Individual and Aggregate Mismatch in Higher Education

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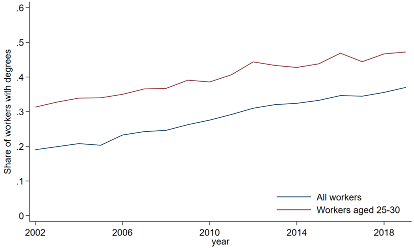
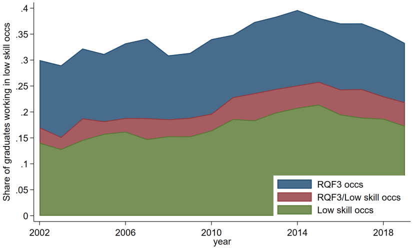
As more graduates go to university, incidence of 'overeducation' increased



(a) Share of workers with degrees



(b) Share of graduates in low skill occupations by Home Office classification

Figure: Changes in the share of workers with degrees and the share of graduates in low-skill jobs (Home Office Classification) from 2002-19 (Source: UK Quarterly Labour Force Survey)

Overeducation by HE subject

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  - A worker is ex-post individually mismatched if they could have had a higher utility under a different choice.
  - There is aggregate mismatch if aggregate utility (in some sense) changes when the education profile changes

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   - Carries out policy counterfactuals to analyse optimal level of education

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  - Optimal policy trades off congestion externalities with hold-up externalities

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4. Jobs are ex-ante heterogeneous in their productivity, y, the distribution of which differs between occupations
5. After education, workers with heterogeneous skills match with jobs with heterogeneous productivity in a frictionless matching market with transfers, producing joint output g(s,y) (Becker (1973); Sattinger (1993))

▸ Function assumptions ▸ Matching details ▸ Worker's problem

Main Implications

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- Optimal HE attendance relative to the equilibrium is ambiguous as these externalities offset

Empirical Implementation

- Parameterise and estimate the model to quantify the extent and utility cost of education mismatch

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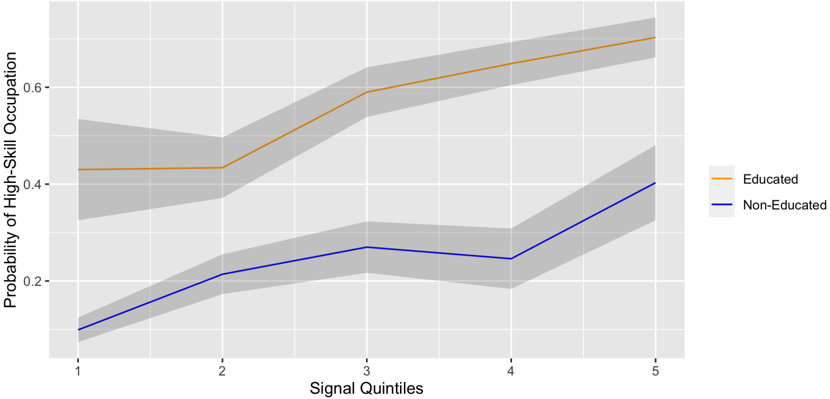
- Data on within-occupation firm productivity from two-way FE regressions on UK hours and earnings data (ASHE)
  - ▸ Occupation data
  - ▸ Parameter Estimates

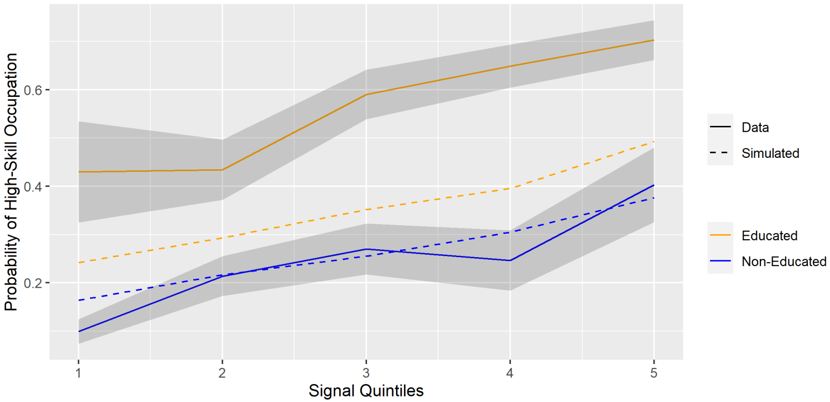
Dependence of Overeducation on Grades

Figure: Actual probabilities of matching to high-skill occupations



Dependence of Overeducation on Grades

Figure: Actual and simulated probabilities of matching to high-skill occupations (untargeted)



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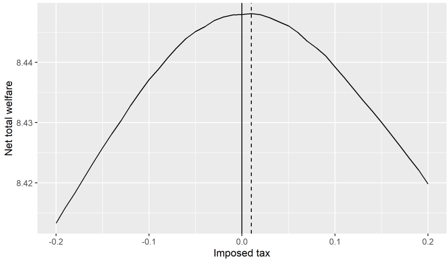
  - 27.6% of non-graduates (14.7% of workers) would choose to go.
- Average cost amounts to 1.61% of average wages for ‘over-educated’ workers and 2.32% for ‘under-educated’ workers respectively.

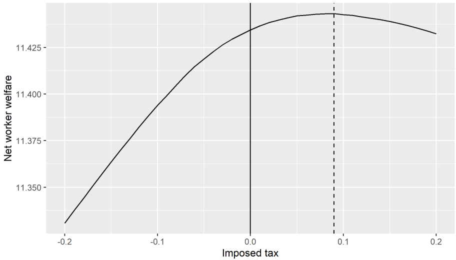
Optimal Policy

Empirically, it is welfare-improving to reduce HE attendance by 1.6pp by imposing a revenue neutral flat tax. ▸ Considered Policy

Figure: Net welfare under different compensated tax levels

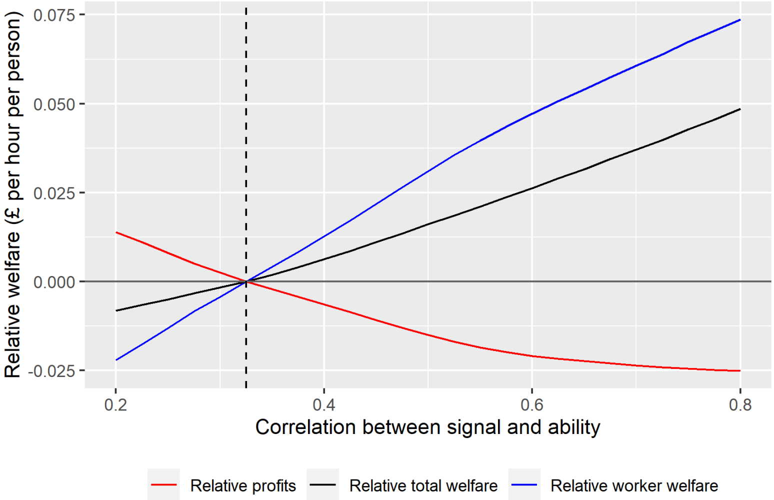


(a) Net total welfare



(b) Net worker welfare

Reducing Variance of Signal



Conclusion

1. Heterogeneity in post-education skill explains graduates matching to low-skill occupations...
2. ...while uncertainty about returns can explain why low-ability workers may nevertheless select into higher education.
3. Worker's uncertainty leads to 32.9% of workers being mismatched in their education choice.
4. Optimal policy trades off congestion and hold-up externalities; optimal policy at baseline is a small reduction in college attendance
5. Reducing uncertainty makes workers better off but makes firms worse off by increasing wages.

Appendices

Contributions

- Models of human capital investment in matching models of the labour markets
  - Chade & Lindenlaub (2021); Shephard & Sidibe (2019); Macera & Tsujiyama (2020)

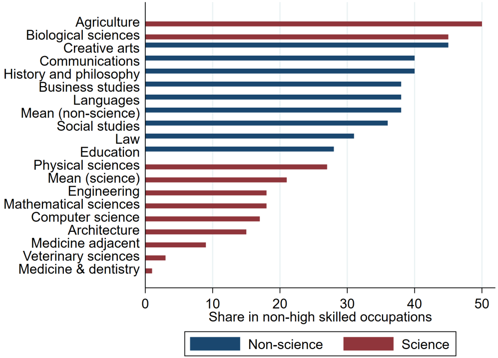
  → This paper: Extends Chade & Lindenlaub (2021) to incorporate endogenous selection into education by ability
- Papers exploring matching of workers with heterogeneous skill to jobs with heterogeneous productivity
  - Acemoglu (1999); Albrecht & Vroman (2002); Jackson (2021)

  → This paper: Reproduces main results from this literature while allowing for a more general specification of education mismatch (beyond labour market frictions)
- Papers exploring individual overeducation/education mismatch
  - Leuven & Oosterbeek (2011); Clark et al. (2017)

  → This paper: Proposes imperfect information about ability as an explanation, and quantitatively evaluates the extent of the mismatch

Motivation

Figure: Workers by share in non high-skill occupation by degree subject (2018-19)



Data from HESA outcomes survey for 2018-19 for graduates one-year from graduation.

Matching in the Model

Back

- Frictionless matching with perfectly transferable utility (Becker (1973), Sattinger (1993))
- If the output function is supermodular, then the optimal matching is positive assortative

$$\mu(s) = F_y^{-1}(F_s(s))$$

- The shape of the wage function depends on the marginal impact on total output of skill

$$\frac{\partial g(s,y)}{\partial s} = q\gamma_1 s^{\gamma_1 - 1} y^{\gamma_2}$$

$$w(s) = w_0 + \int_{-\infty}^{s} \frac{\partial g(s,y)}{\partial s}(x, \mu(x))dx$$

Assumptions on Exogenous Model Functions

Back

1. Assumptions on education technology $s(a, e)$
   - The skill function $s(a, e)$ is continuous and differentiable in a for both values of e.
   - $\frac{\partial s(a,1)}{\partial a} > \frac{\partial s(a,0)}{\partial a}$ for all values of a, such that the difference of $s(a, 1) - s(a, 0)$ is increasing in a.
2. Assumptions on joint output $g(s, y)$
   - The joint output function $g(s, y)$ is increasing in both s and y, and twice continuously differentiable.
   - The function is assumed to be supermodular, which is equivalent to the following condition since it is twice-continuously differentiable: $\frac{\partial^2 g}{\partial s \partial y} \geq 0$.

The value of education

The value of choosing education option e for a worker with signal θ is thus as follows.

$$V(\theta, e) = (\kappa \times e) + \eta(e) + \beta E\{w(s(a, e))|\theta\} \tag{1}$$

Workers face a discrete choice problem. Their optimal education option e^* therefore is given as follows.

$$e^*(\theta) = \arg\max_{e \in \{0,1\}} V(\theta, e) \tag{2}$$

◂ Back

The probability of choosing education

Proposition

Under certain functional form assumptions,

1. *the solution to the individual problem is characterised by a cut-off signal, $\theta^*(\Delta\eta)$, conditional on net HE preferences;*
2. *the optimal cut-off $\theta^*(\Delta\eta)$ is decreasing in $\Delta\eta$.*

The probability of a worker with signal θ choosing to invest in education, denoted by $P(\theta)$, is given by the following expression.

$$P(\theta) = Pr\left\{\Delta\eta > -\left(\kappa + \beta E\left\{w(s(a,1)) - w(s(a,0))|\theta\right\}\right)\right\} \tag{3}$$

◂ Back

Resulting skill distribution

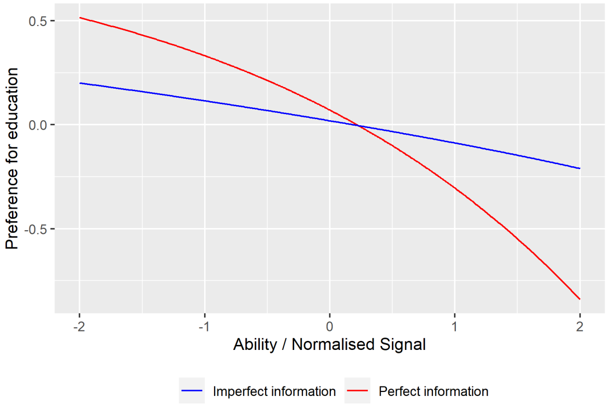
Compute the distribution of skill in the economy using the Law of Total Probability from $P(\theta)$ and the skill function.

$$f_S(s) = \int_{\varepsilon \in \mathbb{R}} P(s^{-1}(s,1)+\varepsilon) f_A(s^{-1}(s,1)) \left| \frac{ds^{-1}(s,1)}{ds} \right| + (1 - P(s^{-1}(s,0)+\varepsilon)) f_A(s^{-1}(s,0)) \left| \frac{ds^{-1}(s,0)}{ds} \right| dF_\varepsilon(\varepsilon) \tag{4}$$

$$F_S(s) = \int_{-\infty}^{s} f_S(x)dx \tag{5}$$

Back

Figure: Boundary Lines Describing Optimal Education Investment in Perfect and Imperfect Info



Parameterisation

No	Object	Notation	Parametric Form	Parameters
	Exogenous functions			
1	Skill function	$s(a,e)$	$\exp(a)(1+\delta e)$	δ
2	Joint output function	$g(s,y)$	$qs^{\gamma 1}y^{\gamma 2}$	$q, \gamma 1, \gamma 2$
	Exogenous distributions			
3	Ability distribution	$f_A(\cdot)$	$N(0,1)$	-
4	Dist. for signal noise	$f_\varepsilon(\cdot)$	$N(0,\sigma_\varepsilon^2)$	σ_ε
5	Dist. for heterogeneous educ pref	$f_\eta(\cdot)$	EV type I with loc κ and scale ξ	κ, ξ
	Other parameters			
6	Minimum wage	-	-	w_0

Empirical Implementation

Identification and Estimation

1. Non-parametrically construct the share of workers who choose HE cond. on θ, $\hat{P}(\theta)$.

2. Estimate the parameters governing wages, the occupational match and the returns to education conditional on $\hat{P}(\theta)$ using simulated method of moments.
   - This recovers the estimated partial parameter vector, $(\hat{\delta}, \hat{q}, \hat{\gamma}_1, \hat{\gamma}_2, \hat{w}_0, \hat{\sigma}_\varepsilon)$.

   ▸ Moments

3. Using $(\hat{\delta}, \hat{q}, \hat{\gamma}_1, \hat{\gamma}_2, \hat{w}_0, \hat{\sigma}_\varepsilon)$ and $\hat{P}(\theta)$, construct the return to education $E[\hat{\Delta w}|\theta]$.

4. Under the assumptions that workers have rational expectations and that the model is in equilibrium, find κ, ξ that minimise $\frac{\exp(\kappa E[\hat{\Delta w}|\theta]+\xi)}{1+\exp(\kappa E[\hat{\Delta w}|\theta]+\xi)} - \hat{P}(\theta)$

▸ Empirical Implementation

Data

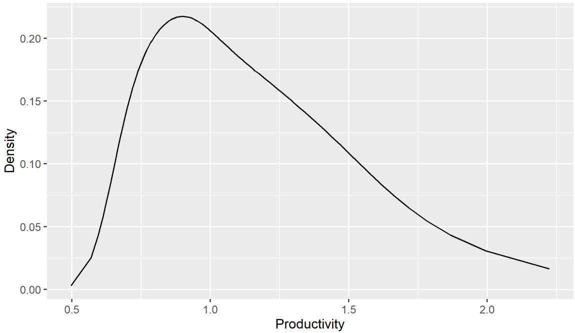
- Moments, and $\hat{P}(\theta)$
  - Pooled 1988-93 cohorts from Understanding Society survey
  - Log hourly wages at age 30
    - Adjusted for sex, year, ethnicity and age
    - Post-tax and transfers, but excluding student loan repayments
  - Signal - KS4 score, normalised within the academic year
    - *Interpretation:* Workers take their school performance as a signal of their labour market performance before the education decision

▸ Summary Statistics ▸ Mincer equation estimation

▸ Empirical Implementation

Data

- Mixture of occupations p_k, μ_k, σ_k
  - 3-digit SOC00 occupations
  - Shares of occupations p_k, from the Annual Survey of Hours and Earnings (ASHE)
  - μ_k, σ_k within occupations taken from means and variances of job fixed effects within occupations from Hou and Milsom (2022)



Moments

◂ Identification and Estimation

Table: Moments

No.	Moments category	Number of moments
1	Mean log wage within income deciles	10
2	Mean log wage within income deciles cond. on education status	20
3	Log wage quartiles cond. on signal quintile	20
4	Log wage quartiles cond. on signal quintile and education	40
5	Mean and variance of log wages	2
6	Mean and variance of log wages cond. on education	4
7	Mean and variance of wages cond. on signal quintile	10
8	Mean of wages cond. on signal quintile and education	10
9	R^2 of regressing log earnings on a polynomial of grades conditional on degree	2

Summary Statistics

◂ Data

Table: Summary statistics

Variable	N	Mean	Sd
Log hourly labour earnings net of taxes and transfers	1113	2.43	0.26
New style KS4 point score, normalised within student's academic year	1113	0.22	0.91
Whether worker has a degree by age 32	1113	0.49	0.50
Female	1113	0.53	0.50
Non-white ethnicity	1113	0.27	0.44
In 1988 birth cohort	1113	0.17	0.38
In 1989 birth cohort	1113	0.20	0.40
In 1990 birth cohort	1113	0.18	0.39
In 1991 birth cohort	1113	0.16	0.36
In 1992 birth cohort	1113	0.16	0.36
In 1993 birth cohort	1113	0.13	0.34

Descriptive Mincer equation ◂ Data

Table: Results of a Mincer regression on sample

	(1) Log net hourly labour income
Degree=1	0.0721*
	(3.43)
Normalised KS4 score	0.0752*
	(6.02)
Degree x Normalised KS4 score	0.0462
	(1.86)
Female	-0.0781*
	(-3.95)
Age	0.0363*
	(5.96)
Observations	3122
Individuals	1128

t statistics in parentheses

* indicates statistical significance at the 1% level. The standard errors were clustered at the individual level.

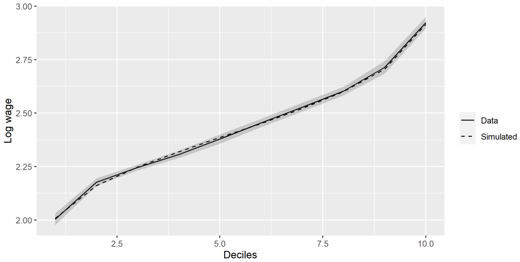
Parameter Estimates

Table: Parameter Estimates

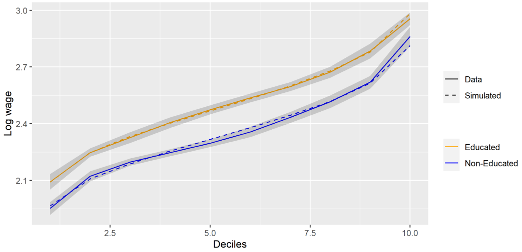
No.	Parameter	Notation	Value	SE
Stage 1				
1	Signal noise	σ_ε	2.92	3.75×10^{-5}
2	Skill return to education	δ	0.364	0.000639
3	Joint output function scale	q	7.83	0.0796
4	Joint output function - exponent on s	γ_1	0.344	0.00329
5	Joint output function - exponent on y	γ_2	0.0318	0.0106
6	Minimum wage	w_0	4.46	0.00953
Stage 2				
7	Location parameter of het pref for educ relative to no educ	κ	-11.0	0.00447
8	Scale parameter of het pref for educ/no educ	ξ	11.6	0.00417

Fit: Wage quantiles | Fit: Wages conditional on grades | Fit: Other wage moments | Fit: HE choice
Untargeted moment: Matching to high-skill occupations | Empirical Implementation

Figure: Actual and simulated wage quantiles



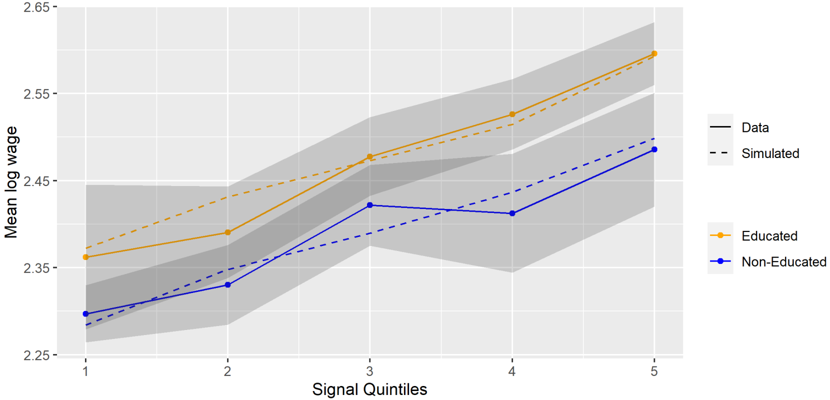
(a) Simulated and actual wage quantiles



(b) Simulated and actual wage quantiles cond. on educ

Estimates

Figure: Actual and simulated mean wages conditional on education and signal quintile



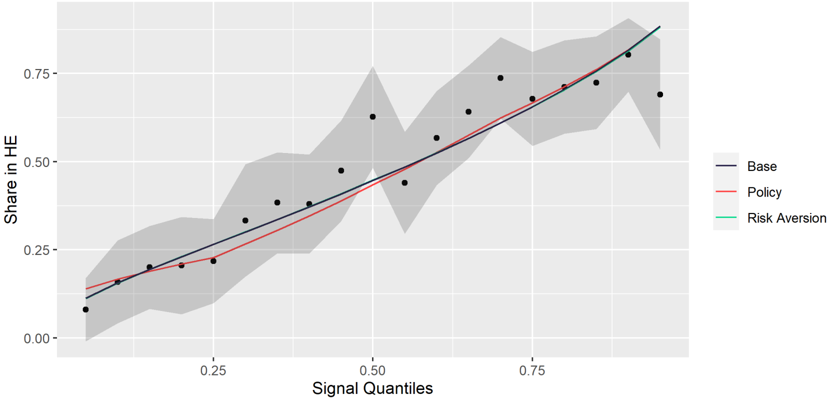
Estimates

Table: Targeted log wage moments, overall and conditional on degree

Statistic	Data	Conf Interval	Simulated
Mean log wage	2.43	[2.42,2.45]	2.43
Mean log wage (e=1)	2.51	[2.49,2.53]	2.51
Mean log wage (e=0)	2.36	[2.34,2.38]	2.36
Variance log wage	0.0688	[0.0634,0.0743]	0.0675
Variance log wage (e=1)	0.062302	[0.0553,0.0693]	0.0652
Variance log wage (e=0)	0.064314	[0.0566,0.0720]	0.0588
R^2 of regressing log wages on grades (e=1)	0.125	[0.0737,0.176]	0.0917
R^2 of regressing log wages on grades (e=0)	0.0659	[0.0251,0.107]	0.0964

◂ Estimates

Figure: Predicted probabilities of investing education conditional on θ



Estimates

Figure: Actual and simulated probabilities of matching to high-skill occupations (untargeted)

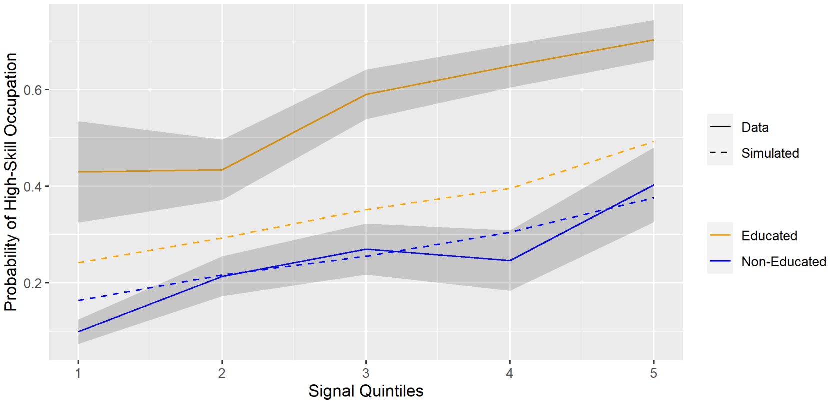


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Table: Descriptive Statistics in Counterfactual Scenarios

	Baseline	Graduate tax	Graduate subsidy
Share with degree	0.4662	0.3598	0.5773
Average hourly post-tax wage	11.38	11.29	11.46
Average hourly post-tax wage (graduates)	12.35	12.49	12.23
Average hourly post-tax wage (non-graduates)	10.59	10.67	10.49
University wage premium	0.1669	0.1715	0.1658
Average firm profits	-2.986	-2.996	-2.974
Share in skilled occs	30.97	30.89	30.86
Share grads in skilled occs	39.82	42.07	37.63
Share non-grads in skilled occs	23.24	24.60	21.59

Is it possible to increase welfare by changing who chooses HE?

- Consider a simple scheme in which a government imposes a graduate subsidy or tax which is compensated by a flat tax or subsidy on all workers

$$V^*(\theta, e) = \left((\kappa - \underbrace{\tau}_{\text{Graduate tax/subsidy}}) \times e \right) + \eta(e) + \underbrace{\left[\int P(\theta) d\theta \right] \tau}_{\text{Compensation}} + \beta E\{w(s(a, e))|\theta\}$$

- The compensation makes the scheme revenue neutral
- This tax (subsidy) can be thought of as shifting the share of workers in higher education uniformly across the grade distribution

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