# Grades and employer learning

Anne Toft Hansen (UCPH & VIVE), Ulrik Hvidman (AU) and Hans H. Sievertsen (UoB & VIVE)

IZA - workshop Oct 2018

## Grades and employer learning

#### How are workers sorted when they enter the labor market?

- Substantial costs of job mismatch (Fredriksson et al, 2018).
- ► Employers do not directly observe productivity of labor market entrants → use educ. degrees as a signals to sort workers (Spence, 1973; Arrow, 1973; Wise, 1975; Riley, 2001).
- ► As university degrees are increasingly common → sorting within degrees (e.g. such as GPA) may become more important. (⇒ Show data)

"degrees so common [...] a crude way to screen applicants." (The Economist, Feb 2018)

#### Our research question:

▶ What is the role of university GPAs for labor market sorting?

## How does such a signal look?

	It is hereby certified that		
	was awarded the degree of		
	Master of Science		
	in Economics		
	(with distinction)		
	of this University by the Senate on		
	Monday 16 November 2009	)	
Nigel Think		Johan .	

W/A RW/ICK

## How does such a signal look?

has completed the Master's programme in Feonomies



Summary of examinations and grades page 1 of 2

The following grades were awarded	Grade 7-point scale	Grade 13-point scale	Grade ECTS scale	ECTS credits
Resource and Environmental I conomies	7	9	с	8,0
Leonomies of Housing	02	6	1-	8.0
Game Theory Fram language English	4	7	D	8,0
Macro Finance	7	8	c	8,0
Credits Transferred from Universität Wien Public Choice : Growth and Income Distribution.	Passed		Passed	16,0
Private Equity	10		в	8.0
The Economics of Climate Change Exam language English	7		(°	8.0
Strategic Management	02		1	8.0
Extended Essay in lieu of a Written Examination	Passed		Passed	2.0
Seminar: Environmental economies and the econom- ics of resources	7	9	с	8,0
Seminar: Cost-Benefit analyses in practice	7		c	8,0
Master Thesis	10		н	30,0

Grade point average: 7.1

3 June 2010

# This paper

#### Framework: employer learning model

- A Employers use noisy signals of educational achievement to sort workers.
- **B** Initially: A signal that is purely noise has the same return as a signal that contains actual information.
- **C** As firms learn about the noise, the former goes to zero, the latter does not.

#### **Empirical approach**

- 1 Goal: Identify noise in university graduates' GPA.
- 2 Grade reform in Denmark caused variation in GPA.
- **3** We assess whether reform-induced variation in GPA "behaves like" noise.
- **4** We test for labor market returns to reform-induced variation GPA.

(How GPAs may be used to screen workers)

### This paper: Results



### This paper: Results



# **Related literature**

#### A Labor market matching

 Labor market sorting and (Lentz et al., 2018) and match (Fredriksson et al., 2018).

#### **B** Employer learning

- ► Educational attainment ↓ as firms learn about skills (Farber & Gibbons, 1995; Altonji & Pierret, 2001; Lange, 2007, Arcidiacono et al, 2010).
- Degrees (Clark & Martorell, 2014; Jepsen et al., 2016).
- University prestige (Bordon & Braga, 2015)

#### C GPA in the hiring process

 Experimental evidence (Koedel and Tyhurst, 2012; Protsch and Solga, 2015; Piopiunik, 2018; Quadlin, 2018)

#### Our contribution

- Signals and sorting on the "intensive margin": employer learning within degrees based on achievement (e.g. grades).
- Novel empirical strategy: Test for labor market returns to a noise component in grades.

## Conceptual framework

#### Employer learning model a la Farber & Cibbons (1995)

- $g^f$ : GPA as observed by firm & researcher.
- $e^r$ : A noise component of  $g^f$  observed by researcher.
- $g^r = g^f e^r$ : GPA without observed noise component.
- Employers reward a noisy signal of educational achievement due to both a direct and an indirect effect of educational achievement on productivity.
- ► Initially, the noise component  $e^r$  will have the same return as the informative signal  $g^r$ .
- ► As firms learn about the noise, the former goes to zero, the latter not.
- We can test this empirically, if we can observe  $g^{f}$ ,  $g^{r}$ , and  $e^{r}$ .

Show model

# Identifying GPA noise using a grading reform

- **Empirical challenge:** Identify  $g^{f}$ ,  $g^{r}$ , and  $e^{r}$ .
- Empirical strategy: Exploit a recoding of grades in Denmark.

## Identifying GPA noise using a grading reform

- **Empirical challenge:** Identify  $g^{f}$ ,  $g^{r}$ , and  $e^{r}$ .
- Empirical strategy: Exploit a recoding of grades in Denmark.



Jul 31, 2007 Grades GPA

## Identifying GPA noise using a grading reform

- **Empirical challenge:** Identify  $g^{f}$ ,  $g^{r}$ , and  $e^{r}$ .
- Empirical strategy: Exploit a recoding of grades in Denmark.



⇒ Compare labor market outcomes for Alice, Bob, and Carol. 9/26

# Why and how?

#### Why?

- 2004: Danish Gov't launched campaign to "Modernize tests, exams, and grades"
- ▶ 2005: Gov't decided to introduce new scale on Aug 1, 2007.

#### How?

- 1 Completed < Aug 1: Translate GPA.
- **2** Enrolled > Aug 1: Only new scale.
- **3** Enrolled < Aug 1 & Completed > Aug 1: Each grade transformed to the new scale.

Table Mapping scheme: old to new grades.

Old: 13 scale	00	03	5	6	7	8	9	10	11	13
New: 7-point scale	-3	00	)	02	4	7	7	10	1	2

University studies in DK  $\approx$  90% continue after bachelor degree













Figure Original and recoded grades

×



Figure Original and recoded grades



Figure Original and recoded grades



Figure Original and recoded grades

# **Empirical strategy**

#### Step 1: OLS estimation of:

$$GPA7 = \gamma_0 + f(GPA13) + u \tag{1}$$

Construct:  $\hat{g}^r = \widehat{GPA7}$  $\hat{e}^r - \overline{GPA7} - \widehat{GPA7}$ 

Step 2: OLS estimation of:

$$y = \beta_0 + \beta_{g^r} \hat{g}^r + \beta_{e^r} \hat{e}^r + \beta' \mathbf{X} + u$$
(2)

*y* log earnings (or other labor market outcomes). *GPA*7 recoded GPA.

GPA13 original GPA.

- f() 3rd order polynomial.
- **X** program and institution fixed effects.

▶ Bootstrap SE clustered at the pre recoding GPA level.

Show why not linear

# The data

#### Sources

- Complete student records from Aarhus University and University of Copenhagen.
- ► Administrative registers from Statistics Denmark.

#### Sample selection

► All master students with ≤40 ECTS remaining on Aug 1, 2007. (Dissertation is between 30 and 60 ECTS).

Figure Remaining ECTS



# Who are these people?

Table Summary statistics

	Mean	SD	P10	P50	P90
Female	0.64	0.48			
Non-western origin	0.04	0.19			
Age at entry	27.07	6.07	22.69	25.31	33.43
Parents' with university degree	0.26	0.44			
University of Copenhagen	0.43	0.50			
ECTS remaining	22.88	13.41	0.00	30.00	40.00
Graduated	0.88	0.32			
Earnings>0 in year 1	0.88	0.32			
Earnings in year 1	42.29	22.40	6.57	44.88	66.72
Public sector in year 1	0.64	0.48			
Unemployment in year 1	0.08	0.17	0.00	0.00	0.33

#### Observations 4576

Notes: Variables are measured in 2007 unless otherwise described. PIO, P5O, and P9O are pseudopercentiles for respectively the 10th, 50th and 90th percentile. The pseudopercentiles show the arithmetic mean of at least five individuals centred around the actual percentile.

Show distribution of treatment. Show GPA distribution

# **Results: GPA and earnings**

#### Tab Regression results. Dependent variable: log earnings y1 after graduation.

	(1)	(2)	(3)	(4)	(5)
	3rd	2nd	4th	Median	Mean
$g^r$ (SD)	0.031**	0.030**	0.031**	0.032**	0.034**
	(0.014)	(0.014)	(0.014)	(0.014)	(0.014)
e <sup>r</sup> (SD)	0.031***	0.030***	0.031***	0.027**	0.027***
	(0.010)	(0.010)	(0.010)	(0.010)	(0.010)

Observations	3443	3443	3443	3443	3443
Notes: Bootstrap sta	ndard errors c	lustered at th	ne GPA level ir	n parenthesi	s. * p< 0.1, **
p< 0.05 and *** p<	< 0.01. g <sup>f</sup> : GP	A observed b	y the firm an	id the resear	cher, g <sup>r</sup> : GPA
observed by the rese	earcher, and e	r: GPA noise	observed by t	he researche	er.

Show full table

# **Results: GPA and earnings**

# **Tab** Regression results. Dependentvariable: log earnings y1 after graduation.

	(1) 3rd	(2) 2nd	(3) 4th	(4) Median	(5) Mean
$g^r$ (SD)	0.031**	0.030**	0.031**	0.032**	0.034**
	(0.014)	(0.014)	(0.014)	(0.014)	(0.014)
e <sup>r</sup> (SD)	0.031***	0.030***	0.031***	0.027**	0.027***
	(0.010)	(0.010)	(0.010)	(0.010)	(0.010)
Share of g <sup>f</sup>					
g <sup>r</sup>	0.81	0.81	0.81	0.84	0.85
e <sup>r</sup>	0.19	0.19	0.19	0.16	0.15
Observations	3443	3443	3443	3443	3443

Notes: Bootstrap standard errors clustered at the CPA level in parenthesis. \* p < 0.1, \*\* p < 0.05 and \*\*\* p < 0.01.  $g^{f}$ : GPA observed by the firm and the researcher,  $g^{r}$ : GPA observed by the researcher, and  $e^{r}$ : GPA noise observed by the researcher.

Show full table

## But is e<sup>r</sup> really noise?

We saw that e<sup>r</sup> is correlated with earnings.
 But is e<sup>r</sup> really noise, or what if...

#### (A) treatment is correlated with individual characteristics?

(Potentially through anticipation effects.) Show that covariates are balanced.

# (B) the recoding algorithm is related to outcomes?

Show placebo results.

#### (C) students reacted to the shock?

Show behavioral response.

## (A) Do covariates predict treatment?

# **Tab** Regression results. Dependentvariables in column header.

	Female	High school GPA	Parents' Income	Parents' Unempl.	Parents' uni degr.	Predicted earnings
e <sup>r</sup>	-0.019	0.001	2.820	-0.004	0.021	-0.001
	(0.016)	(0.031)	(2.304)	(0.004)	(0.019)	(0.004)
Observations	3808	3216	3364	3810	3323	3810
Mean dep var	0.65	0.75	39.38	0.02	0.27	3.62

Notes: Bootstrap standard errors clustered on the CPA level in parenthesis. \* p < 0.1, \*\* p < 0.05 and \*\*\* p < 0.01.  $g^{f}$ : GPA observed by the firm and the researcher, g': GPA observed by the researcher, and e': GPA noise observed by the researcher.

# (B) Placebo test

- Assess whether grade combinations that lead to e<sup>r</sup> are related to outcomes.
- ▶ Implement a placebo reform on August 1, 2004.

**Tab** Regression results. Dependent variable: log earnings y1 after graduation. Placebo cohort.

	(1) 3rd	(2) 2nd	(3) 4th	(4) Median	(5) Mean
$g^r$ (SD)	0.077***	0.079***	0.078***	0.079***	0.076***
	(0.018)	(0.019)	(0.018)	(0.019)	(0.019)
$e^r$ (SD)	-0.020	-0.024	-0.022	-0.028	-0.026
	(0.019)	(0.018)	(0.019)	(0.019)	(0.018)
Observations	1900	1900	1900	1900	1900

Notes: Bootstrap standard errors clustered on the GPA level in parenthesis. \* p < 0.1, \*\* p < 0.05 and \*\*\* p < 0.01.  $g^{f}$ : GPA observed by the firm and the researcher,  $g^{r}$ : GPA observed by the researcher, and  $e^{r}$ : GPA noise observed by the researcher.

# (C) Grades and student behavior

Tab Regression results. Dependent variables in column headers.

	(1)	(2)	(3)	(4)
	Craduated	Time to	Course	Post
	Graduated	graduation	FE	GPA
e <sup>r</sup> (SD)	0.000	-0.003	-0.005	-0.011
	(0.000)	(0.013)	(0.010)	(0.059)
Observations	4045	4045	3913	4576
Mean of dep. var	1.000	0.968	1.479	7.565

Notes: Bootstrap standard errors clustered on the GPA level in parenthesis. \* p < 0.1, \*\* p < 0.05 and \*\*\* p < 0.01.  $g^{f}$ : GPA observed by the firm and the researcher,  $g^{r}$ : GPA observed by the researcher, and  $e^{r}$ : GPA noise observed by the researcher.

Show more details

## Results GPA and earnings over time



## Results GPA and earnings over time



Fig Earnings and GPA over time , shares

♦ Show table ♦ Show placebo long run results

## Results GPA and earnings over time



Fig Earnings and GPA over time , shares

♦ Show table ♦ Show placebo long run results

## **Results: Other outcomes**

**Tab** Regression results. Dependent variables: labor market outcomesin y1-y5 in row titles

	Year								
	1	2	3	4	5				
Earnings>0	-0.007	0.007	0.002	-0.009	-0.006				
	(0.014)	(0.014)	(0.015)	(0.013)	(0.015)				
Public sector	0.006	-0.003	-0.006	0.002	0.029				
	(0.017)	(0.018)	(0.019)	(0.023)	(0.048)				
Unemployment	-0.007	-0.006	-0.007						
	(0.007)	(0.006)	(0.005)						
Job change		-0.017	0.019	-0.018	0.016				
		(0.016)	(0.020)	(0.022)	(0.019)				

Notes: Bootstrap standard errors clustered on the GPA level in parenthesis. \* p < 0.1, \*\* p < 0.05 and \*\*\* p < 0.01.  $g^{f}$ : GPA observed by the firm and the researcher, g': GPA observed by the researcher, and e': GPA noise observed by the researcher.

♦ Show placebo results ♦ Show job change stats

### **Results: Heterogeneity**

# **Tab** Regression results. Dependent variable: log earnings y1 after graduation. By subgroups.

	Gender		Parents' r education		GF	PA	Edu wage dispersion	
	Male	Female	No uni	Uni	< p50	> p50	Low	High
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
e <sup>r</sup>	0.149**	0.058	0.091***	0.042	0.096**	0.059	0.056	0.133***
	(0.062)	(0.043)	(0.034)	(0.050)	(0.043)	(0.043)	(0.035)	(0.050)
Difference	0.0	091	0.0	49	0.0	37	-0.	077
	(0.0	)87)	(0.0	65)	(0.064)		(0.0	063)

Notes: Bootstrap standard errors clustered on the GPA level in parenthesis. \* p < 0.1, \*\* p < 0.05 and \*\*\* p < 0.01.  $g^{f}$ : GPA observed by the firm and the researcher, g': GPA observed by the researcher, and e': GPA noise observed by the researcher.

#### ♦ Show long-run results
#### **Results: Asymmetry**

Fig Earnings yl and GPA



Notes: Graph excludes bottom and top 1% in terms of the observed GPA noise,  $e^r$ .

# Grades and employer learning - summary

#### Reform-induced variation in GPA that is

- unrelated to individual characteristics.
- unrelated to labor market outcomes for non-treated cohorts.
- related to labor market outcomes in the first 2y for treated cohorts.

#### **Results suggest that**

- Initially: a noise component of observed GPA explains almost 20 percent of the earnings return to observed GPA.
- GPA matters for initial labor market sorting, but there is no persistent effect.
- Effects appears to be strongest for men, children of parents without a university degree, GPA's below the median, and for individuals studying degrees with a high wage dispersion.
- ▶ We find no evidence of asymmetric effects.

# Grades and employer learning - conclusion

#### This paper: Employer learning on the intensive margin

 Employers screen workers based on educational achievement (e.g. grades), and learn fast.

#### So what?

- ▶ Worker sorting.
- ▶ We can affect the precision of signals (e.g. Chan et al, 2007).
- Noise and external factors affect signals (e.g. Ebenstein et al, 2016).
- ▶ Student incentives (e.g. Bar et al, 2009).

extra slides

### Choice of bandwidth



#### Figure Bandwidth sensitivity

Notes: Unstandardised coefficients on  $\mathbf{e}^r$  using various ECTS sample definition cutoffs.

# Job change



Figure Job change frequency

Back

# **GPA** and earnings

**Tab** Regression results. Dependent variable: log earnings y1 after graduation.

	(1)	(2)	(3)	(4)	(5)
	3rd	2nd	4th	Median	Mean
$g^{f}$	0.023***	0.023***	0.023***	0.023***	0.023***
	(0.009)	(0.009)	(0.009)	(0.009)	(0.009)
$g^r$	0.020**	0.020**	0.020**	0.020**	0.021**
	(0.009)	(0.009)	(0.009)	(0.009)	(0.009)
$g^{e}$	0.085***	0.080***	0.085***	0.077**	0.077**
	(0.027)	(0.026)	(0.027)	(0.031)	(0.030)
e <sup>r</sup> -g <sup>r</sup>	0.066**	0.060**	0.065**	0.056*	0.056*
	(0.029)	(0.028)	(0.029)	(0.033)	(0.032)
$g^{f}$ (SD)	0.037***	0.037***	0.037***	0.037***	0.037***
	(0.014)	(0.014)	(0.014)	(0.014)	(0.014)
$g^r$ (SD)	0.031**	0.030**	0.031**	0.032**	0.034**
	(0.014)	(0.014)	(0.014)	(0.014)	(0.014)
g <sup>e</sup> (SD)	0.031***	0.030***	0.031***	0.027**	0.027***
	(0.010)	(0.010)	(0.010)	(0.010)	(0.010)
Observations	3443	3443	3443	3443	3443
$\sigma_{g^f}$	1.60	1.60	1.60	1.60	1.60
$\sigma_{g^r}$	1.56	1.56	1.57	1.57	1.60
$\sigma_{e'}$	0.37	0.37	0.36	0.35	0.35

Notes: Bootstrap standard errors clustered on the CPA level in parenthesis. \* p < 0.1, \* p < 0.05 and \*\*\* p < 0.00. d'. CPA observed by the firm and the researcher, d'. CPA observed by the researcher, and e''. CPA noise observed by the researcher.

### Results: Heterogeneity in the long run.

Tab Regression results. Dependent variable: log earnings y1-y5

		-	Year	-	
	1	2	3	4	5
Male	0.149**	0.102	0.040	0.021	-0.053
	(0.062)	(0.066)	(0.058)	(0.052)	(0.066)
Female	0.058	0.064	-0.010	-0.010	0.004
	(0.043)	(0.042)	(0.033)	(0.029)	(0.037)
Difference	-0.091	-0.038	-0.051	-0.030	0.057
	(0.087)	(0.087)	(0.071)	(0.060)	(0.069)
Without_uni	0.091***	0.117***	0.022	0.012	0.010
	(0.034)	(0.040)	(0.036)	(0.034)	(0.046)
With_uni	0.042	-0.043	-0.021	-0.042	-0.108*
	(0.050)	(0.057)	(0.044)	(0.051)	(0.061)
Difference	-0.049	-0.160**	-0.043	-0.053	-0.118*
	(0.065)	(0.071)	(0.064)	(0.066)	(0.072)
Below_median_GPA	0.096**	0.093*	0.007	-0.004	-0.049
	(0.043)	(0.051)	(0.044)	(0.032)	(0.054)
Above_median_GPA	0.059	0.046	-0.001	-0.040	-0.010
	(0.043)	(0.051)	(0.044)	(0.042)	(0.058)
Difference	-0.037	-0.048	-0.008	-0.036	0.038
	(0.064)	(0.074)	(0.061)	(0.055)	(0.079)
Low_wage_disp	0.056	0.076**	-0.014	-0.060**	-0.070
	(0.035)	(0.034)	(0.029)	(0.028)	(0.048)
High_wage_disp	0.133***	0.090	0.044	0.088**	0.063
	(0.050)	(0.070)	(0.056)	(0.043)	(0.059)
Difference	0.077	0.013	0.058	0.148***	0.133*
	(0.063)	(0.081)	(0.066)	(0.048)	(0.073)

Notes: Bootstrap standard errors clustered on the CPA level in parenthesis. \* p < 0.1, \*\* p < 0.05 and \*\*\* p < 0.01. g': CPA observed by the firm and the researcher, g': CPA observed by the researcher, and e': CPA noise observed by the researcher.

### GPA and earnings in the long-run.

Tab Regression results. Dependent variable: log earnings y1-y5

	Year					
	1	2	3	4	5	
g <sup>f</sup> (SD)	0.037***	0.037***	0.037***	0.036***	0.041***	
	(0.014)	(0.012)	(0.013)	(0.011)	(0.012)	
$g^r$ (SD)	0.031**	0.031***	0.037***	0.037***	0.043***	
	(0.014)	(0.012)	(0.013)	(0.011)	(0.011)	
$e^r$ (SD)	0.031***	0.029**	0.004	0.001	-0.005	
	(0.010)	(0.011)	(0.009)	(0.009)	(0.014)	
Observations	3443	3463	3420	3385	3363	

Notes: Bootstrap standard errors clustered on the GPA level in parenthesis. \* p < 0.1, \*\* p < 0.05 and \*\*\* p < 0.01.  $g^{f}$ : GPA observed by the firm and the researcher,  $g^{f}$ : GPA observed by the researcher, and  $e^{f}$ : GPA noise observed by the researcher.



#### Placebo long-run effects

Implemented a placebo reform on August 1, 2004.

Figure Return to GPA y1-y5 (log earnings)



### Placebo long-run effects

Tab Regression results. Dependent variable: log earnings y1-y5

	Year					
	1	2	3	4	5	
$g^{f}$ (SD)	0.071***	0.047***	0.051***	0.052***	0.056***	
	(0.019)	(0.017)	(0.013)	(0.013)	(0.012)	
$g^r$ (SD)	0.077***	0.049***	0.052***	0.054***	0.055***	
	(0.018)	(0.017)	(0.013)	(0.015)	(0.012)	
$e^r$ (SD)	-0.020	-0.003	0.001	-0.005	0.009	
	(0.019)	(0.017)	(0.013)	(0.015)	(0.013)	
Observations	1900	1954	1955	1936	1924	

Notes: Bootstrap standard errors clustered on the GPA level in parenthesis. \* p < 0.1, \*\* p < 0.05 and \*\*\* p < 0.01.  $g^{f}$ : GPA observed by the firm and the researcher, g': GPA observed by the researcher, and e': GPA noise observed by the researcher.

### Results: Other outcomes - placebo

**Tab** Regression results. Dependent variables: labor market outcomesin y1-y5 in row titles

	Year					
	٦	2	3	4	5	
Earnings>0	-0.002	-0.018	-0.016	-0.016	-0.013	
	(0.020)	(0.017)	(0.022)	(0.016)	(0.018)	
Public sector	0.027	0.065	0.005	0.008	-0.001	
	(0.094)	(0.042)	(0.035)	(0.030)	(0.032)	
Unemployment	-0.002	-0.006	0.002			
	(0.015)	(0.011)	(0.008)			
Job change		3.557	3.076	-2.855	0.334	
		(4.883)	(3.613)	(2.453)	(0.560)	

Notes: Bootstrap standard errors clustered on the GPA level in parenthesis. \* p < 0.1, \*\* p < 0.05 and \*\*\* p < 0.01.  $g^{f}$ : GPA observed by the firm and the researcher, g': GPA observed by the researcher, and e': GPA noise observed by the researcher.

#### Back

#### How did a diploma look at UCPH?

has completed the Master's programme in Feonomies



Summary of examinations and grades page 1 of 2

The following grades were awarded	Grade 7-point scale	Grade 13-point scale	Grade ECTS scale	ECTS credits
Resource and Environmental Leonomies	7	9	c	8.0
Leonomies of Housing	02	6	1-	8.0
Game Theory Fram language English	4	7	D	8,0
Maero Finance	7	8	c.	8,0
Credits Transferred from Universität Wien Public Choice : Growth and Income Distribution.	Passed		Passed	16,0
Private Equity	10		в	8.0
The Economics of Climate Change Exam language English	7		C	8.0
Strategic Management	02		1	8.0
Extended Essay in lieu of a Written Examination	Passed		Passed	2.0
Seminar: Environmental economics and the econom- ics of resources	7	9	c	8,0
Seminar: Cost-Benefit analyses in practice	7		c	8,0
Master Thesis	10		н	30,0

Grade point average: 7.1

#### How did a diploma look at UCPH?





Summary of examinations and grades page 1 of 2

The following grades were awarded	Grade 7-point scale	Grade 13-point scale	Grade ECTS scale	ECTS credits	
Resource and Environmental Leonomies	7	9	с	8,0	
Leonomies of Housing	02	6	ŀ	8.0	
Game Theory Fram language English	4	7	D	8.0	
Macro Finance	7	8	C.	8,0	
Credits Transferred from Universität Wien Public Choice : Growth and Income Distribution.	Passed		Passed	16.0	
Private Equity	10		в	8.0	
The Economics of Climate Change Exam language English	7		C	8.0	
Strategic Management	02		1	8.0	
Extended Essay in lieu of a Written Examination	Passed		Passed	2.0	
Seminar: Environmental economics and the econom- ics of resources	7	4)	c	8,0	
Seminar: Cost-Benefit analyses in practice	7		c	8,0	
Master Thesis	10		н	30,0	

Grade point average: 7.1

3 June 2010

10/33

#### How did a diploma look at UCPH?

has completed the Master's programme in Economics



Summary of examinations and grades page 1 of 2

The following grades were awarded	Grade 7-point scale	Grade 13-point scale	Grade ECTS scale	ECTS credits
Resource and Environmental I conomies	7	9	c	8,0
Leonomies of Housing	02	6	1-	8.0
Game Theory Fram language English	4	7	D	8,0
Macro Finance	7	8	c	8,0
Credits Transferred from Universität Wien Public Choice : Growth and Income Distribution.	Passed		Passed	16,0
Private Equity	10		в	8.0
The Economics of Climate Change Exam language English	7		(°	8.0
Strategic Management	02		1	8.0
Extended Essay in lieu of a Written Examination	Passed		Passed	2.0
Seminar: Environmental economies and the econom- ics of resources	7	9	с	8,0
Seminar: Cost-Benefit analyses in practice	7		c	8,0
Master Thesis	10		н	30,0

Grade point average: 7.1

3 June 2010

#### How did a diploma look at AU?

#### AARHUS UNIVERSITE





THE FACULTY OF SOCIAL SCIENCES

Pursuant to Ministerial Order no. 338 of 6 May 2004 issued by the Danish Ministry of Science, Technology and Development bachledr's and master's degree programmes at Danish universities, the bachledr's degree programme is a research-based programme qualifying students to independently work in a professional capacity based on the knowledge and methods acquired in one or more subject area.

Bachelor's degree in Economics and Business Management is rated at: 180 ECTS

has obtained the following results:

	00-13 scale 7-po	int scale E	CIS scale	
1st and 2nd year Introduction to Economics, Management, Information Technology and Statistics 10 ECTS	9	7	с	Passed
Principles of Economics 10 ECTS	11	12	А	Passed
Organization 10 ECTS	10	10	В	Passed
Microeconomics, Mathematics and Statistics 20 ECTS	10	10	В	Passed
Accounting 10 BCTS	10	10	в	Passed
2. år Macroeconomics, Mathematics and Statistics 20 ECTS	9	7	С	Passed
Finance and Investment 10 ECTS	10	10	В	Passed
International Economics and Microeconomic The 10 ECTS	ory 8	7	С	Passed

			SOB	ICES	
Regression Analysis 5 ECTS	9	7	С	Passed	
Marketing Management and Strategy 10 ECTS	9	7	С	Passed	
Mathematics - Dynamic Analysis 5 BCTS	9	7	С	Passed	
3. år					
Financial Markets and Corporate Strategy 10 ECTS		10	в	Passed	
Macro 1 10 ECTS		7	С	Passed	
Econometrics 1 10 ECTS		12	А	Passed	
Time Series Econometrics 10 ECTS		10	В	Passed	
Philosophy of Science and Bachelor's project 20 ECTS		12	А	Passed	
Average for Bachelor's degree in Economics and with the Danish 7-point grading scale	Business Mar	agement: 9,	3 in acco	rdance	
The validity of this document is confirmed 18 June 2018					

#### Figure Danish Graduate Diploma (AU, treated individual)

#### How did a diploma look at AU?

#### AARHUS UNIVERSITE





#### THE FACULTY OF SOCIAL SCIENCES

Pursuant to Ministerial Order no. 338 of 6 May 2004 issued by the Danish Ministry of Science, Technology and Development bachledr's and master's degree programmes at Danish universities, the bachledr's degree programme is a research-based programme qualifying students to independently work in a professional capacity based on the knowledge and methods acquired in one or more subject area.

Bachelor's degree in Economics and Business Management is rated at: 180 ECTS

has obtained the following results:

Assessment 00-13 scale 7-point scale ECTS scale

1st and 2nd year					
Introduction to Economics, Management, Information Technology and Statistics 10 ECTS	9	7	с	Passed	
Principles of Economics 10 ECTS	11	12	Α	Passed	
Organization 10 ECTS	10	10	В	Passed	
Microeconomics, Mathematics and Statistics 20 ECTS	10	10	В	Passed	
Accounting 10 ECTS	10	10	в	Passed	
2. ár					
Macroeconomics, Mathematics and Statistics 20 ECTS	9	7	С	Passed	
Finance and Investment 10 ECTS	10	10	В	Passed	
International Economics and Microeconomic Theory 10 ECTS	8	7	С	Passed	

			THE FACULTY OF SOCIAL SCIENCES		
Regression Analysis 5 DCTS	9	7	С	Passed	
Marketing Management and Strategy 10 ECTS	9	7	С	Passed	
Mathematics - Dynamic Analysis 5 ECTS	9	7	С	Passed	
3. år					
Financial Markets and Corporate Strategy 10 ECTS		10	в	Passed	
Macro 1 10 ECTS		7	С	Passed	
Econometrics 1 10 ECTS		12	А	Passed	
Time Series Econometrics 10 ECTS		10	в	Passed	
Philosophy of Science and Bachelor's project 20 ECTS		12	Α	Passed	
Average for Bachelor's degree in Economics and B with the Danish 7-point grading scale	kusiness Man	agement: 9,	3 in acco	rdance	
The validity of this document is confirmed 18 June 2008					

Page 2 of 3

#### Figure Danish Graduate Diploma (AU, treated individual)

#### How did a diploma look at AU?

#### AARHUS UNIVERSITE





Pursuant to Ministerial Order no. 328 of 6 May 2004 issued by the Danish Ministry of Science, Technology and Development on bachlor's and matter's degree programmes at Danish universite, the bachclor's degree programme is a research-based programme qualifying students to independently work in a professional capacity based on the knowledge and methods acquired in once or more subject area.

Bachelor's degree in Economics and Business Management is rated at: 180 ECTS

has obtained the following results:

	00-13 scale 7-po	3 scale 7-point scale		
1st and 2nd year Introduction to Economics, Management, Information Technology and Statistics 10 ECTS	9	7	с	Passed
Principles of Economics 10 ECTS	11	12	А	Passed
Organization 10 ECTS	10	10	В	Passed
Microeconomics, Mathematics and Statistics 20 ECTS	10	10	В	Passed
Accounting 10 BCTS	10	10	В	Passed
2. år Macroeconomics, Mathematics and Statistics 20 ECTS	9	7	с	Passed
Finance and Investment 10 ECTS	10	10	В	Passed
International Economics and Microeconomic The 10 ECTS	ory 8	7	С	Passed

			THE P SCIP	THE FACULTY OF SOCIAL SCIENCES	
Regression Analysis 5 ECTS	9	7	С	Passed	
Marketing Management and Strategy 10 ECTS	9	7	С	Passed	
Mathematics - Dynamic Analysis 5 ECTS	9	7	С	Passed	
3. år					
Financial Markets and Corporate Strategy 10 ECTS		10	в	Passed	
Macro 1 10 ECTS		7	С	Passed	
Econometrics 1 10 ECTS		12	А	Passed	
Time Series Econometrics 10 ECTS		10	В	Passed	
Philosophy of Science and Bachelor's project 20 ECTS		12	Α	Passed	
Average for Bachelor's degree in Economics and E with the Danish 7-point grading scale	kusiness Man	agement 9,	3 a acco	rdance	
The validity of this document is confirmed 18 June 2008					

Page 2 of 3

#### Figure Danish Graduate Diploma (AU, treated individual)

### Anticipation



**Figure** Google search trend for "den nye karakterskala" (English: "the new grading scale").



#### Does the noise depend on number of grades?

Figure Return to GPA y1-y5 (log earnings)



Back

#### Where does the variation come from?

**1** Fewer grades on new scale  $\Rightarrow$  grades are **collapsed** 

2 Varying distance  $\Rightarrow$  varying "penalty"

Figure GPA mapping pre and post



### Distribution of residuals



Figure Distribution of reform-induced noise, based on a 3rd order polynomial



## **GPA** distribution



Figure Histogram of final GPA's, cohorts

## Grades and student behavior

- ► Student could react to the recoding ⇒ relationship could be driven by student responses in terms of:
  - 1 Drop-out decisions  $\Rightarrow$  estimate effect on likelihood to graduate.
  - 2 Subsequent performance  $\Rightarrow$  estimate effect on subsequent grades.
  - 3 Select harder or easier elective units  $\Rightarrow$ ...
    - Identify unit (U) difficulty:
       Based on pre reform cohorts, we estimate:

$$exam\_grade = \alpha_0 + \alpha_1 HS\_GPA + \beta' U + e$$
(3)

and use estimated fixed effects as dependent variable.

4 Delay or advance graduation  $\Rightarrow$  estimate effect on time to graduation.

#### Why not linear - an illustration 1/3



Figure A simulated example

# Why not linear - an illustration 2/3

- We let γ be between 0 (grades should have no effect, given ability) to 0.5.
- ► We estimate the relationship between earnings and the recoding "noise" using five specifications.
  - Spec 1-4:  $log(y) = \alpha_0 + \alpha_1 GPA7 + f(GPA13) + u$ , where f() is respectively a 1st, 2nd, 3rd, and 4th order polynomial.
  - Spec 5:  $log(y) = \alpha_0 + \alpha_1 deviation + u$ , where deviation = GPA7 – median for each GPA level (on 1 decimal).
- We run 10,000 replications with N = 5000.
- We then check how often we reject H0 : α₁ = 0 on a 5 percent level.

Back

#### Why not linear - an illustration 3/3



Figure Rejection rates

#### Are degrees really so common?

Figure Completed tertiary degree (share of 25-34y).



Source: OECD.

Back

- ▶ The question What is the role of GPAs for labor market sorting?
- ► Why should it matter ? A GPA acts as a noisy signal of how well the worker masters the studied degree, which (potentially) is
  - A directly related to labor market productivity.
  - B correlated with unobserved factors that affect productivity.
  - $\Rightarrow$  Employers may sort workers according to the noisy signal.
- ► The challenge Distinguish between a pure "sorting effect" and direct effects on labor market outcomes (A and B above).
- Conceptual framework Employer learning model a al Altonji and Pierret (2001) (henceforth AP). Intuition:
  - Initially return to a pure noise signal should be similar to the return to an informative signal.
  - Over time employers learn about the noise in the signal.
  - The return to the pure noise signal should go towards zero, the return to the informative signal should not.

#### We consider a simple employer learning (EL) model

Let log labor market productivity, y, at time t be described by:

$$y_t = \beta \mathbf{s} + \eta \tag{4}$$

where

- *s* is true educational achievement (i.e. how well the worker masters the studied degree).
- $\eta$  is an unobserved factor affecting productivity.
- Compared to AP we ignore the experience-productivity relationship, and factors only observed by respectively the researcher and the employer.

Back

The employer only observes a noisy signal of educational achievement, g<sup>f</sup>, for example a GPA:

$$g^f = s + e \tag{5}$$

with E[e] = 0 and cov(e, s) = 0.

► The employer forms conditional expectations  $E[s|g^{f}] = g^{f} - \varepsilon$   $E[\eta|g^{f}] = \gamma E[s|g^{f}] + v = \gamma (g^{f} - \varepsilon) + v$ (7)

 Every period t the employer receives a signal about the worker's productivity dt, and updates expectations

$$E[\varepsilon|d_0\dots d_{t-1}] = \tilde{e}_t \tag{8}$$

$$E[v|d_0\ldots d_{t-1}] = \tilde{v}_t \tag{9}$$

► By setting  $w_t = y_t$  (competitive labor markets) we obtain the following log wage expression:

$$w_t = (\gamma + \beta)g^f - (\gamma + \beta)\tilde{\mathbf{e}}_t + \xi_t$$
  

$$w_t = \beta_{g^f}g^f + \beta_{\tilde{\mathbf{e}}_t}\tilde{\mathbf{e}}_t + \xi_t$$
(10)

- The coefficient on  $g^{f}$  (i.e. on observed GPA) captures
  - the direct effect of how well the worker masters the studied subject on productivity,  $\beta$ .
  - and the relationship between the unobserved factor v and how well the worker masters the studied subject,  $\gamma.$
- ► AP approach: Employers learn about *v* and the coefficient on schooling declines as they include hard to observe variables that are correlated with *v*.
- ▶ Our approach: Employers learn about the noise in the signal of educational achievement,  $\tilde{e}_t \rightarrow e$ , and the return to noise should decline.

Our approach: We observe a pure noise component:

$$eg^{f} = s + e^{u} + e^{r} = g^{r} + e^{r}$$
 (11)

- e<sup>r</sup> is a measurement error that is observed by the researcher, but not the firm.
- e<sup>u</sup> is a measurement error that is unobserved by both the firm and the researcher.

Which gives the following log wage expression:

$$w_t = \beta_{g^r} g^r + \beta_{e^r} e^r + \beta_{\tilde{e}_t} \tilde{e}_t + \epsilon_t$$
(12)

Note that

- $\tilde{\mathbf{e}}_t$  is the employers expectation of the error in the signal of educational achievement.
- Initially,  $\tilde{e}_t = 0$ , but over time as the employer observes the workers productivity  $\tilde{e}_t \rightarrow e = e^r + e^u$
- Note that:  $\beta_{\mathbf{e}^r} = -\beta_{\tilde{\mathbf{e}}_t}$

#### Implications

- ► Initially, the coefficient on  $e^r$  captures both the return to true educational achievement and the link to the unobserved factor ( $\beta + \gamma$ ).
- As firms learn about the measurement error, the coefficient on e<sup>r</sup> goes towards zero.

#### What does the coefficient on $g^{f}$ capture?

- ► The initial coefficient on the GPA signal observed by the firm is a weighted average of
  - The return to the GPA without the measurement error observed by the researcher, *g*<sup>*r*</sup>.
  - The return to the measurement error observed by the researcher, e<sup>r</sup>:

$$\hat{\beta}_{g^{f}} = \beta_{g^{r}} \frac{\sigma_{g^{r}}^{2}}{\sigma_{g^{r}}^{2} + \sigma_{e^{r}}^{2}} + \beta_{e^{r}} \frac{\sigma_{e^{r}}^{2}}{\sigma_{g^{r}}^{2} + \sigma_{e^{r}}^{2}}$$
(13)

► Derivation of the OLS estimates:

$$\begin{split} \hat{\beta}_{g^{f}} &= \frac{\operatorname{cov}(g^{f}, y)}{\operatorname{var}(g^{f})} \\ &= \frac{\operatorname{cov}(g^{r} + e^{r}, \beta_{g^{r}}g^{r} + \beta_{e^{r}}e^{r} + \beta_{\tilde{e}_{t}}\tilde{e}_{t} + \epsilon_{t})}{\operatorname{var}(g^{r} + e^{r})} \\ &= \frac{\operatorname{cov}(g^{r}, \beta_{g^{r}}g^{r})}{\operatorname{var}(g^{r} + e^{r})} + \frac{\operatorname{cov}(e^{r}, \beta_{e^{r}}e^{r})}{\operatorname{var}(g^{r}) + \operatorname{var}(e^{r})} + \frac{\operatorname{cov}(e^{r}, \beta_{\tilde{e}_{t}}\tilde{e}_{t})}{\operatorname{var}(g^{r}) + \operatorname{var}(e^{r})} \\ &= \beta_{g^{r}}\frac{\operatorname{var}(g^{r})}{\operatorname{var}(g^{r}) + \operatorname{var}(e^{r})} + \beta_{e^{r}}\frac{\operatorname{var}(e^{r})}{\operatorname{var}(g^{r}) + \operatorname{var}(e^{r})} + \beta_{\tilde{e}_{t}}\frac{\operatorname{cov}(e^{r}, \tilde{e}_{t}^{r})}{\operatorname{var}(g^{r}) + \operatorname{var}(e^{r})} \end{split}$$

- ▶ Initially, the third term is zero.
- As  $t \to \infty$ , the second and third cancel out.

▶ Note that we also have that:

$$\hat{\beta}_{e^{r}} = \frac{\operatorname{cov}(e^{r}, w)}{\operatorname{var}(e^{r})} = \frac{\operatorname{cov}(e^{r}, \beta_{g^{r}}g^{r} + \beta_{e^{r}}e^{r} + \beta_{\tilde{e}_{t}}\tilde{e}_{t} + \epsilon_{t})}{\operatorname{var}(e^{r})}$$

$$= \beta_{e^{r}} + \beta_{\tilde{e}_{t}}\frac{\operatorname{cov}(e^{r}, \tilde{e}_{t})}{\operatorname{var}(e^{r})}$$

$$= \beta_{e^{r}} \left[ \frac{\sigma_{e^{r}}^{2} - \sigma_{e^{r}, \tilde{e}_{t}^{r}}}{\sigma_{e^{r}}^{2}} \right]$$

$$(14)$$

$$= \beta_{e^{r}} \left[ \frac{\sigma_{e^{r}}^{2} - \sigma_{e^{r}, \tilde{e}_{t}^{r}}}{\sigma_{e^{r}}^{2}} \right]$$

$$(15)$$

• Where we assume that 
$$\tilde{e} = \tilde{e}_t^u + \tilde{e}_t^r$$

Back
# Conceptual framework

### To summarize

- ► EL framework: Employers learn about the noise in the signal of educational achievement.
- Initially, a pure noise signal will have the same return as a signal that contains information about actual educational achievement.
- ► As firms learn about the noise, the former goes to zero, the latter not.
- ► We can test this empirically, if we can identify a component of GPA that is pure noise.

Back

# How do grades work as a sorting device?

#### ► Types of signals

- ▶ Degree classification (e.g. a first, a lower second etc.).
- ► As a continuous measure (e.g. a GPA of 3.5).

#### How GPAs are used as signals

▶ Hard: as a requirement to be invited for a job interview.

- ► Soft: as a signal on your CV
- 70% of employers plan to screen based on GPA in 2017 (NACE, 2016)

#### Back

# How did this happen?

► Jan 2004: Danish Government launched campaign to "Modernize tests, exams, and grades"

#### ▶ Why new grading system?

- (i) International comparisons (7 grades + 13 was extra-ordinary).
- (*ii*) Standardize use of grading across educational programs & subjects.
- Nov 2004: A "Grade commission" presented recommendations:
  - (i) Replace 13-scale with 7-point scale
  - (ii) Precise and standardized descriptions
  - (iii) Evaluate every fifth year.
- 2005: Government decided to introduce new scale on August 1, 2007.

Back

## How was the new grading scale implemented?

- 1 All grades given after August 1, 2007: new scale.
- **2** Degrees completed before August 1, 2007: transform GPA using scheme provided by the Ministry for Education.
- **3** Enrolled in program on August 1, 2007: Each grade transformed to the new scale.

Table Mapping scheme: old to new grades.

Old: 13 scale	00	03	5	6	7	8	9	10	11	13
New: 7-point scale	-3	00		02	4	7		10	12	