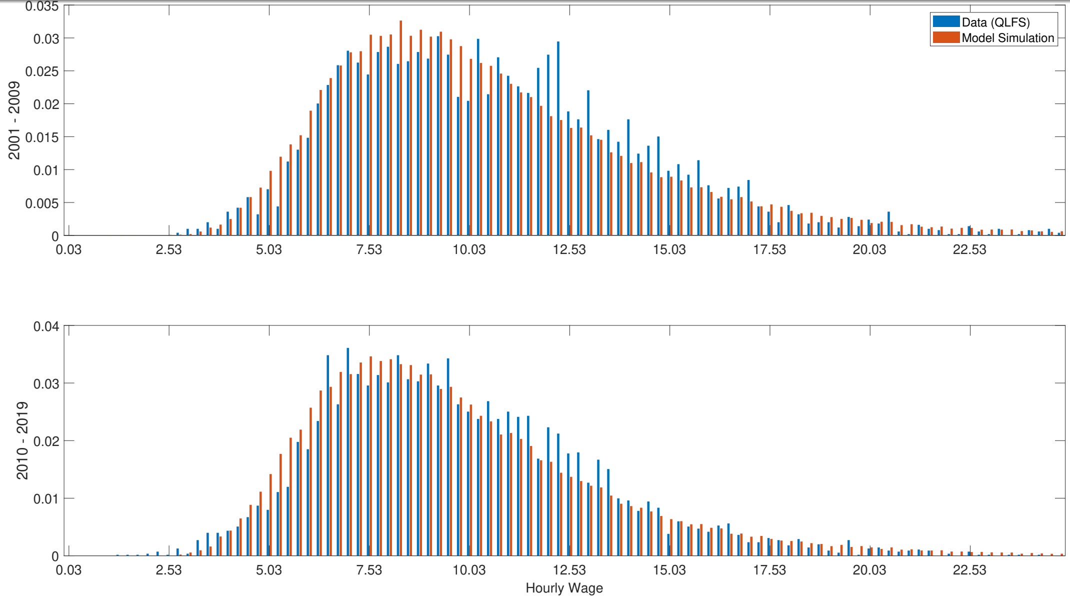
Taking the model to the data

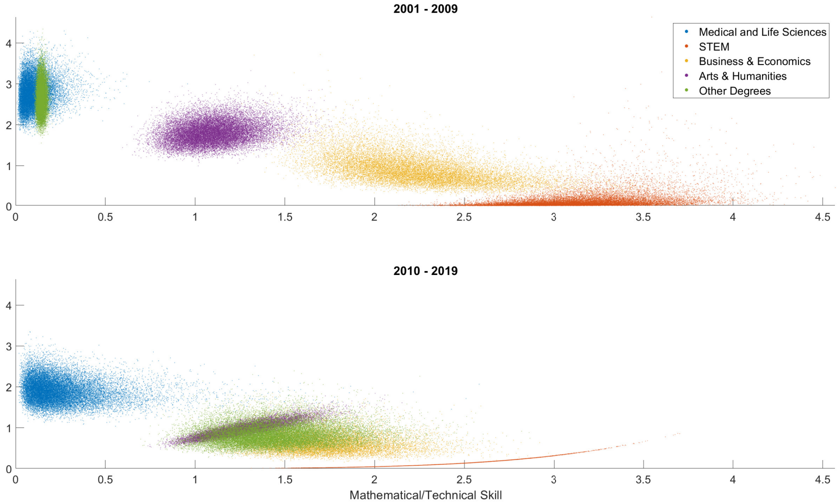
- Split sample into 2 periods: 2001 - 2009, 2010 - 2019. ▸ Sample details
- Aggregate degree subjects: Medical & Life Sciences, STEM, Business & Economics, Arts & Humanities, Other
- Two types of skill: **abstract** & **interpersonal**. Skill prices are estimated from SES. ▸ Skill Prices ▸ Task Examples
- Ask the computer (nicely) to maximize the LL given the observables while integrating out the distribution of unobservable skills. ▸ Estimation

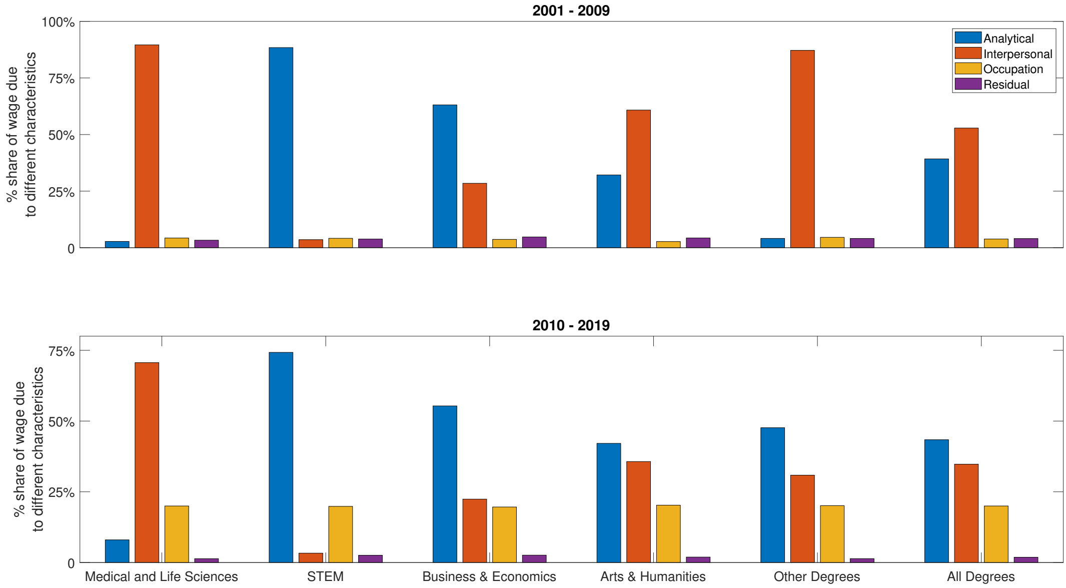


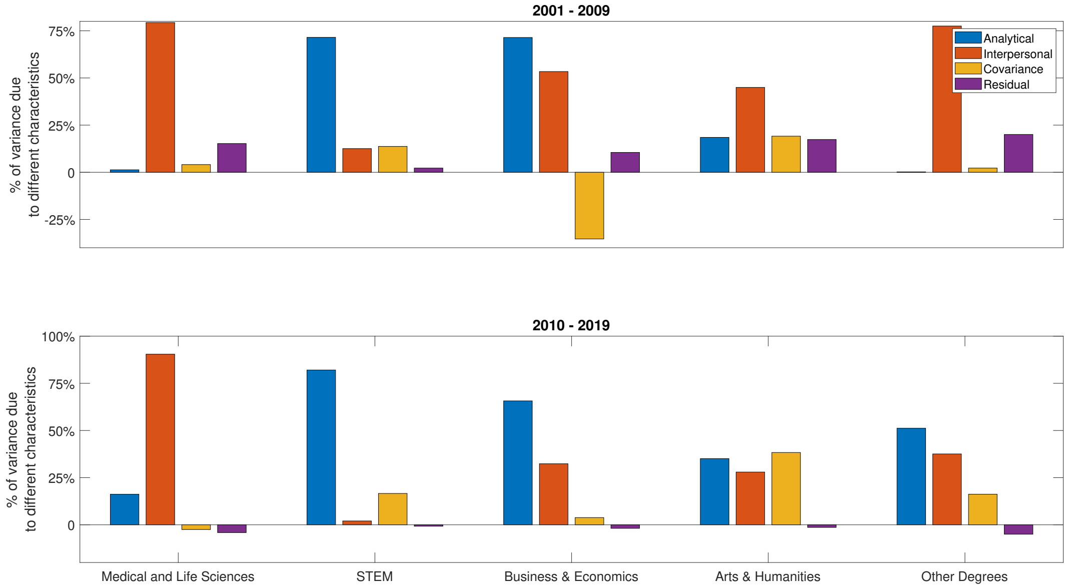


Source: QLFS and Model Simulation


Data (QLFS)
Model Simulation
2001 - 2009
2010 - 2019
0.035
0.03
0.025
0.02
0.015
0.01
0.005
0
0.04
0.03
0.02
0.01
0
0.03
2.53
5.03
7.53
10.03
12.53
15.03
17.53
20.03
22.53
Hourly Wage

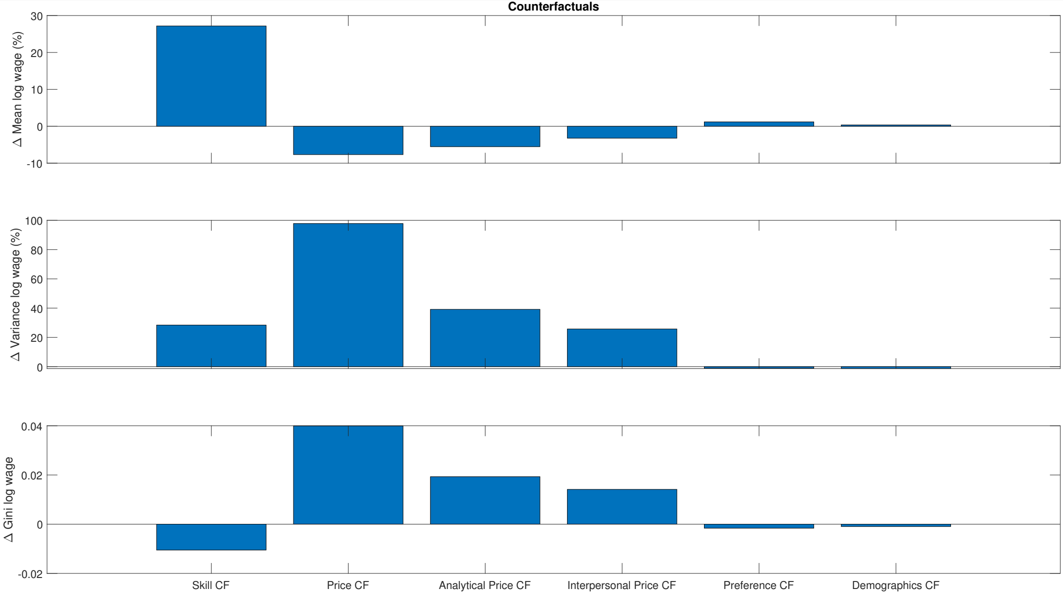

2001 - 2009
Medical and Life Sciences
STEM
Business & Economics
Arts & Humanities
Other Degrees
0
1
2
3
4
0
0.5
1
1.5
2
2.5
3
3.5
4
4.5
2010 - 2019
0
1
2
3
4
0
0.5
1
1.5
2
2.5
3
3.5
4
4.5
Mathematical/Technical Skill

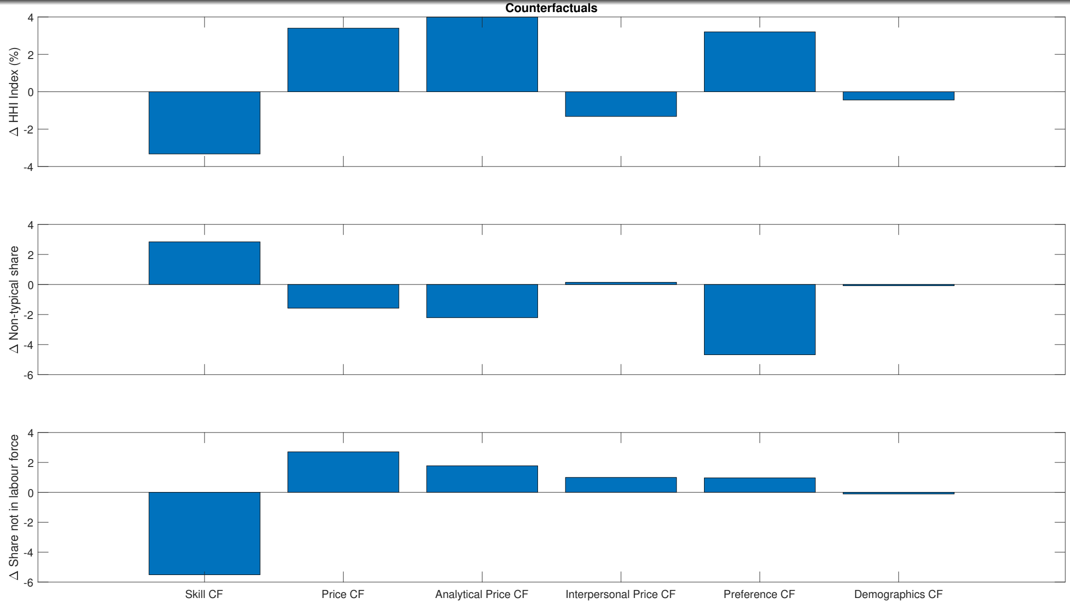

2001 - 2009
100%
75%
50%
25%
0
% share of wage due to different characteristics
Analytical
Interpersonal
Occupation
Residual
2010 - 2019
75%
50%
25%
0
% share of wage due to different characteristics
Medical and Life Sciences
STEM
Business & Economics
Arts & Humanities
Other Degrees
All Degrees


2001 - 2009
75%
50%
25%
0
-25%
% of variance due
to different characteristics
Analytical
Interpersonal
Covariance
Residual
2010 - 2019
100%
75%
50%
25%
0
% of variance due
to different characteristics
Medical and Life Sciences
STEM
Business & Economics
Arts & Humanities
Other Degrees

Counterfactuals

- Having estimated the parameters of the economy, I perform some counterfactual analyses by keeping different parts of the parameter space fixed at the period 1 values. Specifically consider:
  1. Keeping the skill distribution fixed.
  2. Keeping the skill prices fixed at 2001 values (abstract, interpersonal & both).
  3. Keeping demographic composition fixed.
  4. Keeping non-monetary preferences fixed.


Counterfactuals
Δ Mean log wage (%)
30
20
10
0
-10
Δ Variance log wage (%)
100
80
60
40
20
0
Δ Gini log wage
0.04
0.02
0
-0.02
Skill CF
Price CF
Analytical Price CF
Interpersonal Price CF
Preference CF
Demographics CF


Counterfactuals
∆ HHI Index (%)
∆ Non-typical share
∆ Share not in labour force
4
2
0
-2
-4
-6
Skill CF
Price CF
Analytical Price CF
Interpersonal Price CF
Preference CF
Demographics CF

Counterfactuals

1. Skill Counterfactual: **higher mean wages, moderately higher variance (lower tail), less unemployment $\rightarrow$ Interpersonal skills matter for young graduates wages**
2. Price Counterfactual(s): **small wage effect, large increase in variance (analytic $>$ interpersonal), more concentration, less non-typical (analytical!) $\rightarrow$ Changing demand for analytical skill drew graduates into non-typical occupations.**

Counterfactuals

4. Demographic Counterfactual: **very little effect on either outcome**
5. Preference Counterfactual: **some impact on occupation concentration → non-typical occupations have become more attractive**

Conclusion - what have we learned?

- This paper has provided novel quantitative evidence on the changing distribution of graduate's skills in the UK. There are clear differences of skill endowments for students from different subject areas over time.
- On average, graduates tend to have more mathematical skills today, but less verbal skills. Inequality has also been falling somewhat. (But be mindful of heterogeneity and selection!)
- Overall, the skill supply appears to have evolved to take advantage of opportunities in the labour market, providing an inequality reducing thrust. So if large disparities exist and persist, we should probably look for complementary explanations.

The end.

qr-code.png

Derivation of marginal product

$$h_{io} = e^{\sum_K \lambda_{ok} s_{ik}} \qquad \text{(Workers HC)}$$

$$Y = F(H_1, ..., H_O) \qquad \text{(Aggregate Production Function)}$$

$$\frac{\partial Y}{\partial h_{io}} = \frac{\partial F}{\partial H_o}\frac{\partial H_o}{\partial h_{io}} = \frac{\partial F}{\partial H_o} e^{\sum_K \lambda_{ok} s_{ik}} \qquad \text{(Take derivative)}$$

$$\frac{\partial F}{\partial H_o} = \eta_o$$

$$w_{io} = \eta_o + \sum_K \lambda_{ok} s_{ik} \qquad \text{(Log Wage Equation)}$$

back

Data Sources

- Quarterly Labour Force Survey (2001 - 2019)
  - Degree Subject
  - Gross hourly wages (CPI deflated)
  - Occupation (2 Digit SOC)
  - Age
  - Gender
  - Geographic location
- Skills and Employment Survey (2001, 2006, 2012, 2017)
  Examples
- Focus on *fresh* graduates (≤ 24 years). Resulting in a sample of $46,637$ individuals. Go back

Simulated Maximum Likelihood

- By combining the elements of the model, we can form the likelihood function:

▸ Derivation

Likelihood Function

$$\Pr(o_i^*, w_i^{obs}) = \int \left(\underbrace{\left(\frac{e^{\eta_{o^*} + \sum_K \lambda_{o^*k} s_{ik}}}{\sum_{o=1}^{O} e^{\eta_o + \sum_K \lambda_{ok} s_{ik}}} \right)}_{Occupation} \underbrace{\left(\frac{e^{(-\frac{\nu_i^2}{2\phi^2})}}{\sqrt{2\pi\phi^2}} \right)}_{Wage} \right) f(s)d(s)$$

- The estimation procedure works via *simulated maximum likelihood* - we find the vector of economic parameters θ, that maximizes the probability of observing the actual outcomes.
- Use $1,000$ *quasi-random* Halton draws to approximate the integral.
- Additional controls: Year and geography Fixed Effects, experience, part-time status and gender. As well as occupation specific non-pecuniary benefits.

1. Find $\Pr(o^*, w_i^{obs}|s_i;\theta)$ using the structure of the economic model.
2. Integrate over the unobserved skill distribution $f(s|\theta))$:
$\Pr(o^*, w_i^{obs}|\theta)) = \int \Pr(o^*, w_i^{obs}|s_i;\theta))f(s|\theta))ds$.
3. Find vector of parameters $\hat{\theta}$ that maximizes the Log Likelihood function:
$$ll(\theta) = \sum_{i=1}^{N} \log(\Pr_i(o^*, w_i^{obs}|\theta)))$$

back

Derivation of Likelihood

$$\Pr(o_i^*, w_i^{obs}) = \int \Pr(o_i^*, w_i^{obs}|s_i) f(s) d(s) \qquad \text{(Rewrite unconditional probability)}$$

$$\frac{\Pr(o_i^*, w_i^{obs}|s_i)}{\Pr(o_i^*|s_i)} = \Pr(w_i^{obs}|s_i, o_i^*) \qquad \text{(Bayes Rule)}$$

$$\Pr(o_i^*, w_i^{obs}|s_i) = \Pr(o_i^*|s_i) * \Pr(w_i^{obs}|s_i, o_i^*) \qquad \text{(rearange)}$$

$$\Pr(o_i^*, w_i^{obs}) = \int \Pr(o_i^*|s_i) \Pr(w_i^{obs}|s_i, o_i^*) f(s) d(s)$$

(Integrate over skill distribution)

Derivation of Likelihood cont.

$$\Pr(o_i^*|s_i) = \frac{e^{\eta_{o^*} + \sum_K \lambda_{o^* k} s_{ik}}}{\sum_{o=1}^{O} e^{\eta_o + \sum_K \lambda_{ok} s_{ik}}} \qquad \text{(Logit Choice Probability)}$$

$$\Pr(w_i^{obs}|s_i, o_i^*) = \frac{e^{\left(-\frac{\nu_i^2}{2\phi^2}\right)}}{\sqrt{2\pi\phi^2}} \qquad \text{(Normal PDF)}$$

$$\Pr(o_i^*, w_i^{obs}) = \int \left(\left(\frac{e^{\eta_{o^*} + \sum_K \lambda_{o^* k} s_{ik}}}{\sum_{o=1}^{O} e^{\eta_o + \sum_K \lambda_{ok} s_{ik}}} \right) \left(\frac{e^{\left(-\frac{\nu_i^2}{2\phi^2}\right)}}{\sqrt{2\pi\phi^2}} \right) \right) f(s) d(s) \qquad \text{(insert)}$$

back

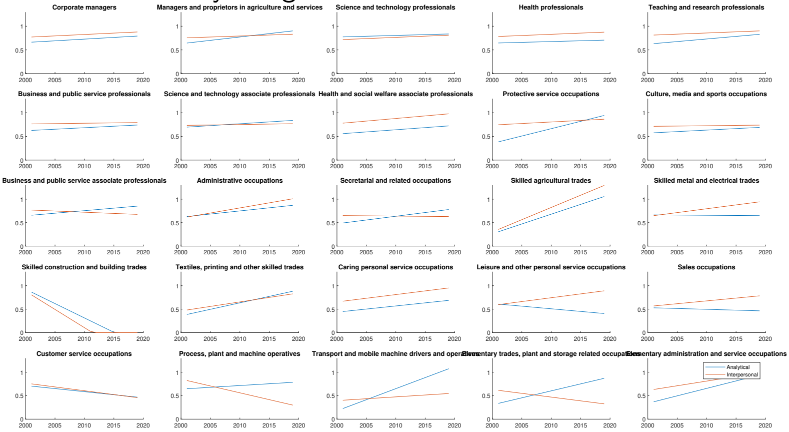
Tasks (with Examples)

1. Abstract Tasks
   - Specialist knowledge and understanding
   - Complexity level of computer use
   - Advanced Mathematics/Statistics
2. Interpersonal
   - Making Speeches/Presentations
   - Persuading or influencing others
   - Cooperating with colleagues

back

Skill Prices

Task intensities by 2 digit SOC



Source: SES, authors own calculations ▶ back