Return on education around the European Union: A reappraisal

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Motivations

This paper offers a fresh new (???) look at an old debated issue: the **return on education *around EU***.

The minor qualification *around EU* brings non-trivial technical complications in the exercise related to

1. the existence of an instrument
2. fair international comparison

Two contributions of this paper:

1. Address technical complications in an international comparison
2. Update existing estimates thanks to previous point

Outline

Motivations

Why return on education:

It is a **key policy indicator** within a single country and across different countries:

- The investment in schooling is (economically) more convenient if returns are higher. To the extent that this form of human capital increases individual and aggregate productivity, it fosters *economic growth* of the countries (Sianesi and Van Reenen (2003)).
- The focus on wage is a narrow view of education, which can exert a positive impact on other dimensions of the life, like
  - probability of employment (e.g., von Simson (2015))
  - health (e.g., Conti et al. (2010))
  - crime (e.g., Lance (2011); Lochner and Moretti (2004))
  - ...

Motivations

Although the return of education on wages has been largely investigated for several countries, there is still little consensus not only about its size, but also about its mere existence ▸ Examples

These differences reflect

- different reference populations
- different reference periods
- different identification assumptions

Different identification assumptions

The estimated parameters depend on imposed hypotheses, that often are untestable (Blundell et al. (2005) for an extensive discussion).

The relevance of the 'law of decreasing credibility' (Manski (2011)) that the credibility of inference decreases with the strength of the assumptions maintained is an issue.

In this paper

In this paper I adopt a different approach by exploiting only the assumptions that may be tested and that are indeed verified in the data.
I abandon point identification in favour of set identification (or bounds; Manski (1990) and the following literature). Then

1. No more discussion of legitimacy of the instrument
2. The parameter is identified for the entire population identified by the data (and not only for an unknown population) $\Rightarrow$ fair comparison
3. Taking advantage of these features, in this paper I update the figures concerning the return on education across countries belonging to the European Union.

Summary

The model

Most of the paper on return on education are based on the Mincer (1974) equation. Following Blundell et al. (2005), consider

$$y_i = \beta S_i + \underbrace{u_i}_{\alpha_i + (\beta - b_i) S_i + \varepsilon_i} \tag{1}$$

y_i: wage

S_i: schooling

α_i: individual ability

$(\beta - b_i)$: individual heterogeneous private return

Most **favourable** case

Focus on

$$\alpha_i + (\beta - b_i)\, S_i$$

The simplest possible approach imposes the orthogonality condition that

$$S_i' \, \alpha_i = S_i'(\beta - b_i)\, S_i = 0$$

In this case the average return for the population who reached a certain level of education can be recovered by comparing the average earning of individuals who reached that level to those individuals who didn't reach it.
The **standard OLS-ATE is a nice and simple solution**.

Most **likely** case

More on

$$\alpha_i + (\beta - b_i) S_i$$

In general, OLS conditions are unduly restrictive. Consider

1. $\text{corr}(\alpha_i, S_i) \neq 0$, e.g. if higher ability workers reach higher educational level, which induces an upward bias;
2. $\text{corr}((\beta - b_i), S_i) \neq 0$, which implies a bias in an unpredictable direction.

then **the OLS will be biased**

Standard solutions

The classical solution is based on **instrumental variable** (IV) techniques. Details

Under a set of suitable assumptions (among which, exclusion restriction and monotonicity), I can identify a ***Local* Average Treatment Effect** (LATE).

It is the effect for the *sub*-population of compliers, individuals who are induced to invest in education by a change in the instrument (Imbens and Angrist (1994); Angrist et al. (1996))

IV-LATE

Different instruments target different populations (see Ichino and Winter-Ebmer (1999)).

The *same instrument* identifies sub-populations of compliers that are different from country to country. The reasons may be due, for example, to different cultural background or institutions.

One would like to individually identify the compliers, but this is not possible (Angrist (2004); Angrist and Pischke (2008)).

Even with legitimate IV, a cross countries comparison is no longer appropriate, unless when the parameter is identified for the entire population, which happens in the very special cases (Heckman (1997)).

A different approach

So far I assumed I have a valid instrument.

If the instrument is related to wage, $\beta \leq \beta_{OLS} \leq \beta_{IV}$.

It is possible to identify the parameter of interest without using an instrument!

To this aim I use bounds (Manski (1990)).

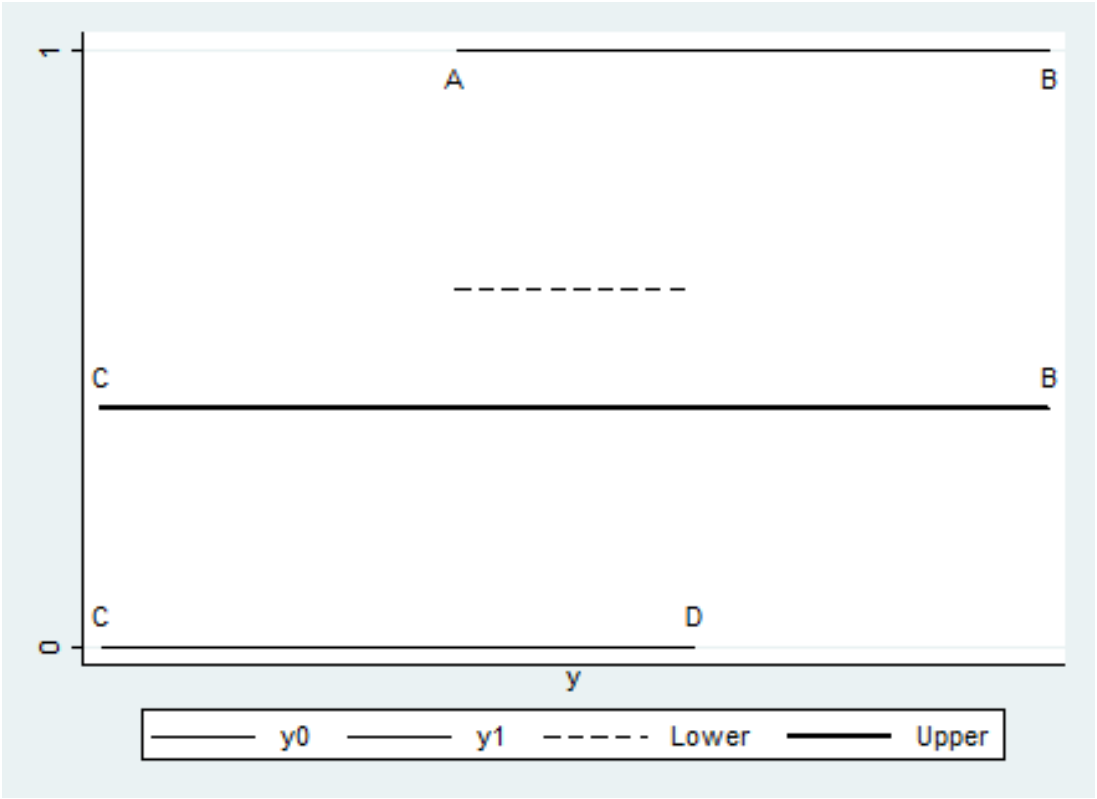
They identify a set (and not a single point) of admissible marginal effects that depend on the underlying assumptions.

More assumptions make bounds narrower

A different approach

$$
\begin{aligned}
E[y(s)|u] &= E[y|v=u,z=s]P(z=s|v=u)+E[y(s)|v=u,z\neq s]P(z\neq s|v=u) \\
&\quad E[y(s)]\in[K0,K1] \\
A &= E[y|v=u,z=s]P(z=s|v=u)+K0P(z\neq s|v=u) \\
B &= E[y|v=u,z=s]P(z=s|v=u)+K1P(z\neq s|v=u)
\end{aligned}
$$

Figure: An intuition of bounds



A different approach

Based on economic theory, as in Manski and Pepper (2000) I impose

- **Monotone Treatment Selection**: individuals of higher ability enjoy a higher mean wage function than those with lower ability &
- **Monotone Treatment Response**: wage is a weakly increasing function of the years of schooling

$$\begin{array}{ccccc} \sum_{u<s} E[y|z=u]\,P(z=u) & + & E[y|z=s]\,P(z\geq s) \\ & \leq & E[y(s)] & \leq \\ \sum_{u>s} E[y|z=u]\,P(z=u) & + & E[y|z=s]\,P(z\leq s). \end{array} \quad (2)$$

1. The **hps are jointly testable**.
2. These bounds:
   - i are **robust to non random schooling achievement**;
   - ii apply **to the population as defined by the conditioning set** (Manski and Pepper (2000)) and not to unknown compliers only.

Summary

The data

- Data are taken from the survey 'European Union Statistics on Income and Living Conditions' (**EU-SILC**)
- This study covers **25 European Union** countries. ▸ Countries
- Reference period **2004-2012**.
- The sample is nationally representative of the population residing in private households aged 16 and over, irrespective of language, nationality or legal residence status.
- I exclude self-employed and women
- I focus on **men** in the **age range 25–65**, which I conventionally define as the working age population.
- The outcome of interest is the **(natural logarithm of) the hourly wage**. ▸ Descriptive

The IV

An important issue regards the variables that affect education but not wages.

- In the literature, candidate instruments are usually limited to family background characteristics.
- The instrument considered in this paper is the educational attainment of the partner.
- Trostel et al. (2002) use both parents' and partner's educational attainment and find either remarkably similar results

Summary

Results

- I estimated several model specifications: the benchmark specification conditions on educational achievement, labour market experience and year.
- Coefficients are specific to educational achievement.

OLS-ATE

- The ‘middle-low education’ is rather small, usually smaller than 25%.
- The return on ‘high-middle’ return education with respect to middle education is (usually) above 25%.
- These results confirm that:
  - most of the heterogenity in return is at the high educational attainment.
  - non-linearities matter (as confirmed by a more formal test, coherent with Trostel (2005)).
- These returns are fairly similar to those estimated in the existing literature.
- Italy

OLS results

Table: Estimation by educational level

	OLS		LATE		Bounds	
	Middle-Low	High-Middle	Middle-Low	High-Middle	Middle-Low	High-Middle
AT	0.237***	0.268***	0.718***	0.490***	0.291***	0.266***
BE	0.134***	0.238***	0.259***	0.274***	0.163***	0.221***
CY	0.185**	0.415***	0.746**	0.255	0.300***	0.401***
CZ	0.215***	0.383***	0.739***	0.505***	0.309***	0.394***
DE	0.231***	0.341***	0.484***	0.242***	0.402***	0.366***
DK	0.116***	0.231***	0.509***	0.211***	0.191***	0.257***
EE	0.152***	0.282***	0.552***	0.460***	0.203***	0.315***
ES	0.237***	0.275***	0.350***	0.485***	0.270***	0.317***
FR	0.130***	0.389***	0.460***	0.471***	0.187***	0.322***
GR	0.215***	0.335***	0.454***	0.375***	0.269***	0.436***
HU	0.258***	0.653***	0.568***	0.820***	0.390***	0.677***
IE	0.187***	0.256***	0.395***	0.169***	0.225***	0.290***
IS	0.164***	0.306***	0.304***	0.292***	0.277***	0.335***
IT	0.245***	0.315***	0.462***	0.305***	0.222***	0.350***
LT	0.130***	0.429***	0.532***	0.555***	0.241***	0.444***
LU	0.376***	0.459***	0.802***	0.287***	0.462***	0.466***
LV	0.176***	0.406***	0.520***	0.614***	0.244***	0.449***
NL	0.173***	0.375***	0.140	0.512***	0.288***	0.370***
NO	0.221***	0.212***	0.615***	0.146**	0.280***	0.254***
PL	0.215***	0.534***	0.616***	0.702***	0.289***	0.478***
PT	0.416***	0.539***	0.669***	0.575***	0.375***	0.744***
SE	0.108***	0.163***	0.539***	0.135***	0.144***	0.167***
SI	0.233***	0.520***	0.463***	0.670***	0.299***	0.530***
SK	0.199***	0.355***	0.659***	0.486***	0.268***	0.370***
UK	0.247***	0.344***	0.430***	0.517***	0.362***	0.353***

IV-LATE

- The OLS-ATE is likely biased because schooling may be correlated with components that are unobservable to the researcher, like individual ability ($S_i'\alpha_i \neq 0$) or because workers achieve higher education thanks to heterogeneous private return ($S_i'(\beta - b_i) \neq 0$).
- I instrument the schooling achievement with the highest educational attainment reached by the partner (Trostel et al. (2002)).

IV-LATE

Plan of the talk:

1. I show the results
2. I critically review drawbacks with this instrument
3. I propose easy-to-implement solutions to fix them.

IV-LATE: Results

- Ranking broadly preserved
- Returns from IV-LATE are substantially higher than those from OLS-ATE.
- A formal Hausman (1978) test rejects most of the time the null hypothesis that the difference between the two estimates is not systematic.
- IV-LATE is higher than OLS-ATE by more than 30 percentage points for middle education and about 15 percentage points for high education.
- A striking difference between OLS-ATE and IV-LATE is that the former shows an increasing profile, whilst the latter shows a concave profile.
- In contrast to the OLS-ATE, using IV in 2/3 of the countries the null hypothesis of equal return between the two educational levels is not rejected.

IV results

Table: Estimation by educational level

	OLS		LATE		Bounds	
	Middle-Low	High-Middle	Middle-Low	High-Middle	Middle-Low	High-Middle
AT	0.237***	0.268***	0.718***	0.490***	0.291***	0.266***
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IV-LATE: Issues

- That returns with OLS-ATE are smaller than with IV-LATE is a fairly standard result in the literature.
- Traditionally it has been seen as a puzzle as opposed to the expectation that the most able workers achieve higher education, in which case the OLS-ATE return would be higher than IV-LATE.
- Card (1999) offers different explanations to solve the puzzle, including
  1. **measurement errors**
  2. **legitimacy of instruments**
  3. **identified quantities**.

IV-LATE: measurement errors

- Much of the literature on schooling reach the conclusion that the indicator is fairly reliable.
- The broad classification of the schooling achievement in EU-SILC is reassuring (as found for UK by Battistin and Sianesi (2011); Battistin et al. (2014)).
- I check whether this claim is true or not exploiting the classical measurement error framework. If

$$\begin{aligned} y &= S\beta + \varepsilon \\ \tilde{S} &= S + v \end{aligned} \tag{3}$$

then $\hat{\beta_{OLS}} = \beta \frac{\sigma_S^2}{\sigma_S^2 + \sigma_v^2}$, with σ_j^2 the variance of j.

IV-LATE: measurement errors

In this application, for the OLS-ATE to be coherent with the mis-classification of educational achievement, the variance of the error should be as large as 50% of the education for middle education and smaller for the high educational level (more than 10% for some countries, but usually larger than 20%).

This large error is possible but highly implausible, as also concluded for example by Battistin and Sianesi (2011).

Measurement error in schooling achievement does not seem the best candidate to reconcile the difference between β_{IV} and β_{OLS}.

IV-LATE: Legitimacy of instrument

- The validity of family background as instrument has been questioned in previous papers.
- Corrections are available. I exploit a method based on 'approximately exogenous' instruments (Conley et al. (2012)).

IV-LATE: Legitimacy of instrument

- Let

$$y_i = \beta S_i + \gamma Z_i + \varepsilon_i \tag{4}$$

  if $\gamma = 0 \Rightarrow$ standard IV; if the instrument is only 'approximate exogenous' $\Rightarrow \gamma \neq 0$.
- If I knew γ, I could purge its effect on y and estimate the model on a newly defined dependent variable $\tilde{y}_i = y_i - \gamma Z_i$.
- I don't know γ, but I can impose $\gamma \in [\underline{\gamma}, \overline{\gamma}]$ and estimate the corresponding $\beta \equiv \beta(\gamma)$, where the notation makes clear that β depends on γ.

IV-LATE: Legitimacy of instrument

- The correction is substantial and larger for the middle-low level (on average by 35 percentage points) than for the high-middle (on average, slightly less than 10 points).
- Focusing on these new estimates, in all the countries the high-middle return is again above the middle-low return, on average by 17 percentage points.
- The most important result is that the OLS-ATE return is now above the IV return.

Correction

Table: Various IV estimation by educational level.

	Low			High		
Instrument:	Partner	Partner	Semester	Partner	Partner	Semester
Method:	Standard	Plausible ex.	Standard	Standard	Plausible ex.	Standard
AT	0.718 ***	0.166 ***	0.261 ***	0.490 ***	0.215 ***	0.250 ***
BE	0.259 ***	0.114 **	0.154 ***	0.274 ***	0.228 ***	0.212 ***
CY	0.746 **	0.130	0.025	0.255	0.500 ***	0.510 ***
CZ	0.739 ***	0.166 **	0.229 ***	0.505 ***	0.344 ***	0.383 ***
DE	0.484 ***	0.161 *		0.242 ***	0.344 ***	
DK	0.509 ***	0.098	0.124 ***	0.211 ***	0.216 ***	0.209 ***
EE	0.552 ***	0.114	0.154 ***	0.460 ***	0.230 ***	0.286 ***
ES	0.350 ***	0.197 ***	0.254 ***	0.485 ***	0.254 ***	0.250 ***
FR	0.460 ***	0.093 *	0.146 ***	0.471 ***	0.342 ***	0.356 ***
GR	0.454 ***	0.160 ***	0.236 ***	0.375 ***	0.286 ***	0.300 ***
HU	0.568 ***	0.170 ***	0.250 ***	0.820 ***	0.612 ***	0.669 ***
IE	0.395 ***	0.171 ***		0.169 ***	0.254 ***	
IS	0.304 ***	0.161	0.214 ***	0.292 ***	0.261 ***	0.276 ***
IT	0.462 ***	0.212 ***	0.251 ***	0.305 ***	0.321 ***	0.328 ***
LT	0.532 ***	0.068	0.132 ***	0.555 ***	0.377 ***	0.382 ***
LU	0.802 ***	0.330 ***	0.345 ***	0.287 ***	0.422 ***	0.483 ***
LV	0.520 ***	0.089	0.211 ***	0.614 ***	0.373 ***	0.376 ***
NL	0.140	0.156		0.512 ***	0.348 ***	
NO	0.615 ***	0.178	0.227 ***	0.146 **	0.202 ***	0.228 ***
PL	0.616 ***	0.162 ***	0.213 ***	0.702 ***	0.505 ***	0.539 ***
PT	0.669 ***	0.387 ***	0.474 ***	0.575 ***	0.499 ***	0.461 ***
SE	0.539 ***	0.094	0.133 ***	0.135 ***	0.138 ***	0.155 ***
SI	0.463 ***	0.213 ***		0.670 ***	0.476 ***	
SK	0.659 ***	0.129	0.201 ***	0.486 ***	0.306 ***	0.334 ***
UK	0.430 ***	0.214 ***		0.517 ***	0.305 ***	

IV-LATE: identified quantities

- IV-LATE could be higher than OLS-ATE because the two estimators identify different quantities.
- In this application, IV-LATE is the causal effect for workers who proceed with education *because* their partners proceed, or compliers (Imbens and Angrist (1994); Angrist et al. (1996)).
- In a cost-benefit analysis, the β is for low liquidity constrained/low ability individuals (Blundell et al. (2005)): it does not extend to the whole population.
- **A cross-countries comparison is no longer correct**, e.g. because of differences in sociological background or institutions from one country to another.
- By the characterization of compliers, the education of the spouse does not identify the same populations of compliers across countries.

IV-LATE: Further issues

Several papers exploit policy changes or quarter of birth to identify the return on education.

- Comparable **policy changes** across EU-countries should be introduced in all the countries at the same time. **Not useful**
- **Quarter or semester of birth** (Angrist and Krueger (1991)) is not available for all countries. Its interpretation is similar to family background as IV: β is for low liquidity constrained/low ability individuals. The return on education estimated with the two different instruments are indistinguishable for the high educational level.

Correction

Table: Various IV estimation by educational level.

	Low			High		
Instrument:	Partner	Partner	Semester	Partner	Partner	Semester
Method:	Standard	Plausible ex.	Standard	Standard	Plausible ex.	Standard
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Bounds

Even though IV-LATE is the most used estimator of the return on education, above results support that

1. 'finding a suitable instrument is not an easy task' (Blundell et al. (2005)), and when it is found, the 'credibility of underlying assumptions is always a matter of disagreement' (Manski and Pepper (2000)).
2. When these issues are addressed, the quantities that are identified are inappropriate for a cross countries comparison.

Therefore, finding an approach that is robust to these critiques is necessary to compare estimates of the return on education around the EU.

Bounds

The working hps of Manski and Pepper (2000) are satisfied

The wage process is (strictly) increasing in the educational level. ▸ Table

Bounds

Bounds suggest that selection on unobservables is relevant in some countries (as found in Blundell et al. (2005)), but not all, as instead one would conclude using IV-LATE.

The average return for middle-low education is up to 25–30%.

The average return for the high-middle education is slightly less than 40%.

For both educational level, upper bounds are usually closer to OLS-ATE (from which are indistinguishable) than to IV-LATE.

Bounds results

Table: Estimation by educational level

	OLS		LATE		Bounds	
	Middle-Low	High-Middle	Middle-Low	High-Middle	Middle-Low	High-Middle
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PT	0.416***	0.539***	0.669***	0.575***	0.375***	0.744***
SE	0.108***	0.163***	0.539***	0.135***	0.144***	0.167***
SI	0.233***	0.520***	0.463***	0.670***	0.299***	0.530***
SK	0.199***	0.355***	0.659***	0.486***	0.268***	0.370***
UK	0.247***	0.344***	0.430***	0.517***	0.362***	0.353***

Policy results

- The small middle-low return: the intermediate educational level $\Rightarrow$ highest share of the working age population, and thus the least remunerated (Pischke and von Wachter (2008)).
- The larger high-middle return: relative scarcity of highly educated individuals $\Rightarrow$ in countries like Belgium, Ireland or Spain, where the share of highly educated individuals is higher than that of middle educated, the return is smaller.
- A remarkable exception to this reasoning is Italy ('paradox'; see Visco (2014)h). In countries with comparable shares of high education, the returns are the highest at 45–55% (Poland, Hungary, Slovenia and Portugal).

A comparison across different estimators

Table: Properties of various estimators

Method	α	Pop.	Ident.
OLS	X	V	Point
IV	V	X	Point
Bounds	V	V	Set

A comparison across different estimators

$$\Delta_{UPPER-IV} = \Delta_{OLS-IV} + \Delta_{UPPER-OLS}$$

$\Delta_{UPPER-OLS}$: effect of endogeneity in the population

$\Delta_{UPPER-IV}$: effect of compliers as opposed to the rest of the population

Δ_{OLS-IV}: 'identification difference' between ATE and LATE.

These quantities may be useful also to test exogeneity and common coefficient, because null hypotheses $\Delta_{i-j} = 0$ may be appropriately constructed.

Bounds

Using the correction in Conley et al. (2012), none of the quantities involved is equal to zero, for both educational level.

Middle-low return: Only in Austria, Spain, Greece, Italy, Latvia, Portugal and Slovak Republic $\Delta_{OLS-IV} > \Delta_{UPPER-OLS} \Rightarrow$ not only is endogeneity relevant, but also heterogeneity is far more critical than in other countries.

High-middle return: $\Delta_{UPPER-IV} > \Delta_{OLS-IV} > \Delta_{UPPER-OLS}$ in 15 countries $\Rightarrow$ endogeneity matters but also that heterogeneity of the population is substantial.

The large heterogeneity in $\Delta_{UPPER-IV}$ strongly supports that the subpopulation of compliers is much different from country to country.

Robustness checks

I will investigate whether the results are valid

1. by age class
2. excluding public sector workers,
3. excluding immigrants
4. including women.

Age class

Figure: Estimates of High-Middle by age - Manski and Pepper (2000)

Age class

Figure: Estimates of Middle-Low by age - Manski and Pepper (2000)

Others

Figure: Estimates of High-Middle Various subsamples - Manski and Pepper (2000)

Others

Figure: Estimates of Middle-Low Various subsamples - Manski and Pepper (2000)

Summary

Concluding remarks

This paper estimates **return on education *around EU***.

It solves non-trivial technical complications in the exercise related to

1. the existence of an instrument
2. fair international comparison

OLS might be biased

Even with good instruments, IV identifies hardly comparable parameters

Bounds solves both issues

Concluding remarks

Much of the heterogeneity in the return on education happens in the middle-high level

OLS (possibly augmented) is less biased than IV with invalid instrument

A convenient interpretation is in terms of demand-supply schedules

Thank you for your attention

Questions, critiques, suggestions to: domenico.depalo@bancaditalia.it

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Descriptive wage

Table: Descriptive statistics

Country	Low		Middle		High	
	log(Wage)	Share	log(Wage)	Share	log(Wage)	Share
	(1)	(2)	(3)	(4)	(5)	(6)
AT	2.18676	9.3	2.42483	69.1	2.66886	21.6
BE	2.34406	20.5	2.42489	39.3	2.62894	40.1
CY	2.27954	19.9	2.43283	40.6	2.80356	39.5
CZ	0.99438	4.1	1.23918	79.3	1.62290	16.6
DE	2.46426	4.1	2.70336	50.3	3.05993	45.6
DK	3.06203	16.1	3.17259	50.4	3.41150	33.5
EE	0.95435	10.7	1.08831	66.3	1.38891	23.0
ES	1.92701	43.0	2.11897	23.5	2.35337	33.5
FR	2.27729	18.7	2.36861	50.0	2.67343	31.3
GR	1.77604	28.0	1.93150	43.2	2.32401	28.8
HU	0.79295	10.8	1.05570	69.6	1.70398	19.6
IE	2.55691	30.1	2.67873	29.1	2.93160	40.8
IS	2.67858	23.6	2.87576	48.8	3.16394	27.7
IT	2.10139	40.3	2.28824	47.0	2.56337	12.6
LT	0.70461	6.6	0.81858	64.2	1.25481	29.2
LU	2.53931	32.3	2.88949	36.0	3.24226	31.7
LV	0.80202	14.6	0.94964	62.9	1.37723	22.5
NL	2.88901	19.2	3.04427	41.9	3.38436	38.9
NO	3.02624	12.1	3.21919	50.2	3.44941	37.7
PL	0.70944	6.7	0.90566	73.3	1.37014	20.0
PT	1.47261	72.7	1.79034	16.2	2.30333	11.1
SE	2.43150	12.4	2.52752	56.9	2.68301	30.6
SI	1.47458	14.7	1.67586	65.8	2.17674	19.5
SK	0.96607	2.5	1.15606	76.1	1.52151	21.5
UK	2.51086	12.2	2.74354	48.0	3.06811	39.8

Back

OLS results

Table: Estimation by educational level

	OLS		LATE		Bounds	
	Middle-Low	High-Middle	Middle-Low	High-Middle	Middle-Low	High-Middle
AT	0.237 ***	0.268 ***	0.718 ***	0.490 ***	0.291 ***	0.266 ***
BE	0.134 ***	0.238 ***	0.259 ***	0.274 ***	0.163 ***	0.221 ***
CY	0.185 **	0.415 ***	0.746 **	0.255	0.300 ***	0.401 ***
CZ	0.215 ***	0.383 ***	0.739 ***	0.505 ***	0.309 ***	0.394 ***
DE	0.231 ***	0.341 ***	0.484 ***	0.242 ***	0.402 ***	0.366 ***
DK	0.116 ***	0.231 ***	0.509 ***	0.211 ***	0.191 ***	0.257 ***
EE	0.152 ***	0.282 ***	0.552 ***	0.460 ***	0.203 ***	0.315 ***
ES	0.237 ***	0.275 ***	0.350 ***	0.485 ***	0.270 ***	0.317 ***
FR	0.130 ***	0.389 ***	0.460 ***	0.471 ***	0.187 ***	0.322 ***
GR	0.215 ***	0.335 ***	0.454 ***	0.375 ***	0.269 ***	0.436 ***
HU	0.258 ***	0.653 ***	0.568 ***	0.820 ***	0.390 ***	0.677 ***
IE	0.187 ***	0.256 ***	0.395 ***	0.169 ***	0.225 ***	0.290 ***
IS	0.164 ***	0.306 ***	0.304 ***	0.292 ***	0.277 ***	0.335 ***
IT	0.245 ***	0.315 ***	0.462 ***	0.305 ***	0.222 ***	0.350 ***
LT	0.130 ***	0.429 ***	0.532 ***	0.555 ***	0.241 ***	0.444 ***
LU	0.376 ***	0.459 ***	0.802 ***	0.287 ***	0.462 ***	0.466 ***
LV	0.176 ***	0.406 ***	0.520 ***	0.614 ***	0.244 ***	0.449 ***
NL	0.173 ***	0.375 ***	0.140	0.512 ***	0.288 ***	0.370 ***
NO	0.221 ***	0.212 ***	0.615 ***	0.146 **	0.280 ***	0.254 ***
PL	0.215 ***	0.534 ***	0.616 ***	0.702 ***	0.289 ***	0.478 ***
PT	0.416 ***	0.539 ***	0.669 ***	0.575 ***	0.375 ***	0.744 ***
SE	0.108 ***	0.163 ***	0.539 ***	0.135 ***	0.144 ***	0.167 ***
SI	0.233 ***	0.520 ***	0.463 ***	0.670 ***	0.299 ***	0.530 ***
SK	0.199 ***	0.355 ***	0.659 ***	0.486 ***	0.268 ***	0.370 ***
UK	0.247 ***	0.344 ***	0.430 ***	0.517 ***	0.362 ***	0.353 ***

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IV results

Table: Estimation by educational level

	OLS		LATE		Bounds	
	Middle-Low	High-Middle	Middle-Low	High-Middle	Middle-Low	High-Middle
AT	0.237 ***	0.268 ***	0.718 ***	0.490 ***	0.291 ***	0.266 ***
BE	0.134 ***	0.238 ***	0.259 ***	0.274 ***	0.163 ***	0.221 ***
CY	0.185 **	0.415 ***	0.746 **	0.255	0.300 ***	0.401 ***
CZ	0.215 ***	0.383 ***	0.739 ***	0.505 ***	0.309 ***	0.394 ***
DE	0.231 ***	0.341 ***	0.484 ***	0.242 ***	0.402 ***	0.366 ***
DK	0.116 ***	0.231 ***	0.509 ***	0.211 ***	0.191 ***	0.257 ***
EE	0.152 ***	0.282 ***	0.552 ***	0.460 ***	0.203 ***	0.315 ***
ES	0.237 ***	0.275 ***	0.350 ***	0.485 ***	0.270 ***	0.317 ***
FR	0.130 ***	0.389 ***	0.460 ***	0.471 ***	0.187 ***	0.322 ***
GR	0.215 ***	0.335 ***	0.454 ***	0.375 ***	0.269 ***	0.436 ***
HU	0.258 ***	0.653 ***	0.568 ***	0.820 ***	0.390 ***	0.677 ***
IE	0.187 ***	0.256 ***	0.395 ***	0.169 ***	0.225 ***	0.290 ***
IS	0.164 ***	0.306 ***	0.304 ***	0.292 ***	0.277 ***	0.335 ***
IT	0.245 ***	0.315 ***	0.462 ***	0.305 ***	0.222 ***	0.350 ***
LT	0.130 ***	0.429 ***	0.532 ***	0.555 ***	0.241 ***	0.444 ***
LU	0.376 ***	0.459 ***	0.802 ***	0.287 ***	0.462 ***	0.466 ***
LV	0.176 ***	0.406 ***	0.520 ***	0.614 ***	0.244 ***	0.449 ***
NL	0.173 ***	0.375 ***	0.140	0.512 ***	0.288 ***	0.370 ***
NO	0.221 ***	0.212 ***	0.615 ***	0.146 **	0.280 ***	0.254 ***
PL	0.215 ***	0.534 ***	0.616 ***	0.702 ***	0.289 ***	0.478 ***
PT	0.416 ***	0.539 ***	0.669 ***	0.575 ***	0.375 ***	0.744 ***
SE	0.108 ***	0.163 ***	0.539 ***	0.135 ***	0.144 ***	0.167 ***
SI	0.233 ***	0.520 ***	0.463 ***	0.670 ***	0.299 ***	0.530 ***
SK	0.199 ***	0.355 ***	0.659 ***	0.486 ***	0.268 ***	0.370 ***
UK	0.247 ***	0.344 ***	0.430 ***	0.517 ***	0.362 ***	0.353 ***

Back

Descriptive wage

Table: Descriptive statistics

Country	Low		Middle		High	
	log(Wage)	Share	log(Wage)	Share	log(Wage)	Share
	(1)	(2)	(3)	(4)	(5)	(6)
AT	2.18676	9.3	2.42483	69.1	2.66886	21.6
BE	2.34406	20.5	2.42489	39.3	2.62894	40.1
CY	2.27954	19.9	2.43283	40.6	2.80356	39.5
CZ	0.99438	4.1	1.23918	79.3	1.62290	16.6
DE	2.46426	4.1	2.70336	50.3	3.05993	45.6
DK	3.06203	16.1	3.17259	50.4	3.41150	33.5
EE	0.95435	10.7	1.08831	66.3	1.38891	23.0
ES	1.92701	43.0	2.11897	23.5	2.35337	33.5
FR	2.27729	18.7	2.36861	50.0	2.67343	31.3
GR	1.77604	28.0	1.93150	43.2	2.32401	28.8
HU	0.79295	10.8	1.05570	69.6	1.70398	19.6
IE	2.55691	30.1	2.67873	29.1	2.93160	40.8
IS	2.67858	23.6	2.87576	48.8	3.16394	27.7
IT	2.10139	40.3	2.28824	47.0	2.56337	12.6
LT	0.70461	6.6	0.81858	64.2	1.25481	29.2
LU	2.53931	32.3	2.88949	36.0	3.24226	31.7
LV	0.80202	14.6	0.94964	62.9	1.37723	22.5
NL	2.88901	19.2	3.04427	41.9	3.38436	38.9
NO	3.02624	12.1	3.21919	50.2	3.44941	37.7
PL	0.70944	6.7	0.90566	73.3	1.37014	20.0
PT	1.47261	72.7	1.79034	16.2	2.30333	11.1
SE	2.43150	12.4	2.52752	56.9	2.68301	30.6
SI	1.47458	14.7	1.67586	65.8	2.17674	19.5
SK	0.96607	2.5	1.15606	76.1	1.52151	21.5
UK	2.51086	12.2	2.74354	48.0	3.06811	39.8

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Bounds results

Table: Estimation by educational level

	OLS		LATE		Bounds	
	Middle-Low	High-Middle	Middle-Low	High-Middle	Middle-Low	High-Middle
AT	0.237 ***	0.268 ***	0.718 ***	0.490 ***	0.291 ***	0.266 ***
BE	0.134 ***	0.238 ***	0.259 ***	0.274 ***	0.163 ***	0.221 ***
CY	0.185 **	0.415 ***	0.746 **	0.255	0.300 ***	0.401 ***
CZ	0.215 ***	0.383 ***	0.739 ***	0.505 ***	0.309 ***	0.394 ***
DE	0.231 ***	0.341 ***	0.484 ***	0.242 ***	0.402 ***	0.366 ***
DK	0.116 ***	0.231 ***	0.509 ***	0.211 ***	0.191 ***	0.257 ***
EE	0.152 ***	0.282 ***	0.552 ***	0.460 ***	0.203 ***	0.315 ***
ES	0.237 ***	0.275 ***	0.350 ***	0.485 ***	0.270 ***	0.317 ***
FR	0.130 ***	0.389 ***	0.460 ***	0.471 ***	0.187 ***	0.322 ***
GR	0.215 ***	0.335 ***	0.454 ***	0.375 ***	0.269 ***	0.436 ***
HU	0.258 ***	0.653 ***	0.568 ***	0.820 ***	0.390 ***	0.677 ***
IE	0.187 ***	0.256 ***	0.395 ***	0.169 ***	0.225 ***	0.290 ***
IS	0.164 ***	0.306 ***	0.304 ***	0.292 ***	0.277 ***	0.335 ***
IT	0.245 ***	0.315 ***	0.462 ***	0.305 ***	0.222 ***	0.350 ***
LT	0.130 ***	0.429 ***	0.532 ***	0.555 ***	0.241 ***	0.444 ***
LU	0.376 ***	0.459 ***	0.802 ***	0.287 ***	0.462 ***	0.466 ***
LV	0.176 ***	0.406 ***	0.520 ***	0.614 ***	0.244 ***	0.449 ***
NL	0.173 ***	0.375 ***	0.140	0.512 ***	0.288 ***	0.370 ***
NO	0.221 ***	0.212 ***	0.615 ***	0.146 **	0.280 ***	0.254 ***
PL	0.215 ***	0.534 ***	0.616 ***	0.702 ***	0.289 ***	0.478 ***
PT	0.416 ***	0.539 ***	0.669 ***	0.575 ***	0.375 ***	0.744 ***
SE	0.108 ***	0.163 ***	0.539 ***	0.135 ***	0.144 ***	0.167 ***
SI	0.233 ***	0.520 ***	0.463 ***	0.670 ***	0.299 ***	0.530 ***
SK	0.199 ***	0.355 ***	0.659 ***	0.486 ***	0.268 ***	0.370 ***
UK	0.247 ***	0.344 ***	0.430 ***	0.517 ***	0.362 ***	0.353 ***

Back

Correction

Table: Various IV estimation by educational level.

	Low			High		
Instrument:	Partner	Partner	Semester	Partner	Partner	Semester
Method:	Standard	Plausible ex.	Standard	Standard	Plausible ex.	Standard
AT	0.718 ***	0.166 ***	0.261 ***	0.490 ***	0.215 ***	0.250 ***
BE	0.259 ***	0.114 **	0.154 ***	0.274 ***	0.228 ***	0.212 ***
CY	0.746 **	0.130	0.025	0.255	0.500 ***	0.510 ***
CZ	0.739 ***	0.166 **	0.229 ***	0.505 ***	0.344 ***	0.383 ***
DE	0.484 ***	0.161 *		0.242 ***	0.344 ***	
DK	0.509 ***	0.098	0.124 ***	0.211 ***	0.216 ***	0.209 ***
EE	0.552 ***	0.114	0.154 ***	0.460 ***	0.230 ***	0.286 ***
ES	0.350 ***	0.197 ***	0.254 ***	0.485 ***	0.254 ***	0.250 ***
FR	0.460 ***	0.093 *	0.146 ***	0.471 ***	0.342 ***	0.356 ***
GR	0.454 ***	0.160 ***	0.236 ***	0.375 ***	0.286 ***	0.300 ***
HU	0.568 ***	0.170 ***	0.250 ***	0.820 ***	0.612 ***	0.669 ***
IE	0.395 ***	0.171 ***		0.169 ***	0.254 ***	
IS	0.304 ***	0.161	0.214 ***	0.292 ***	0.261 ***	0.276 ***
IT	0.462 ***	0.212 ***	0.251 ***	0.305 ***	0.321 ***	0.328 ***
LT	0.532 ***	0.068	0.132 ***	0.555 ***	0.377 ***	0.382 ***
LU	0.802 ***	0.330 ***	0.345 ***	0.287 ***	0.422 ***	0.483 ***
LV	0.520 ***	0.089	0.211 ***	0.614 ***	0.373 ***	0.376 ***
NL	0.140	0.156		0.512 ***	0.348 ***	
NO	0.615 ***	0.178	0.227 ***	0.146 **	0.202 ***	0.228 ***
PL	0.616 ***	0.162 ***	0.213 ***	0.702 ***	0.505 ***	0.539 ***
PT	0.669 ***	0.387 ***	0.474 ***	0.575 ***	0.499 ***	0.461 ***
SE	0.539 ***	0.094	0.133 ***	0.135 ***	0.138 ***	0.155 ***
SI	0.463 ***	0.213 ***		0.670 ***	0.476 ***	
SK	0.659 ***	0.129	0.201 ***	0.486 ***	0.306 ***	0.334 ***
UK	0.430 ***	0.214 ***		0.517 ***	0.305 ***	

Back

Correction

Table: Various IV estimation by educational level.

	Low			High		
Instrument:	Partner	Partner	Semester	Partner	Partner	Semester
Method:	Standard	Plausible ex.	Standard	Standard	Plausible ex.	Standard
AT	0.718 ***	0.166 ***	0.261 ***	0.490 ***	0.215 ***	0.250 ***
BE	0.259 ***	0.114 **	0.154 ***	0.274 ***	0.228 ***	0.212 ***
CY	0.746 **	0.130	0.025	0.255	0.500 ***	0.510 ***
CZ	0.739 ***	0.166 **	0.229 ***	0.505 ***	0.344 ***	0.383 ***
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NL	0.140	0.156		0.512 ***	0.348 ***	
NO	0.615 ***	0.178	0.227 ***	0.146 **	0.202 ***	0.228 ***
PL	0.616 ***	0.162 ***	0.213 ***	0.702 ***	0.505 ***	0.539 ***
PT	0.669 ***	0.387 ***	0.474 ***	0.575 ***	0.499 ***	0.461 ***
SE	0.539 ***	0.094	0.133 ***	0.135 ***	0.138 ***	0.155 ***
SI	0.463 ***	0.213 ***		0.670 ***	0.476 ***	
SK	0.659 ***	0.129	0.201 ***	0.486 ***	0.306 ***	0.334 ***
UK	0.430 ***	0.214 ***		0.517 ***	0.305 ***	

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Motivations - additional

- For Germany, Trostel et al. (2002) estimate a positive return of 4–7% per year of education, whereas Pischke and von Wachter (2008) and Kamhöfer and Schmitz (2015) further qualify that the return is non significant for compulsory education.
- For higher education versus anything less in UK, the estimated wage return each additional educational year is 11-15% in Trostel et al. (2002) compared to 27% in Blundell et al. (2005).

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More on IV

The identification of β with IV hinges on a suitable instrument (Z) that must be correlated with education, i.e. relevant, but not with ability, i.e. exogenous ($\alpha' Z = 0$).

Even in this case, IV will not recover the effect for the entire population, because $E[y_i|Z_i, X_i] = \beta\, E[S_i|Z_i, X_i] + E[(\beta - b_i)\, S_i|Z_i, X_i]$.

The last term is different from zero, unless either return is homogeneous or, focusing on treated individuals, the instrument is uncorrelated with the individual extra-return on education (i.e., the schooling decisions is unrelated to the individuals-specific return).

Both are particular cases, that may be unrealistic in the real world (Heckman (1997)).

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EU - SILC countries

I consider 25 countries: Austria, Belgium, Cyprus, Czech Republic, Germany, Denmark, Estonia, Spain, France, Greece, Hungary, Ireland, Island, Italy, Lithuania, Luxembourg, Latvia, The Netherlands, Norway, Poland, Portugal, Sweden, Slovenia, Slovak republic and United Kingdom.

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