Differences in Unemployment by Educational Attainment in the US and Europe: What Role for Skill-Bias Technological Change and Institutions?

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Abstract

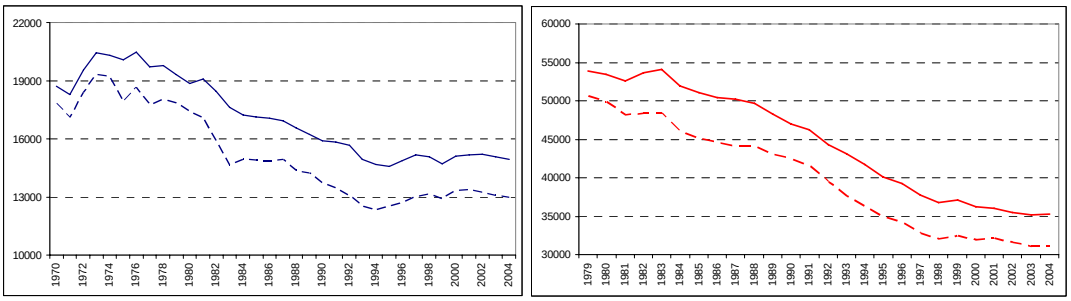
This study is about differences in unemployment rate by educational attainment between the US and Europe over the past three decades. Apart from usual explanatory variables, like wage differentials between educational groups in the two regions, specific attention will be given to complementarities between capital and skilled labour. Increasing capital stock raises skilled wages more than unskilled wages, i.e. raises demand for skilled workers and hence leads to a relative fall in unemployment among high skilled. We find that this skilled biased technology effect is larger in the US than in Europe. European institutions favour wage equality but these also imply less incentives to migrate to higher education classes. This has a depressing effect on skilled labour supply. This means there is less mobility in the European labour market compared to the US, not just from a spatial but also from an educational perspective.

1. Introduction

The past three decades demand for low skilled labour has steadily been decreasing throughout Europe and in the US. The same is true for labour supply of low skilled, because of the increase in further and higher education. Figures 1 and 2 show the patterns of demand for low educated workers (dashed lines) and their supply (solid lines), for the US and Europe, respectively.[1] A number of phenomena in figures 1 and 2 catches the eye. First, low educated labour demand and supply in both Europe and the US have a declining trend. In the 25 years between 1979 and 2004 employment of low educated dropped almost 40% in both regions. Second, this demand really started to tumble down during and after the severe recession of the early 1980's. This has been documented by e.g. OECD (1987,1989), Berman et al. (1994), Nickell and Bell (1995,1996) and references therein.

Figure 1/2. Supply of (solid line) and demand for (dashed line) low educated workers, aged 16 and over

USA **Europe (EU-5)**



Source: own calculation based on BLS, ILO, OECD, SBA, INSEE, ONS, ISTAT, CBS

Furthermore, this fall in demand for low skilled labour has been larger than the fall in low skilled supply. This means that, at both sides of the Atlantic, unemployment among the low educated has increased. At the same time, both demand for and supply of higher educated labour has risen (not shown here). Also for this group demand fell short of supply, so the unemployment among the high educated has increased as well the past decades.

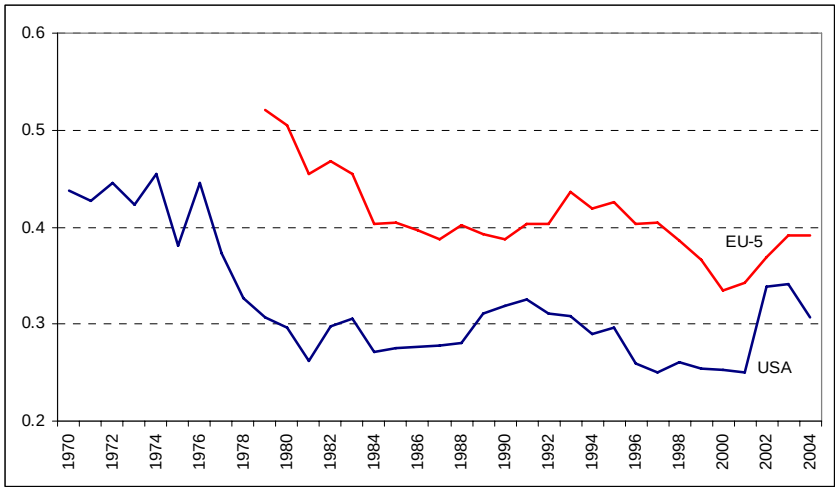
The ratio between high and low educated unemployment rates in figure 3 shows which one of the two has increased most: low or high educated unemployment. Initially, this ratio fell sharply in both Europe and the US. Hence, in both regions low educated unemployment rates increased stronger than those of high educated. Next, the ratio stabilised, between say 1980 and 1995, in Europe at roughly 0.4 and at 0.3 in the US. So in that period low and high educated unemployment rates changed very much in the same way. Thereafter the ratio fell again, but fluctuated substantially. The overall level of the ratio is approximately 10% higher in Europe than in the US, but the time pattern of Europe does resemble that of the USA with a lag of about three years. This higher ratio in Europe is due to the fact that here unemployment rates for low educated are below their US counterparts.[2]

[1] Europe represented by Germany, France, UK, Italy and The Netherlands, together comprising 75% of Europe's labour force and GDP. These countries have sufficiently long time series available.

[2] This contradicts common belief that rigid wages in Europe cause high unemployment, particularly among lower skilled, whereas US wages are much more flexible creating more jobs for the unskilled so a lower unemployment rate of low educated would be more in order. One reasons for this phenomenon is the fact that ratio of unemployment rates in figure 1 is based on the age group of 16-75 years. Hence, unemployment of high

Figure 3 also shows that in recession periods unemployment for higher educated increases stronger than that for low educated, so there is a rising ratio. The subsequent recovery periods are characterised by a relatively stronger fall in unemployment for higher educated than for low educated, i.e. a falling ratio.

Figure 3. Ratio of high vs. low educated unemployment rates in Europe and the USA

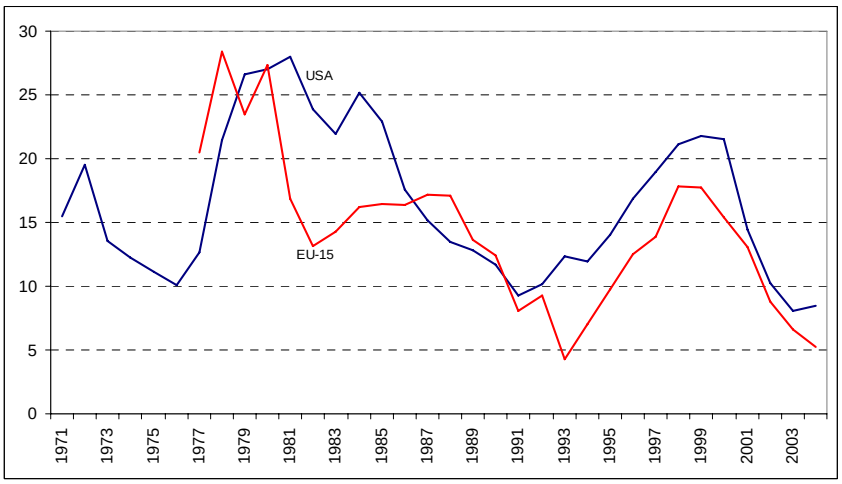


Source: own calculation based on BLS, ILO, OECD, SBA, INSEE, ONS, ISTAT, CBS

The downward trend of the unemployment ratio of figure 3 is thus strongly related to the fall in demand for low skilled workers of figures 1 and 2. This phenomenon is usually explained by increases in technological change or by the rise in international competition and globalisation. The latter has led to outsourcing (off-shoring) of much of the industrialised world's labour intensive, low skilled production to low-wage countries. See Berman et al. (1998). On the other hand, new technology has increased the use of advanced capital equipment for which high skills are required, but which replaced low skilled labour. The annual growth rates of advanced capital, represented by ICT capital services in figure 4, corroborate that periods of rising ICT capital growth, i.e. late 1970's/early 1980's and the 1990's, correspond to periods of a falling unemployment ratio in figure 3, i.e. falling demand for low skilled labour. See also Feenstra and Hanson (1999).

educated is understated relative to that of low educated, because many young persons are still in the (higher) education instead of looking for work. This is maybe more the case in the US than in Europe. More in-depth analysis on this issue is beyond the scope of this paper.

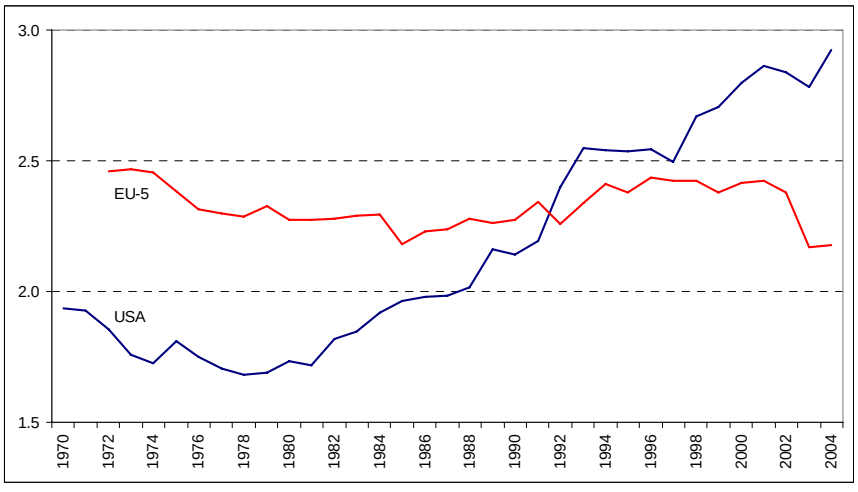
Figure 4. Percentage growth of volume of ICT-capital services, USA and Europe



Source: own calculation based on EUKLEMS Data Base

This is known as skilled biased technological change (sbtc). It not only is a major cause for the fall in low skilled labour demand, but also shifted demand from less skilled, or less educated, to higher skilled (higher educated) workers. In its turn, this has a depressing effect on the wages of less skilled labour, compared to skilled wages. At the same time, despite this increase in the relative costs of skilled labour, the demand for skilled labour still increased, i.e. the unemployment ratio fell. This wage effect of sbtc has been particularly strong in the USA, while in Europe it was much weaker. Figure 5 gives the time pattern of the US and European ratio of the wage rate of high to low educated workers between 1970 and 2004. For the US it is clear that this ratio has been declining between 1970 and 1980, after which it started its ascend. In 2004 the high educated wage rate was about 3 times larger than that of low educated, against 1.7 in 1980. The European ratio of high to low educated wage rates also has this U-shaped pattern, but much less pronounced. See Krusell et al. (2000), Hornstein et al. (2004), Linquist (2005) for empirical support of sbtc in various countries.

Figure 5. Ratio of hourly wages of high vs. low educated workers, USA and Europe



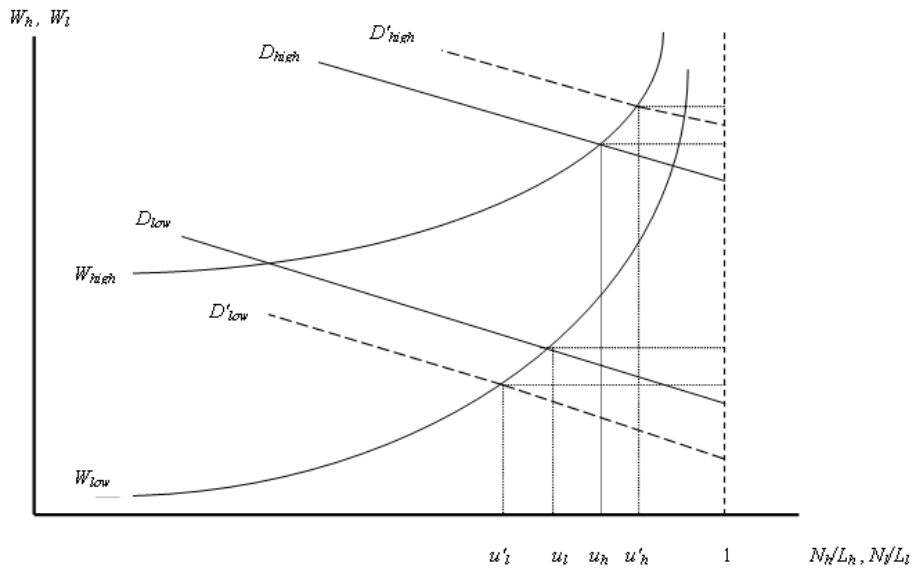
Source: own calculations based on EUKLEMS Data Base

This paper aims to explain the changing pattern of the unemployment ratio by education. This ratio will be analysed using the ingredients of the sbtc-hypothesis and institutions in Europe and the USA. This paper is organised as follows. In section 2 the fall in low skilled labour demand and the subsequent rise in demand and supply for high skilled labour will be addressed from a theoretical perspective. Section 3 describes model specification and section 4 is about the data. Section 5 shows the results of the empirical analysis and provides an interpretation. Finally section 6 concludes.

2. Shifts in labour demand and supply by education

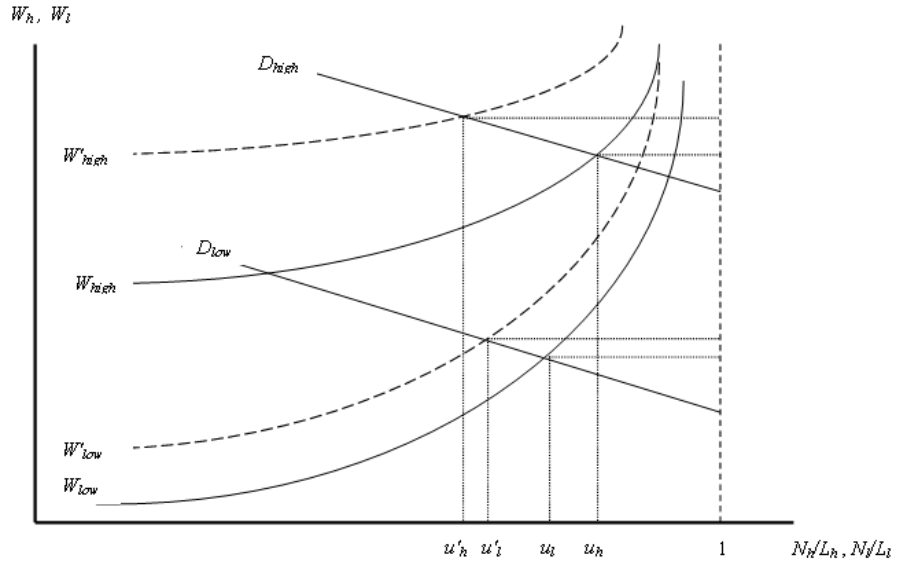
The connection between on the one hand the documented fall in low skilled labour demand of figure 1 and 2 and the falling ratio of high to low educated unemployment rates (of figure 3) can be made clear in figure 6. This figure shows a theoretical diagram of labour demand and supply by education. The lines *D* representing labour demand by education, where subscript *high* refers to high education and *low* to low education, are downward sloping in the wage rate by education. The wage rates by education are themselves represented by upward sloping curves in the employment rate. Wage rates for higher educated are higher than those for low educated workers.

Figure 6. A relative labour demand shift: falling demand for low educated workers, higher demand for high educated workers



The relative demand shock causes D_{high} to rise to D'_{high} and D_{low} to fall to D'_{low}. The high educated unemployment rate falls from u_h to u'_h and that for low educated rises from u_l to u'_l. The wages move in opposite directions, high educated wages rise, while those of low educated fall. Hence, the relative shift in labour demand corresponds to a falling ratio of high to low educated unemployment rates. When the supply of labour, represented by the wage curves of figure 6, with a high education rises stronger than that of low educated workers, the opposite occurs, as figure 7 shows. Now wages for low educated rise only slightly, against the strong increase in wages for high educated workers (i.e. wage inequality increases). In this case, the unemployment rate for high educated workers rises much stronger than that of low educated ones an the unemployment ratio will rise.

Figure 7. A relative labour supply shift: relative falling supply of low educated workers, higher supply of high educated workers



This means that in case of a combination of the two shifts it depends on the wage elasticity of demand and supply, how the unemployment ratio will react to these shifts. If wages are relatively more inelastic to supply than to demand, the effects of the demand sift dominate, so the combined shifts are more likely to cause a falling unemployment ratio. If on the other hand wages are more inelastic to demand, the supply shift dominates and the unemployment ratio will increase.

However, when the wage of low educated is more inelastic with respect to supply than that of the high educated, for example because their reservation wage is closer to the benefit level than that for the high educated, a shift in labour supply will largely leave the low educated unemployment rate unaffected, while the same shift does influence high educated unemployment. This will cause a falling unemployment rate. The increase in the ratio, caused by inelastic labour supply in general is mitigated by differences in elasticity of labour supply by education. A similar argument holds for elasticity of high versus low educated labour demand.

Differences in supply (or demand) elasticity by level of education are linked to the institutional setting in which the local labour market operates. High or low educated persons react differently to shocks to the labour market, depending on benefit level, benefit duration, or employment protection.

3. Model specification

This paper attempts to get an explanation for the time pattern of the ratio of high to low unemployment rates and assess the differences between Europe and the US. In order to obtain the specification of a model of this ratio, we move back to the two building blocks of labour demand and labour supply by education. Labour demand follows from the production function of the firm. Following Krusell et al. (2000), we assume that output y is generated by capital and labour inputs, labelled k and h, where the latter is divided between hours worked by high educated workers and

hours worked by low educated. Capital and low educated labour are assumed to be perfect substitutes and have unit substitution elasticity with high educated labour, or

$$y = (k + h_{low})^{\theta} h_{high}^{1-\theta} \tag{1}$$

The marginal product of labour by education determines labour demand by education. The ratio of this marginal product equals

$$\left(\frac{\partial y / \partial h_{high}}{\partial y / \partial h_{low}} \right) = \left(\frac{1-\theta}{\theta} \right) \left(\frac{k + h_{low}}{h_{high}} \right) \tag{2}$$

Given the firm aims at profit maximisation, the ratio of labour demand *D* by education can be specified in general terms as

$$\frac{D_{high}}{D_{low}} = f\left(\frac{k}{h_{high}}, \frac{h_{high}}{h_{low}}, \frac{w_{high}}{w_{low}}, \ldots \right) \tag{3}$$

where *w* represents the wage rate by education and institutional setting, like the system of taxes, social security and the like, also have an effect on labour demand.

Labour supply is determined by utility of the workers. A simple function, in which income determines utility, gives a general specification of labour supply

$$\Omega = \left(w_{high} h_{high} \right)^{\mu} \left(w_{low} h_{low} \right)^{1-\mu} \tag{4}$$

in which case the ratio of supply of marginal utility determines labour supply of high versus low educated workers, or

$$\left(\frac{\partial \Omega / \partial h_{high}}{\partial \Omega / \partial h_{low}} \right) = \left(\frac{\mu}{1-\mu} \right) \left(\frac{w_{low}}{w_{high}} \right) \tag{5}$$

Utility maximisation combined with a budget restriction gives a general specification of labour supply *S* by education

$$\frac{S_{high}}{S_{low}} = g\left(\frac{w_{high}}{w_{low}}, \ldots \right) \tag{6}$$

Our aim is to evaluate the ratio of high to low educated unemployment, i.e. the difference between equation (6) and (3). This means that we will use the following explanatory variables:

1. ICT capital - skilled labour ratio. It shows whether ICT capital, representing advanced capital equipment, is indeed complementary to high educated labour. If it is then a rise in this variable (i.e. increasing ICT investments) will lead to less high educated unemployed compared those with a low education, so the unemployment ratio will fall.
2. Ratio of hours worked by high versus low educated workers. This variable merely reflects the possible shift in labour demand and supply from low to high skilled.
3. Ratio of wage rates of high versus low educated workers. It reflects the magnitude of the reaction of labour demand and supply to a shift in this wage ratio. A negative relation implies labour demand is dominant, while the opposite holds for labour supply.

In addition, we also include a number of variables reflecting the institutional setting of the labour markets in Europe and the US. The impact of the variables is difficult to assess beforehand, as we need to know whether they specifically affect high or low educated workers.

4. Employment protection legislation (epl). The usual argument is that the harder it gets to fire redundant workers (high epl), the higher unemployment, because hiring out of unemployment will be low. However, at the same time one can argue that the inflow of layoffs into unemployment is also low. The net unemployment result is hence ambiguous. What the impact on unemployment by different educational attainment will be is even more difficult to assess.
5. Benefit replacement ratio (brr). The higher the replacement ratio, i.e. the benefit-wage ratio, the less job search will be and hence the higher unemployment. Whether this is specific for low or high educated unemployed remains to be seen. Benefit duration (bd). Longer benefit durations slow down search effort and lead to higher unemployment.

Given our limited dataset (see below) our model specification will be kept simple. Based on a log-linear specification, we start with the following specification for both the USA and the EU-5.

$$\log\left(\frac{u_{high}}{u_{low}}\right)_{t,r} = \alpha_0 + \alpha_1 \log\left(\frac{k_{ICT}}{h_{high}}\right)_{t,r} + \alpha_2 \log\left(\frac{h_{high}}{h_{low}}\right)_{t,r} + \alpha_3 \log\left(\frac{w_{high}}{w_{low}}\right)_{t,r} + \\ + \alpha_4 \log(epl)_{t,r} + \alpha_5 \log(brr)_{t,r} + \alpha_6 \log(bd)_{t,r} \qquad (7)$$

where index *t* refers to time and *r* to the region involved (US or EU-5). Basically equation (7) tests for three possibilities to explain the ratio of unemployment by education: (i) differences in skill biased technological change; (ii) differences in the impact of wages on unemployment; (iii) differences in institutions.

4. Data

The data we use for estimating the various forms of equation (7) are described in more detail in Appendix 1. The unemployment by level of education has been compiled from different sources. The key source is the ILO Labour Statistics Database, which provides unemployment and labour force statistics by gender and educational attainment. Individual country sources were used to extend the series to cover the period 1970-2004.

The EUKLEMS database is the major source for the non-institutional explanatory variables. It contains data on a large number of European and other industrial countries on ICT capital, hours worked by educational attainment, employee labour compensation by educational attainment and so on for the period 1970-2004.

The institutional variables, employment protection, benefit replacement ratio and benefit duration are all drawn from Nickell (2001) covering the period 1960-2001. They have been updated using data from the OECD on benefit duration and the others have been updated using international comparable data from Statistics Netherlands.

5. Empirical results

Next, equation (7) is the basis for explaining differences in the unemployment ratio in the US and Europe (EU-5) separately, covering the period 1970-2004. At a later stage (7) also serves as a starting point for an analysis of the six countries under consideration pooled together. The advantage of pooling series is that the number of observations increases substantially and make the estimation results more reliable. Finally, in an attempt to evade possible simultaneity between the ratio's of unemployment and wage rate, (7) is seen as an equation of a system in which it is estimated simultaneously with a wage equation. For each of these relationships, we will assess the differences between the US and the European countries.

5.1. US vs. Europe

An assessment of the differences in estimation results of (7) for the US and Europe has to be based on a relatively short time span, 1970-2004. This implies that application of unit root tests becomes highly unreliable, since unit root test are known to have low size and power properties in the case of small samples. The various ratio's of high to low educated of the explanatory variables in (7) are likely rising implying a positive time trend. Figure 3 shows that the dependent variable for both regions has an overall negative trend. Only at the end the ratio is again increasing. The wage ratio of figure 5 also shows a U-shaped pattern. A quadratic time trend is be added to equation (7) to account for these patterns.

Another problem that has to be dealt with, related to the relatively short sample, is the fact that the explanatory variable are likely to be correlated. The correlation matrix for the variables involved in (7) for both the US and the EU-5 shows particularly high correlations between the capital-skill ratio and the ratio of hours worked by education. In Europe there is also a high correlation between the institutional variables and for the US between the capital-skill and the wage ratio. Appendix 2 shows these correlation matrices. In order to evade problems of multicollinearity, entering these mutually correlated variables simultaneously in a model should be judged with care.

Table 1 shows the estimation results for both areas of equation (7). Due to the above discussed multicollinearity, the hours ratio will be skipped. The estimation results show that in both Europe and the USA the capital-skill ratio has had a strong effect on the ratio of high to low educated unemployment. This effect has been stronger in Europe, with an elasticity of -1.1, than in the US (elasticity of -0.4).

Table 1. Estimation results of equation (7) for the USA and Europe (EU-5)

	USA general	USA simplified	Europe general	Europe simplified	Europe US lag 3
Intercept	-1.64	-1.84	0.35	0.75	0.11
	(-4.41)	(-10.68)	(1.09)	(3.33)	(0.37)
$\log\left(\frac{k_{ICT}}{h_{high}}\right)$	-0.39	-0.42	-0.88	-1.11	-0.16
	(-3.13)	(-9.10)	(-5.81)	(-8.28)	(-3.13)
$\log\left(\frac{w_{high}}{w_{low}}\right)$	0.05		-0.09	-0.38	-0.19
	(0.16)		(-0.26)	(-1.83)	(-0.67)
$\log(epl)$			-0.53		
			(-1.39)		
$\log(brr)$	-0.35	-0.40	0.51	0.36	0.11
	(-1.90)	(-3.12)	(2.63)	(3.83)	(0.57)
$\log(bd)$	0.08		-0.26		
	(0.59)		(-1.29)		
time	-0.21		6.07	5.94	
	(-0.12)		(3.76)	(6.23)	
$(\text{time})^2$	0.13	0.14	-0.05		
	(4.22)	(8.66)	(-1.28)		
$\log\left(\frac{u_{high}}{u_{low}}\right)_{t-3,USA}$					0.35
					(3.18)
Adjusted R^2	0.69	0.72	0.90	0.90	0.80
N	35	35	26	26	26
DW	1.46	1.45	1.77	1.74	1.62
JB	0.97	1.35	0.22	0.92	1.69

Note: heteroscedasticity consistent (White) *t*-statistics between parentheses. Both linear and quadratic time trend have been scaled by 0.01 to yield comparably sized coefficients as the other variables.

A 1%-point rise in the ratio of ICT capital to high educated labour has a more depressing effect on the unemployment ratio of high to low educated in Europe than in the US. Given demand for high educated workers, such an impulse would lead to a larger drop in US low educated demand than in Europe. This implies a stronger rise in low educated unemployment in the US and thus a smaller increase in the unemployment ratio than in Europe. Given the larger increase in US ICT capital (figure 2) and stronger response to low educated unemployment in the US to such an increase, leads us to conclude that skilled biased technological change has been more pronounced in the US than in Europe. Lagging skill biased technological change in Europe caused a relative rise in high educated unemployment.

There is no impact of the US wage ratio to the unemployment ratio. A different growth rate of US high skilled versus unskilled wages has a similar impact on US unemployment for both groups. Hence, a smaller wage rise for low educated compared to higher educated, leads in the US to a similar rise in labour supply. Low educated labour supply is hence more elastic than high educated supply. In Europe, on the other hand, a rise in wage inequality does have a weak (negative) effect on the unemployment ratio. Here, a smaller wage rise for low educated compared to high educated leads to more low educated labour supply than that of high educated. Hence, labour supply of low educated in Europe is even more elastic than in the US, while labour supply of high educated is likely less elastic in Europe than in the US.

In both regions the benefit replacement rate has a significant impact on the unemployment ratio. In the US a rise in the replacement rate, lowers the unemployment ratio, while in Europe it raises the ratio. Hence, in the US the search effort of low educated unemployed falls more from an overall rise in the replacement rate than that of the high educated. In Europe, on the other hand, a rise in the replacement rate leads to relatively less search effort of the high educated unemployed.

Finally, we check the premise made in the introduction that the European pattern of the unemployment ratio is merely a lagged (and 10% higher) version of the US pattern in the final column of table 1. It shows the extent to which the American explanation for the unemployment ratio also holds for Europe with a 3 year lag. The intercept of this specification shows that indeed the European level is 0.11 (11%) higher than in the USA and furthermore only the European capital-skill ratio significantly adds to the US explanation of the European unemployment ratio. The effect of capital-skill complementarities on the unemployment ratio is larger in Europe than in the US.

Hence, a 1%-point rise in the ratio of ICT capital and high educated labour has a more depressing effect on the unemployment ratio of high to low educated in Europe than in the US. Therefore, in the US such an impulse leads to a larger drop in demand for low educated than in Europe, which implies a stronger rise in low educated unemployment and thus less of an increase in the unemployment ratio. Hence, skill biased technological change has been more of an issue in the US than in Europe. Looking at the supply of low educated, the rise in US wage inequality (figure 3) has had no effect on the unemployment ratio, while the more flat European wage ratio did. Hence, US supply of low educated workers is more inelastic than that in Europe. The combination with a generous benefit system may have added to this European problem, by a relatively strong adverse effect on the search behaviour of the high educated.

5.2. Pooled time series

Equation (7) will also be estimated based on pooling data information of the six individual countries (USA, Germany, France, UK, Netherlands and Italy). This will provide a larger number of observations for estimation and hence more reliable inference. Differences between the US and Europe, however, are less easier to make. Using pooled time series, equation (7) will be extended with country fixed effects. In addition, (7) will be estimated using weighted least squares, using country weights to take account of the differences in size. Period fixed effects cannot be included in the model, which is why we have included a time trend. This way the estimated coefficients of (7) represent the average effects over all six countries of changes in the explanatory variables to the unemployment ratio. The country fixed effects in the model reveal the country-specific effect to these explanatory variables in the explanation of the country-specific unemployment ratio.

Table 2 shows the estimation results of this pooled estimation exercise. Notice the trend variable is now no longer significant. The overall effect of the capital-skill ratio is, as before, negative, but small. Still it indicates that lagging skill biased technological change leads to a relative rise in high educated unemployment. The benefit replacement rate has a negative impact. The more generous the benefit level, relative to wage income, the lower the unemployment ratio. Hence, the higher the benefits, the less search effort low educated unemployed will entail, compared to high educated. The effect of the wage rate is now however no longer significant. The country fixed effects in combination with the intercept term shows how country specifics influence the unemployment ratio. Table 3 shows the estimated fixed effect coefficients. Those of the USA and the UK clearly have the largest negative values. Here, country specifics imply a lower ratio, i.e. more search effort (or outflow) of the high educated unemployed relative to the low educated. For a number of European countries, notably Italy and The Netherlands, this is just the other way around.

Table 2. Estimation results of equation (7) for pooled data of the six countries, 1970-2004 with weighted least squares (country weights) and country fixed effects included

	Equation (7) based on pooled data all six countries	
	general	Simplified
Intercept	-0.97 (-11.9)	-0.94 (-21.9)
$\log\left(\frac{k_{ICT}}{h_{high}}\right)$	-0.08 (-3.67)	-0.08 (-4.51)
$\log\left(\frac{w_{high}}{w_{low}}\right)$	0.33 (0.39)	
log(*epl*)	0.06 (0.43)	
log(*brr*)	-0.16 (-2.29)	-0.21 (-5.03)
log(*bd*)	-0.05 (-1.03)	
time	-0.01 (-0.01)	
Adjusted R^2	0.82	0.82
N	181	181
Note: heteroscedasticity consistent (White) *t*-statistics between parentheses. F-tests on omitting country fixed effects not accepted at 5%		

Table 3. Country fixed effects of table 2

Country	fixed effect
USA	-0.34
Germany	-0.09
France	0.06
UK	-0.52
Netherlands	0.24
Italy	0.49

5.3. System of equations

In order to avoid possible simultaneity between unemployment and wages, we also do a system estimation based on equation (7) and an equation of the wage ratio. This wage equation is specified in growth rates, because in this wage ratio the presence of a unit root cannot be rejected. Both the wage growth and unemployment equation contain country fixed effects, but only the unemployment equation comprises the explanatory variables of (7). Adding a time trend correlates highly to the capital-skill ratio, so this is not included here.

Table 4. Estimation of system of wage growth ratio and equation (7) for pooled data of the six countries, 1970-2004

	wage growth ratio general	unemployment ratio	wage growth ratio simplified	unemployment ratio
Intercept	0.028	-0.694	0.027	-0.473
	(1.566)	(-1.650)	(1.638)	(-2.938)
$\log\left(\frac{u_{high}}{u_{low}}\right)$	-0.075		-0.075	
	(-2.735)		(-2.831)	
$\log\left(\frac{k_{ICT}}{h_{high}}\right)$		-0.087		-0.083
		(-3.397)		(-3.943)
$\log\left(\frac{w_{high}}{w_{low}}\right)$		0.139		
		(0.721)		
$\log(epl)$		0.069		
		(0.283)		
$\log(brr)$		-0.182		-0.218
		(-4.219)		(-5.407)
$\log(bd)$		-0.053		
		(-0.677)		
Adjusted R^2	0.067	0.705	0.072	0.710
N	178	178	178	178

Note: system is estimated with FIML. Country fixed effects in both equations are all significantly different from zero.

Table 5. Country fixed effects of table 4, relative to Italy

Country	wage growth	unemployment
USA	-0.10	-0.83
Germany	-0.08	-0.39
France	-0.09	-0.42
UK	-0.11	-1.01
Netherlands	-0.11	-0.22

Note that the estimation results of (7) as a single pooled equation in table 2 are very much the same as that of the systems' unemployment ratio. Simultaneity between wages and unemployment does in this case not have a large effect on the estimation results. The country specific effects on the unemployment ratio in table 5 also have the same pattern as before.

5.4. Interpretation of the results

We find that capital-skill complementarities, represented by the ratio of ICT capital and hours worked by high educated workers and the benefit replacement rate are most important in determining the pattern of the ratio of high to low educated unemployment rates. Table 6 shows the contribution that of each of the explanatory variables makes to the explanation of the variation in the unemployment ratio in each of the model specifications of table 1.

Table 6. Percentage contribution to the explained variation of the dependent variable of the simplified models of table 1

	Europe	Europe as lagged US	US
$\log\left(\frac{k_{ICT}}{h_{high}}\right)$	55.7	32.9	32.1
$\log\left(\frac{w_{high}}{w_{low}}\right)$	8.5	17.4	
log(*brr*)	9.1	11.4	32.6
$\log\left(\frac{u_{high}}{u_{low}}\right)_{t-3,USA}$		38.3	
time	26.7		
$(\text{time})^2$			35.3

We can conclude from table 6 that both in Europe and the US capital-skill complementarities have a large effect on the changing pattern of the high to low educated unemployment ratio. In the US they account for one third of the explained unemployment ratio, while in Europe their impact is well over 50%. The contribution of the replacement rate is also substantial, particularly in the US. The extent of wage inequality, represented by the ratio of wage rates of high to low educated employees, only contributes in Europe. In fact the European time pattern of the unemployment ratio by education is for about 40% explained by the three year lagged pattern in the US.

In the models based on pooled data, the same explanatory variables are important. Because the time series are pooled over all six countries, we loose the specific separate information about the US and Europe. The coefficient values, and hence their contribution to explaining the pooled unemployment ratio, are based on the (weighted) average of the individual countries and are therefore not comparable to the ones of table 6.

The interpretation of the ratio of ICT capital to hours worked by high educated can clearly be seen as a way of representing capital-skill complementarities. Skilled biased technological change (sbtc) provides a larger contribution to the explanation of the European unemployment ratio of high to low educated. This does not mean that sbtc it is a more important issue in Europe. The relatively high European sbtc-elasticity implies that a shock in the ratio of ICT capital to high educated labour has a more depressing effect on the unemployment ratio in Europe than in the US. Therefore, in the US such an impulse leads to a larger drop in demand for low educated than in Europe, which implies a stronger rise in low educated unemployment and thus less of an increase in the unemployment ratio. Hence, skill biased technological change has been more of an issue in the US than in Europe.

The benefit replacement ratio has an opposite effect in Europe compared to the US. In the US a rise in the replacement rate, lowers the unemployment ratio, while in Europe it raises the ratio. This can be interpreted as that in the US the search effort of low educated unemployed falls more from an overall rise in the replacement rate than that of the high educated. In Europe, on the other hand, a rise in the replacement rate leads to relatively less search effort of the high educated unemployed. Less effort of the high educated hampers the progress to be achieved by sbtc, because they are essential in operating advanced new (unskilled labour replacing) capital. This is more of a problem in Europe than in the US.

Finally, we find in our separate models that the ratio of high to low educated wage rates, only has an effect in Europe but not in the US. Wage changes – as changes in the price of labour – are much more in agreement with an efficient operation of the labour market in Europe than in the US, where there is no effect at all. This seems contrary to the premise that US markets are more efficient, i.e. work more freely, than European. However looking at the wage ratio itself, the European flat pattern (cf. figure 5) points towards a small wage inequality. Given differences in demand and supply of low and high educated labour a fixed wage ratio points towards similar wage adjustments for both education groups, or less flexibility.

To consolidate both views, we have to look at the migration from low to high education. Large wage differentials in the US may have caused a lot of migration from low to high education classes. The small differentials in Europe imply less incentives to move to higher education classes. There was, in other words, a substantial reservoir of long term, low educated unemployed in Europe who benefited from the economic upsurge of the late 1990's. The flat wage ratio in Europe might on the other hand not just be caused by a relatively high wage rate for low educated workers, but more by wages for high educated workers lagging behind. This also explains why supply of high educated workers lags in Europe and migration to move to higher education classes is low. Hence, Europe is not so much suffering from inflexibility on the labour market, but inflexibility on the education market combined with a high sense of wage solidarity between low and high educated workers.

6. Concluding remarks

We have distinguished the difference in effects of skilled biased technological change in Europe and the US on the ratio or high to low unemployment rates. Using long time series for six major industrialised countries (USA, Germany, France, UK, Italy, Netherlands), we found that the effect of sbtc is larger in the USA than in Europe, thereby explaining a large proportion in the difference of high to low educated unemployment rates. Also institutional differences, primarily differences in the benefit replacement rate between the countries, explain a substantial part of the unemployment ratio.

Apart from differences in sbtc, the labour market in both areas also differs with respect to the extent of wage inequality. Increasing wage US inequality implies more incentives to move to higher education classes. The fact that there is no sing of rising European inequality indicates wage solidarity, maybe union induced, between low and high education. But this solidarity in turn leads to less incentives to migrate to higher education classes and hence has a depressing effect on high educated labour supply. Given the stronger sbtc-effect in the US the demand for high educated workers would also have been lower in Europe. The growing awareness of skilled biased technological change has thus also brought another renewed awareness of education and its influence on labour and labour markets.

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Appendix 1. Data, sources and definitions

Name	Symbol	Source
Unemployed by educational attainment	U_{edu} *edu=low (l) intermediate (m) or high (h)*	USA: ILO and Bureau of Labor Statistics Germany: ILO and Statistisches Bundesambt France: ILO and INSEE UK: ILO and ONS Netherlands: ILO and CBS (Statistics Netherlands) Italy: ILO and ISTAT
Labour force by educational attainment	LF_{edu} *edu=low (l) intermediate (m) or high (h)*	USA: ILO, OECD, Bureau of Labor Statistics Germany: ILO and Statistisches Bundesambt France: ILO and INSEE UK: ILO, OECD, ONS Netherlands: ILO and CBS (Statistics Netherlands) Italy: ILO and ISTAT
Unemployment rate by educational attainment	$u_{edu}=U_{edu}/LF_{edu}$	
Wage compensation by educational attainment	W_{edu}	EU KLEMS database
Hours worked by educational attainment	h_{edu}	EU KLEMS database
Wage rate by educational attainment	$w_{edu}=W_{edu}/h_{edu}$	
ICT capital services	k_{ICT}	EU KLEMS database
Employment protection legislation	*epl*	Nickell and Nunziata (2001) database at http://cep.lse.ac.uk/pubs/download/data0502.zip plus augmenting data from OECD and CBS. *Epl* is a {0,2} dummy variable, *brr* and *bd* are continuous variables as defined in Nickell and Nunziata. The EU-5 variables were constructed by summing the GDP-weighted variables for the individual countries
Benefit replacement rate	*brr*	
Benefit duration	*bd*	

Appendix 2. Correlation matrices

Table A1. Correlation matrix EU-5 countries, 1970-2004

	$\log\left(\frac{k_{ICT}}{h_{high}}\right)$	$\log\left(\frac{h_{high}}{h_{low}}\right)$	$\log\left(\frac{w_{high}}{w_{low}}\right)$	log(*epl*)	log(*brr*)	Log(*bd*)
$\log\left(\frac{k_{ICT}}{h_{high}}\right)$	1.000					
$\log\left(\frac{h_{high}}{h_{low}}\right)$	0.994	1.000				
$\log\left(\frac{w_{high}}{w_{low}}\right)$	0.211	0.247	1.000			
log(*epl*)	-0.809	-0.814	-0.003	1.000		
log(*brr*)	0.797	0.807	0.304	-0.879	1.000	
log(*bd*)	0.977	0.966	0.188	-0.736	0.766	1.000

Table A2. Correlation matrix USA, 1970-2004

	$\log\left(\frac{k_{ICT}}{h_{high}}\right)$	$\log\left(\frac{h_{high}}{h_{low}}\right)$	$\log\left(\frac{w_{high}}{w_{low}}\right)$	log(*brr*)	log(*bd*)
$\log\left(\frac{k_{ICT}}{h_{high}}\right)$	1.000				
$\log\left(\frac{h_{high}}{h_{low}}\right)$	0.964	1.000			
$\log\left(\frac{w_{high}}{w_{low}}\right)$	0.923	0.821	1.000		
log(*brr*)	0.243	0.279	0.142	1.000	
log(*bd*)	0.205	0.084	0.307	-0.205	1.000

Note: epl for the USA is a constant dummy for the whole period

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