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Okun's Laws Differentiated by Education

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Abstract: Our aim in this note is to set Okun's Law in a new perspective. We argue that highly educated labour should react differently to economic downturns and recoveries than lesser-educated labour. A simple model shows that when highly educated workers are engaged in long-run projects, the adjustments of their (un)employment to GDP changes become ambiguous. If the access to capital is not too affected by the cycle, these adjustements can be the opposite of the employment changes of the lesser- educated workforce. Estimations for the United States, the European Union and across Europe support the coexistence of different Okun's laws according to educational attainment. This observation may help to explain recent puzzling macroeconomic facts.

Keywords: Okun, low-middle educated, high-educated, business cycle

JEL Classification: E24, E32, J21.

Lois d'Okun par niveau de diplôme

Résumé : Cette note propose un regard nouveau sur la loi d'Okun. Le travail très diplômé doit réagir différemment aux récessions et reprises que l'emploi moins qualifié. Un modèle simple montre ainsi que lorsque les plus diplômés participent à des projets de long terme, l'ajustement de leur emploi ou de leur chômage aux variations du PIB sont ambigus. Et si l'accès au capital n'est pas trop affecté par le cycle économique, les évolutions pour les plus qualifiés peuvent être opposées à ceux observés pour moins qualifiés. Des estimations sur des données trimestrielles européennes et américaines sont cohérentes avec des lois d'Okun différenciées par niveau d'éducation.

Mots-clefs : Okun, éducation, cycle économique, Europe, Etats-Unis

Classification JEL : E24, E32, J21.

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Introduction

Okun's Law – a negative (positive) short-run correlation between (un)employment and output – is one of the key notions in macroeconomics. The Great Recession has renewed interest in empirical research on the law. The main concern has been its temporal stability. For example, Gordon (2010), Cazes *et al.* (2014) and Owyang *et al.* (2012) highlight possible temporal breaks, while Ball et al. (2013) support the permanence of the law for numerous countries. Analyses, however, converge on the finding of significant differences across countries that cannot be fully explained (e.g. by different employment protection legislations). Authors of these contributions assume there exist long-run levels of output (potential output), employment, and unemployment (natural rate of unemployment), determined by technology, potential labour supply or labour-market institutions.

Our purpose here is to place Okun's law in a new perspective. We argue that there are strong arguments supporting the belief that highly educated labour reacts differently to economic downturns and recoveries than lesser-educated labour. Consequently, the standard approach may be too aggregated. Rather than a unique Okun's law, we estimate two Okun's laws according to educational level.

The vast literature in labour economics is consistent with labour-market segmentation according to education. In the short or medium run, less educated workers are less mobile (Machin et al., 2012); highly educated workers thus have, especially in the case of economic downturn, more job opportunities. On the demand side, firms may fear the risks of a significant skills shortage when the recovery eventually comes. Globalization and technological changes, including the revolution in information and communications technology (ICT), have favoured the demand for the most educated. They are more likely to work in key occupations or on long-term projects that are independent of the business cycle. In fact, firms invest in their educated workforce. For example, according to the European Labour Force Survey, during each month of 2013, in Germany 9% of the tertiary-educated workers aged 25-54 received some training compared to about 3% for less educated workers; in France, the figures are respectively 12% and 6%. These arguments are crucial for explaining the strong labour-hoarding process in Germany during the Great Recession (see Bellmann *et al.*, 2015). Establishment-level evidence shows significant labour hoarding in highly skilled occupations in both France and the UK (Askenazy *et al.*, 2015; Bryson *et al.*, 2015).

To study the impact of these mechanisms with respect to Okun's law, we built a simple model with two levels of educational attainment. The low or middle-educated workforce is involved in short-run production, while highly educated workers participate in longer projects. In this framework, the (un)employment of low or middle-educated follows the standard Okun's law. However, the relative opportunity cost of highly educated workers is counter-cyclical. Consequently, the relationship between highly educated employment and the business cycle becomes ambiguous and depends on the availability of capital. The adjustments of low-middle *versus* high-educated workforce can even been theoretically in opposite directions. This prediction is thus stronger than the recent results of Cairo and Cajner (2014): following an intuition of Becker, the authors introduce specific-training complementary to education in a search and matching model to replicate the greater stability of educated workers in the US.

We then exploit Eurostat and the Bureau of Labor Statistics (BLS) quarterly data to test our predictions. We run separate regressions of employment or unemployment for highly educated and

low or middle-educated workers. On the both side of the Atlantic, the magnitudes of the Okun coefficients for the most educated labour are systematically lower than the coefficients for workers with up to the secondary educational level; in some cases, their signs are even opposite.

The organisation of this article is as follows: we develop the model in the first section, present the data and the basic findings for the US and for Europe in the second section, and discuss Okun's law for various European countries in the third.

I. Basic theoretical model

In this section, we propose a simple model for analyzing the impact of the business cycle on labour demand according to education. It is an adapted version of Aghion et al. (2012), which focuses on R&D spending *versus* short-run investments.

1. Workers and employers

Assume two types of workers: the highly educated and the middle or low-educated. The middle or low-educated workers are involved in activities that follow decreasing-returns production: i.e., the revenue for a given firm at date t is $a_t l_t^{\alpha}$, where l_t is the middle or low-educated workforce, and $a_t > 1$, $0 < \alpha < 1$. The highly educated work on medium-term linear projects, e.g. innovation or marketing. These projects do not deliver a return at date t. Rather, at date t+1 the firm's revenue will be $a_{t+1} h_t$, where h_t is the number of highly educated workers.

We consider overlapping generations of entrepreneurs living two periods. At date t, a new entrepreneur has an initial wealth of K_t. This wealth is used to pay for hiring and training costs and to pay for the first workers' wages. For sake of simplicity, we assume that the interest rate is zero; all the wages must be paid immediately. The total cost of one middle or low-educated worker is normalized to 1. A highly educated one costs $c > 1$.

2. Labour demand and business cycle

The entrepreneur maximizes her expected total revenue at date t, subject to her initial wealth:

$$\text{Max } a_t l_t^{\alpha} + \text{E}(a_{t+1} | a_t) h_t$$

$$\text{s.c } K_t = l_t + c h_t$$

Assuming that K is sufficiently large that an interior solution exists, we can easily derive h_t and l_t

$$l_t = [\alpha c \, \text{E}(a_{t+1} | a_t) / a_t]^{1/1-\alpha}$$

$$h_t = K_t - [\alpha c \, \text{E}(a_{t+1} | a_t) / a_t]^{1/1-\alpha}$$

Entrepreneurs face demand shocks in each period, which alter the value of a. The parameter a can take on two values: a_b in case of boom and a_d in case of downturn, with $a_d < a_b$. Shocks exhibit some persistence, i.e.

$$\text{E}(a_{t+1} | a_t = a_b) = p \, a_b + (1-p) \, a_d,$$

$$E(a_{t+1} | a_t = a_d) = p\, a_d + (1-p)\, a_b, \text{ where } 0 < p < 1/2$$

Assume first that K_t is constant i.e. that the access to capital is not affected by downturns. Since $1-\alpha > 0$ and despite this persistence, l_t (the employment of low or middle labour) is pro-cyclical; and mechanically h_t (the high-educated labour) is counter-cyclical. Intuitively, in the case of cyclical downturn, an entrepreneur will prefer to invest in highly educated workers who are involved in projects that deliver relatively higher expected returns. In other words, the relative opportunity cost of investing in high-skilled labour declines. The correlative is that the expected sign of the Okun's coefficient for employment is positive for low or middle labour but negative for highly educated labour.

Now, capital endowment may be altered by the business cycle: in case of recession, K should contract. Under this assumption, Okun's coefficients for highly educated labour become ambiguous and can turn positive when access to capital tightens.

II. Empirical Okun's laws by educational level in the European Union and the US

We test the main predictions of our model in this section: the Okun's coefficient should differ according to educational levels. Eurostat and the BLS now offer quarterly data that make it possible to run these estimations. They cover periods of booms and recessions. We present first the data and our strategy, then our main results for the US and the European Union.

1. Data and strategy

We use two main sources for (un)employment: the European Labour Force Survey for Europe and the Current Population for the US. As in the Okun's seminal work, we use quarterly data in order to obtain sufficiently large samples; by construction, however, quarterly data are noisy, which may cause estimates to be quite imprecise, especially for small European countries.

The BLS provides quarterly estimates of employment and unemployment for all workers and by educational attainment. Data stratified by education are available only for workers aged 25 or more. Seasonally adjusted series are given by main educational levels: less than a high school diploma, high school graduates, some college or associate's degree, and bachelor degree or higher. Since the majority of workers in the third category have no degree, we assume that highly educated workers in the US hold a bachelor's degree or more. According to this definition, in 2014 around 40% of workers aged 25 and older were highly educated.

Eurostat provides quarterly estimates of the unemployment rate and the level of employment by educational attainment consistent with the International Standard Classification of Education (ISCED). Homogenous data with a stable classification of diplomas are available from 2005Q1 to 2013Q4.[1] This

1 In January 2005, a common methodology for the EU-LFS, including quarterly waves, was generalized. (Before that date, for example Germany did not carry out quarterly surveys). Because of the requalification of certain diplomas, a significant break occurred in the series by educational level at 2014Q1; for example, the number of workers with ISCED 5-8 employed in Austria jumped from 0.9 to 1.3 million in the previous quarter.

period includes not only the Great Recession but also a period of strong economic growth before 2008 and during the recent recovery. The average quarterly GDP growth of the EU15 is 0.2%.

We assume that highly educated workers are tertiary-educated (ISCED 5-8). Middle and low-educated workers are those holding secondary or lower diplomas (ISCED 0-4). Data are broken down according to different age groups. By construction, numerous young workers are still studying. To avoid that the analysis of the highly educated versus middle or low-educated workforce reflect a composition effect by age, we restrict the sample by educational attainment to workers aged 25 or more (as in the US data). According to the EU-LFS, in 2013 the share in total employment of tertiary-educated workers aged 25 and more was roughly one third in the European Union.

Eurostat does not provide seasonally-adjusted (un)employment data by level of educational attainment. Since such data would be expected to differ according to education and country (or area), we had to include quarterly country or area dummies in the estimations. We also exploited series for quarterly total employment, which are seasonally adjusted.

The quarterly GDP data are from the Bureau of Economic Analysis and Eurostat. They are adjusted for seasonal effects, base year 2010.[2] The data were extracted in May 2015, but we have included semi-definitive data up to 2014Q2 for the US. Descriptive statistics are in the Appendix.

While the seminal Okun's Law relates GDP and unemployment, our model refers rather to an employment versus GDP version of the law. Thus, here we perform tests for both employment and unemployment. Two principal methods are used to estimate an Okun's law. A filter – e.g. Hodrick-Prescott – helps to identify a natural level of (un)employment and the potential output; then regressions in level are performed. Alternatively, Okun's relations can be estimated in first differences. Because our data covers a period of major shocks that raise doubt about the estimations of potential output or natural unemployment, we run first-differences regressions. More precisely, we estimate

$$\delta E_{c,e,t} / E_{c,e,t} = \alpha + \beta(L)\delta Y_{c,e,t} / Y_{c,e,t} + \varepsilon_{c,e,t}$$

$$\delta U_{c,e,t} = \alpha + \beta(L)\delta Y_{c,e,t} / Y_{c,e,t} + \varepsilon_{c,e,t}$$

where $E_{c,e,t}$ is the employment for the level of education *e* in country *c* at quarter *t*. $U_{c,e,t}$ is the unemployment rate, and $\beta(L)$ is a polynomial of lags. We select two specifications for $\beta(L)$: one with contemporaneous GDP growth alone and a second with two lags of quarterly growth. Again, quarterly dummies per country are included when right-side observations are not seasonally adjusted.

2 Main findings

Table 1 reports estimations of the standard Okun's law for employment in the US and the European Union. For Europe, we report both a regression on the aggregated EU with 15 countries and a pooled

2 Except in Portugal, Ireland and Romania, the European statistical institutes also correct for bank holidays.

regression of all the available observations for the EU15 plus new members. For the US, the coefficients from 0.3 to 0.6 are consistent with previous findings (see Ball *et al.*, 2013 for a review). Okun's elasticity in the EU15 is slightly lower, but not statistically different, even though observations fall mainly during the Great Recession and although it is essentially over. When we pooled all available observations for the European countries, the coefficient is in the same range.

Table 1a. Okun's Laws for employment

Equation in first differences with no lag

	US		EU 15		Pooled Europe	
Time	*1975q2-2015q1*	*1992q2-2015q2*	*1998q2-2013q4*	*2005q1-2013q4*	*1998q2-2013q4*	*2005q1-2013q4*
β_0	0.38***	0.27***	0.38***	0.23***	0.35***	0.28***
	(0.05)	(0.10)	(0.13)	(0.02)	(0.04)	(0.03)
Age	16 +	25 +	All	25 +	All	25 +
Seasonally adjusted	Yes	Yes	Yes	No	Yes	No
Cluster quarter-country	No	No	No	Yes	No	Yes
Adj. R^2	0.3447	0.1603	0.1169	0.8418	0.0656	0.5712
Nb. Obs	160	92	67	35	1,470	833

Quarterly data. Robust standard errors.

Pooled Europe: Austria, Belgium, Bulgaria, Croatia, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Latvia, Lithuania, Netherlands, Poland, Portugal, Romania, Slovak Republic, Slovenia, Spain, Sweden, United Kingdom

* statistically significant at 10%; ** at 5%; *** at 1%

Table 1b. Okun's Laws for employment

Equation in first differences with two lags

	US		EU 15		Pooled Europe	
Time	*1975q2-2015q1*	*1992q2-2015q2*	*1998q2-2013q4*	*2005q1-2013q4*	*1998q2-2013q4*	*2005q1-2013q4*
β_0	0.27***	0.10	0.27	0.09***	0.27***	0.18***
	(0.04)	(0.07)	(0.17)	(0.00)	(0.04)	(0.03)
β_1	0.23***	0.32***	0.13	0.12**	0.15***	0.14***
	(0.05)	(0.09)	(0.21)	(0.03)	(0.04)	(0.03)
β_2	0.14***	0.14**	0.05	0.13***	0.04	0.13***
	(0.04)	(0.05)	(0.12)	(0.02)	(0.04)	(0.04)
$\beta_0 + \beta_1 + \beta_2$	0.63***	0.56***	0.44***	0.34***	0.47***	0.45***
	(0.05)	(0.09)	(0.15)	(0.03)	(0.05)	(0.05)
Age	16 +	25 +	All	25 +	All	25 +
Seasonally adjusted	Yes	Yes	Yes	No	Yes	No
Cluster quarter-country	No	No	No	Yes	No	Yes
Adj. R^2	0.5443	0.4306	0.1273	0.8942	0.0773	0.6197
Nb. Obs	159	92	66	35	1,448	831

Quarterly data. Robust standard errors. Pooled Europe: see table 1a

* statistically significant at 10%; ** at 5%; *** at 1%

The regressions for unemployment confirm these findings (see Appendix). Most of the coefficients are still more statistically significant than in the employment regressions, even though their magnitudes are slightly lower. The latter phenomenon may reflect the impact of the business cycle on participation in the labour market.

We may now turn to the estimation of separate Okun's laws according to educational level for workers aged 25 or more. Table 2a reports the results for the Okun's employment relation with no lag, Table 3a with 2 lags. Tables 2b and 3b present respectively the estimations of the unemployment laws with no lag and two lags for GDP. Introducing two lags or not result in similar findings.

Table 2a. Okun's laws for employment by educational attainment

Equations in first differences with no lag – Workers aged 25 and older

	US		EU 15		Pooled Europe	
Educational attainment	*High*	*Medium-Low*	*High*	*Medium-Low*	*High*	*Medium-Low*
β_0	0.20	0.40***	-0.02	0.35**	0.14	0.34***
	(0.15)	(0.10)	(0.12)	(0.07)	(0.15)	(0.06)
Adj. R^2	0.03	0.23	0.63	0.74	0.09	0.49
Nb. Obs	87		35		833	
Time	1992Q2-2013Q4		2005Q2-2013Q4		2005Q2-2013Q4	

Quarterly data. Robust standard errors. Clustered by quarter-country for EU15 and pooled Europe.

Pooled Europe: see Table 1a.

*** statistically significant at 1 %; ** at 5 %; * at 10 %.

Table 2b. Okun's laws for unemployment by educational attainment

Equation in first differences with no lag – Workers aged 25 or more

	US		EU 15		Pooled Europe	
Educational attainment	*High*	*Medium-Low*	*High*	*Medium-Low*	*High*	*Medium-Low*
β_0	-0.14***	-0.54***	-0.16**	-0.28**	-0.07***	-0.23***
	(0.05)	(0.15)	(0.03)	(0.06)	(0.01)	(0.03)
Adj. R^2	0.16	0.29	0.68	0.90	0.22	0.55
Nb. Obs	87		35		813	
Time	1992Q2-2013Q4		2005Q2-2013Q4		2005Q2-2013Q4	

Quarterly data. Robust standard errors. Clustered by quarter-country for EU15 and pooled Europe.

Pooled Europe: see Table 1a.

*** statistically significant at 1 %; ** at 5 %; * at 10 %.

Results for the EU15 and the pooled European countries are consistent with two distinct curves according to educational attainment. Findings are robust to the introduction of two lags of quarterly GDP growth. The Okun's coefficient in the employment equation is virtually null for the tertiary educated: for these workers, there is no longer even an empirical short-run relation between their employment and the GDP, whereas a strong correlation emerges for secondary or less educated

labour. Employment equations still deliver a significant relation between high-educated unemployment and GDP changes; but the estimated coefficient is statistically lower than one for the correlation between GDP and medium-low educated unemployment.

Table 3a. Okun's laws for employment by educational attainment

Equation in first differences with two lags – Workers aged 25 or more

	US		EU 15		Pooled Europe	
Educational attainment	*High*	*Medium-Low*	*High*	*Medium-Low*	*High*	*Medium-Low*
β_0	0.05	0.19**	-0.04	0.15*	0.10	0.22***
	(0.15)	(0.07)	(0.13)	(0.05)	(0.14)	(0.05)
β_1	0.32**	0.35***	-0.09	0.21	0.05	0.18***
	(0.13)	(0.08)	(0.17)	(0.11)	(0.08)	(0.06)
β_2	0.02	0.15**	0.17	0.13**	0.06	0.18***
	(0.10)	(0.07)	(0.08)	(0.04)	(0.08)	(0.04)
$\beta_0+\beta_1+\beta_2$	0.39***	0.69***	0.05	0.49***	0.22	0.57***
	(0.14)	(0.08)	(0.12)	(0.08)	(0.19)	(0.08)
Adj. R^2	0.11	0.44	0.62	0.80	0.09	0.54
Nb. Obs	87		35		831	
Time	1992Q2-2013Q4		2005Q2-2013Q4		2005Q2-2013Q4	

Quarterly data. Robust standard errors. Clustered by quarter-country for EU15 and pooled Europe.

Pooled Europe: see Table 1a.

*** statistically significant at 1 %; ** at 5 %; * at 10 %.

Table 3b. Okun's laws for unemployment by educational attainment

Equation in first differences with two lags – Workers aged 25 or more

	US		EU 15		Pooled Europe	
Educational attainment	*High*	*Medium-Low*	*High*	*Medium-Low*	*High*	*Medium-Low*
β_0	-0.08*	-0.34***	-0.10**	-0.16**	-0.03**	-0.15***
	(0.05)	(0.10)	(0.03)	(0.05)	(0.01)	(0.02)
β_1	-0.10**	-0.40***	-0.07*	-0.16**	-0.06***	-0.14***
	(0.04)	(0.11)	(0.03)	(0.04)	(0.02)	(0.02)
β_2	-0.08**	-0.21***	-0.02	-0.01	-0.07***	-0.10***
	(0.04)	(0.08)	(0.01)	(0.02)	(0.02)	(0.02)
$\beta_0+\beta_1+\beta_2$	-0.25***	-0.94***	-0.19**	-0.33***	-0.16***	-0.38***
	(0.05)	(0.13)	(0.03)	(0.04)	(0.02)	(0.03)
Adj. R^2	0.32	0.56	0.72	0.92	0.28	0.63
Nb. Obs	87		35		811	
Time	1992Q2-2013Q4		2005Q2-2013Q4		2005Q2-2013Q4	

Quarterly data. Robust standard errors. Clustered by quarter-country for EU15 and pooled Europe.

Pooled Europe: see Table 1a.

*** statistically significant 1 %; ** at 5 %; * at 10 %.

Evidence for the US is less clear-cut. However, both the unemployment and employment curves seem to differ according to education. More precisely, whereas the Okun's employment law is still observed

for the highly educated, the elasticity is half the one we observed for workers without a bachelor degree, and it is no longer significant. In addition, Okun's coefficients for unemployment differ widely according to education. These findings are consistent with Cairo and Gajner (2014). The unemployment rate of tertiary-educated workers is statistically less sensitive to the GDP than the rate of secondary or less educated workers.

Overall, our findings confirm the existence of different Okun's curves according to educational level. The sensitivity of (un)employment of highly educated workers to GDP changes appears lower. In the next section, we explore heterogeneity within the European Union that aggregated or pooled estimates conceal.

III. Empirical Okun's laws by educational level across European countries

The previous section supports our theoretical prediction of Okun's laws by educational attainment. However, our model also suggests that the behaviour of the labour demand for the highly educated is altered when firms face difficulties in obtaining capital during an economic downturn. Now, the Great Recession has been associated with a financial crisis and a sovereign debt crisis in the euro area. On the one hand, some countries were particularly affected and still suffer from interest rate tensions and credit restrictions. On the other hand, countries like Germany or France benefited from the intervention of the European Central Bank and historically low interest rates. It is thus worthwhile to estimate Okun's law by educational level for various European countries separately. Note that in comparison to the previous estimations based on the aggregated Europe or the pooled countries, the noise in the data may be even more critical. Consequently, estimates on 35 observations are likely to be imprecise. Recall that despite its small size, our time window from 2005 to 2013 includes periods of booms and strong recessions. On our sample, the (unweighted) quarterly GDP growth is 0.3.

Table 4 reports the estimated Okun's coefficient for the first-difference employment relations. It shows a large heterogeneity across European countries. However, basic regularities emerge.

1. "Core" European countries

In the majority of western European economies that have not been directly hurt by the sovereign debt crisis, the correlation between GDP changes and employment of tertiary-educated workers (aged 25 and older) is negative. Although not statistically significant, the magnitude of the negative correlation is even quite large: -0.3 in Belgium, Germany and Denmark. Finland, Netherlands and Sweden are three exceptions among Northern European countries: standard Okun's employment laws are observed for tertiary-educated employment. This may be explained by e.g. sectoral specializations of these middle-size countries (for example, the sharp decline of the giant Nokia in Finland).

By contrast, from France to Sweden and from Austria to the United Kingdom, the Okun's coefficient for low or middle-educated employment is systematically positive. It is statistically significant in Germany and Austria; the coefficient is also quite large in France, Belgium and Denmark. Recall that we restrict the sample to workers aged 25 and more. When we introduce younger workers, the adjustments are more marked in most of these countries, leading to a standard overall Okun's curve.

That is, for example, the case for the United Kingdom: no significant relation occurs for workers aged 25 and older during the 2005-2013 period, whereas it holds when young workers are included.

Table 4. Okun's Laws for employment by educational attainment.
Medium and large EU Countries 2005-2013
Equation in first differences with no lag.

Age	25 or more	25 or more	25 or more	16 or more
Educational attainment	**High**	**Medium-Low**	**Overall**	**Overall**
"Northern" EU				
Austria	-0.25 (0.19)	0.17*** (0.01)	0.08 (0.04)	0.12 (0.24)
Belgium	-0.33 (1.48)	0.33 (0.65)	0.06 (0.31)	0.24 (0.17)
Denmark	-0.30 (0.28)	0.24 (0.25)	0.13* (0.05)	0.11 (0.15)
France	-0.13 (0.13)	0.31 (0.19)	0.16 (0.15)	0.18 (0.22)
Germany	-0.29 (0.21)	0.26** (0.07)	0.10 (0.05)	0.26 (0.19)
United Kingdom	-0.05 (0.14)	0.12 (0.15)	0.04 (0.13)	0.17** (0.08)
Netherlands	*0.20 (0.09)*	*0.08 (0.18)*	*0.12 (0.13)*	*0.14 (0.10)*
Finland	*0.16*** (0.02)*	*0.14** (0.03)*	*0.15*** (0.01)*	*0.30* (0.18)*
Sweden	*0.13* (0.05)*	*0.12** (0.03)*	*0.11** (0.03)*	*0.45** (0.21)*
"Peripheral" Eurozone				
Greece	0.34*** (0.05)	0.42** (0.10)	0.39** (0.07)	0.44** (0.11)
Ireland	0.08 (0.11)	0.37** (0.10)	0.21*** (0.02)	0.27*** (0.10)
Italy	0.31 (0.49)	0.12 (0.13)	0.15 (0.09)	0.28* (0.15)
Spain	0.79*** (0.12)	1.44*** (0.17)	1.18*** (0.13)	1.35*** (0.22)
Portugal	*-0.13 (0.42)*	*0.58*** (0.09)*	*0.43* (0.14)*	*0.53*** (0.18)*
Eastern EU				
Bulgaria	0.14 (0.11)	0.31 (0.18)	0.26 (0.11)	0.65*** (0.21)
Latvia	0.70 (1.33)	0.51 (0.47)	0.56*** (0.09)	0.60*** (0.12)
Lithuania	0.17 (0.08)	0.30** (0.07)	0.25*** (0.03)	0.36*** (0.04)
Poland	0.27 (0.36)	0.63** (0.015)	0.49* (0.19)	0.62 (0.43)
Romania	0.20 (0.17)	0.18 (0.10)	0.18 (0.11)	0.40 (0.24)
Slovenia	0.28 (0.47)	0.11 (0.08)	0.16 (0.14)	0.47*** (0.16)
Croatia	*-0.25 (0.14)*	*0.74*** (0.11)*	*0.53** (0.11)*	*0.72** (0.31)*
Czech Republic	*-0.25 (0.41)*	*0.27** (0.06)*	*0.16* (0.06)*	*0.27** (0.11)*
Estonia	*-0.03 (0.24)*	*0.36*** (0.03)*	*0.24* (0.09)*	*0.28* (0.15)*
Slovak Republic	*-0.20*** (0.03)*	*0.32*** (0.05)*	*0.22*** (0.04)*	*0.29*** (0.03)*

Quarterly data (35 obs.). Robust standard errors. Clustered by quarter for workers aged 25 or more.
* statistically significant at 10%; ** at 5%; *** at 1%

2. Eurozone countries experiencing sovereign debt crisis and Eastern European countries

Contrary to Northern European countries, the correlation between GDP and employment of tertiary-educated workers is positive and quite large in Spain, Italy and Greece, ranging from 0.3 to 0.8. It is also positive in Ireland, but small. In this framework, Portugal seems a remarkable exception with a negative coefficient, although the estimation is particularly imprecise. In Ireland, Portugal, Spain and Greece, the correlations between GDP changes and employment of non-tertiary-educated workers aged 25 and more are particularly significant and large – up to 1.4. They are higher than the

estimated coefficient for tertiary-educated employment as well. In Italy, the employment of middle or low-educated workers (aged 25 or more) does not seem related to the quarterly change in GDP.

Despite some heterogeneity within the groups of countries, the contrast between the core and the periphery of the Eurozone is consistent with our argument that highly educated employment can be counter-cyclical when there is easy access to capital, but it ought to turn pro-cyclical if the access becomes tricky.

Among Eastern European countries, no clear patterns emerge. However, the estimated Okun's coefficients are generally higher for less educated workers. In Poland, the largest Eastern EU country and hence with a priori less noisy data, there are statistically significant positive relations between GDP and employment. The coefficient is roughly 0.3 for the tertiary-educated aged 25 or more, and 0.6 for middle or low-educated workers.

Conclusion and perspectives

Our empirical estimations for the US and Europe support that for most countries – including the US and most of the largest European economies – the macroeconomic aggregated Okun's Law conceals different Okun's laws according to the educational attainment of workers. In particular, the elasticity of employment or unemployment to GDP changes is in general lower for the highly educated. This result is consistent with our theoretical argument that part of the expense of highly educated workers represents long-term investment for firms and that their opportunity cost, relative to less educated workers, declines in a recession. Exploration by individual European countries also suggests that easy access to credit may protect this sort of investment in human capital.

Such results are an encouragement to introduce into macroeconomic models of the economy heterogeneous workers according to educational attainment. In addition, over the past decades, we have observed a spectacular educational catch-up in Europe[3] and a continuous improvement in the US. The share of the tertiary-educated in the workforce jumped in two decades in numerous European countries, including France and the United Kingdom. According to the annual EU-LFS, the tertiary-educated occupied roughly 20% of jobs in 1995 in the EU15; and by 2014, this proportion had risen to 34%. Such a dramatic increase may have altered the aggregated Okun's law and led to lower than expected adjustments of the workforce during the Great Recession. This change may therefore provide hints as to how to interpret some recent puzzling observations, including the productivity trends during the recession.

3 Due to numerous breaks in the data, we cannot exploit long-run annual series by education for European countries to run our regressions.

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Appendix

Table A. Descriptive statistics

United States

Variable	*Time*	*Nb. Obs*	*Mean*	*Std*	*Q1*	*Q3*
Growth of GDP, working day and seasonally adjusted, percent	1975q1-2015q1	161	0.69	0.78	0.35	1.10
Changes of employed population, seasonally adjusted, percent						
- 16 and above	1975q2-2015q1	160	0.35	0.49	0.08	0.60
- 25 and above, all qualifications	1975q2-2015q1	160	0.42	0.46	0.16	0.65
- 25 and above, high qualification	1992q2-2015q1	92	0.68	0.67	0.36	1.08
- 25 and above, medium-low qualification	1992q2-2015q1	92	0.10	0.52	-0.17	0.43
Changes of the unemployment rate, seasonally adjusted, percentage points						
- 16 and above	1975q2-2015q1	160	-0.02	0.33	-0.20	0.10
- 25 and above, all qualifications	1975q2-2015q1	160	-0.01	0.30	-0.20	0.10
- 25 and above, high qualification	1992q2-2015q1	92	0.00	0.21	-0.10	0.10
- 25 and above, medium-low qualification	1992q2-2015q1	92	-0.02	0.62	-0.36	0.14

European Union 15

Variable	*Time*	*Nb. Obs*	*Mean*	*Std*	*Q1*	*Q3*
Growth of GDP, working day and seasonally adjusted, percent	1998q1-2014q4	69	0.34	0.62	0.20	0.66
Changes of employed population, percent						
- All population, seasonally adjusted	1998q2-2014q4	67	0.20	0.70	-0.30	0.80
- 25 and above, all qualifications	2005q2-2013q4	35	0.14	0.62	-0.21	0.53
- 25 and above, high qualification	2005q2-2013q4	35	0.76	0.74	0.23	1.32
- 25 and above, medium-low qualification	2005q2-2013q4	35	-0.15	0.72	-0.56	0.43
Changes of the unemployment rate, percentage points						
- All population, seasonally adjusted	1998q2-2014q4	67	0.01	0.21	-0.20	0.10
- 25 and above, all qualifications	2005q2-2013q4	35	0.06	0.42	-0.30	0.30
- 25 and above, high qualification	2005q2-2013q4	35	0.04	0.22	-0.10	0.20
- 25 and above, medium-low qualification	2005q2-2013q4	35	0.09	0.56	-0.40	0.45

Pooled Europe: Austria, Belgium, Bulgaria, Croatia, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Latvia, Lithuania, Netherlands, Poland, Portugal, Romania, Slovak Republic, Slovenia, Spain, Sweden, United Kingdom

Variable	*Time*	*Nb. Obs*	*Mean*	*Std*	*Q1*	*Q3*
Growth of GDP, working day and seasonally adjusted, percent	1998q1-2014q4 *with gaps*	1,557	0.51	1.34	0.02	1.10
Changes of employed population, percent						
- All population, seasonally adjusted	1998q2-2014q4	1,490	0.13	1.86	-0.79	1.06
- 25 and above, all qualifications	2005q2-2013q4	833	0.10	1.50	-0.59	0.92
- 25 and above, high qualification	2005q2-2013q4	833	0.87	2.71	-0.25	1.99
- 25 and above, medium-low qualification	2005q2-2013q4	833	-0.22	2.06	-1.14	0.86
Changes of the unemployment rate, percentage points						
- All population, seasonally adjusted	1998q2-2014q4	1,582	0.01	0.53	-0.30	0.20
- 25 and above, all qualifications	2005q2-2013q4	833	0.05	0.77	-0.40	0.40
- 25 and above, high qualification	2005q2-2013q4	820	0.06	0.63	-0.30	0.40
- 25 and above, medium-low qualification	2005q2-2013q4	815	0.08	1.00	-0.52	0.56

Table B. Standard Okun's law for total unemployment in Europe and the US

Equation in first differences with no lag

	US		EU 15		Pooled Europe	
Time	*1975q2-2015q1*	*1992q2-2015q2*	*1998q2-2013q4*	*2005q1-2013q4*	*1998q2-2013q4*	*2005q1-2013q4*
β_0	-0.27***	-0.25***	-0.27***	-0.24***	-0.18***	-0.19***
	(0.04)	(0.07)	(0.02)	(0.04)	(0.01)	(0.02)
Age	16 +	25 +	All	25 +	All	25 +
Seasonally adjusted	Yes	Yes	Yes	No	Yes	No
Cluster quarter-country	No	No	No	Yes	No	Yes
Adj. R^2	0.4030	0.2865	0.6155	0.8809	0.2095	0.4935
Nb. Obs	160	92	67	35	1,538	833

Quarterly data. Robust standard errors. Clustered by quarter-country for EU15 and pooled Europe.

Pooled Europe: see Table 1a.

* statistically significant at 10%; ** at 5%; *** at 1%

Equation in first differences with two lags

	US		EU 15		Pooled Europe	
Time	*1975q2-2015q1*	*1992q2-2015q2*	*1998q2-2013q4*	*2005q1-2013q4*	*1998q2-2013q4*	*2005q1-2013q4*
β_0	-0.21***	-0.14***	-0.16***	-0.15**	-0.11***	-0.12***
	(0.03)	(0.05)	(0.02)	(0.04)	(0.01)	(0.02)
β_1	-0.12***	-0.16***	-0.11***	-0.11**	-0.12***	-0.11***
	(0.03)	(0.05)	(0.02)	(0.03)	(0.01)	(0.01)
β_2	-0.09***	-0.13***	-0.07***	-0.03	-0.09***	-0.09***
	(0.03)	(0.04)	(0.02)	(0.01)	(0.01)	(0.02)
$\beta_0 + \beta_1 + \beta_2$	-0.42***	-0.43***	-0.34***	-0.29***	-0.32***	-0.31***
	(0.04)	(0.06)	(0.01)	(0.03)	(0.02)	(0.03)
Age	16 +	25 +	All	25 +	All	25 +
Seasonally adjusted	Yes	Yes	Yes	No	Yes	No
Cluster quarter-country	No	No	No	Yes	No	Yes
Adj. R^2	0.5785	0.5073	0.7581	0.9102	0.3834	0.5854
Nb. Obs	159	92	66	35	1,509	831

Quarterly data. Robust standard errors. Clustered by quarter-country for EU15 and pooled Europe.

Pooled Europe: see Table 1a.

* statistically significant at 10%; ** at 5%; *** at 1%