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Unit labor cost and productivity recovery under non neutral technical change

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This document proposes a new decomposition of unit labor cost changes (ULC) in terms of efficiency, technical progress and capital deepening. This decomposition is applied to data for western European countries and the US. Results show that sustained growth rates of labor compensation and poor labor productivity gains lead to large losses in cost competitiveness. The poor productivity performance is explained by low technical progress and even technical regress. In addition, it is shown that labor intensive technical change results in positive efficiency changes while capital intensive technical changes improves overall technical change. Last, when technical change is capital intensive cost competitiveness losses are lower.

Ce document présente une nouvelle décomposition du cout unitaire salarial en efficacité, progrès technique et approfondissement en capital. Cette décomposition est appliquée à des pays Européens et les Etats-Unis. Les résultats principaux sont une perte en compétitivité cout expliquée simultanément par une augmentation du cout salarial et une faible augmentation de la productivité. Celle-ci étant expliquée par un faible progrès technique voir un progrès technique négatif. De plus il est montré que quand le progrès technique est biaisé vers une plus grande utilisation du facteur travail les gains en efficacité sont plus importants ; alors que quand il est biaisé vers une plus grande utilisation du capital les progrès technique est plus intense. De plus quand le progrès technique est biaisé en utilisation du capital les pertes en compétitivité cout sont plus faibles.

Jel. codes: J3 - Wages, Compensation, and Labor Costs O3 - Technological Change O4 - Economic Growth and Aggregate Productivity.

Key words: total factor productivity, efficiency, biased technical change, capital deepening, unit labor cost.

INTRODUCTION

Policy responses to cost competitiveness losses are often unattractive: lowering nominal wages (Blanchard, 2007) and/or reducing employers' social contribution (Siebert, 1999) may have large adverse social consequences and be unsustainable in the long run. In addition, such policy move can be seen as largely unsuccessful in time of recession (cases of Greece and Spain). However, the IMF (2012) and the European Commission (2010) advocate reforms and labour market adjustments to achieve economic recovery in the aftermath of the 2007-2009 recession which led to the sovereign debt crisis.

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This study shows that, once the link between determinants of labour productivity and cost competitiveness recovery is clarified, the set of policies available to achieve cost competitiveness recovery is substantially widened. Firstly, unit labour cost changes are decomposed in labour compensation changes and labour productivity changes (Van Ark et. al, 2005). Then, following Kumar and Russell (2002), productivity changes are defined in terms of efficiency changes, technological progress and capital deepening. This presentation of unit labour cost changes emphasizes the role of well functioning inputs markets, R&D and intangibles. Last, technical changes are decomposed in magnitude changes and input biased technical changes as in Fare et. al. (2001). This highlights that inputs' allocation is affected by the relative use of inputs in realised technological changes.

Section 1 proposes the new decomposition of unit labor cost changes emphasizing the role of efficiency gains, biased technical change and capital deepening. Section 2 provides an illustration with European data and the United States. The last section concludes.

I THE UNIT LABOR COST CHANGES DECOMPOSITION

This section is largely inspired by the contributions of Kumar and Russell (2002), Chen and Yu (2012) and Fare et al (2001).

Let us assume that each country produces a single output Y using two inputs: capital (K) and labor (L). The production possibility set is convex, and inputs and output are freely disposable. The output distance function at time t can be defined on the technology set $P^t = \{(X_t, Y_t): X_t \text{ can produce } Y_t\}$, where $X_t = (K_t, L_t)$ as:

$$D_o^t(X_t, Y_t) = \inf\{\theta : (X_t, Y_t/\theta) \in P^t\}.$$

The distance function is the reciprocal of the maximum proportional expansion of output given the level of inputs' use. If $D_o^t(X_t, Y_t) = 1$, the country is on the world production frontier and is said to be efficient (that is, it is impossible to increase output given inputs). If $D_o^t(X_t, Y_t) < 1$, the country is below the frontier and the country is said to be inefficient, in the sense used by Farrell (1957): it is possible to produce more at the same level of inputs' use.

Under the assumption of constant returns to scale, the distance functions can be rewritten in intensive form $D_o^t(x_t, y_t)$, where $x_t = (K_t/L_t, 1)$ and $y_t = (Y_t/L_t)$. Using this framework, Kumar and Russell (2002) show that labor productivity change y_{t+1}/y_t can be decomposed into efficiency change, technical progress and capital deepening.

$$y_{t+1}/y_t = \text{efficiency change} \bullet \text{technical progress} \bullet \text{capital deepening}.$$

The product of the two first components is the Malmquist productivity index. The reasoning is the following. With simple manipulations (omitting the o subscript) one shows that:

$$y_{t+1}/y_t = \frac{\frac{y_{t+1}}{D^{t+1}(x_{t+1},y_{t+1})}D^{t+1}(x_{t+1},y_{t+1})}{\frac{y_t}{D^t(x_t,y_t)}D^t(x_t,y_t)} = \frac{\frac{y_{t+1}}{D^{t+1}(x_{t+1},y_{t+1})}}{\frac{y_t}{D^t(x_t,y_t)}}\frac{D^{t+1}(x_{t+1},y_{t+1})}{D^t(x_t,y_t)}.$$

The first term denotes the optimal evolution of labor productivity and the second term the gain in efficiency. Efficiency gains measure the movements of countries towards the world production frontier: a value over one is an improvement while any value below one indicates a worsening in countries' positions. It is usually referred to as "a catching up" effect. The optimal evolution of labor productivity can be further manipulated:

$$\frac{\frac{y_{t+1}}{D^{t+1}(x_{t+1},q_{t+1})}}{\frac{y_t}{D^t(x_t,q_t)}} = \frac{y_{t+1}}{y_t}\frac{D^t(x_t,y_t)}{D^{t+1}(x_{t+1},y_{t+1})}\frac{D^t(x_{t+1},y_{t+1})}{D^t(x_{t+1},y_{t+1})}\frac{D^{t+1}(x_t,y_t)}{D^{t+1}(x_t,y_t)}$$
$$= \frac{y_{t+1}}{y_t}\left[\frac{D^t(x_t,y_t)D^t(x_{t+1},y_{t+1})}{D^{t+1}(x_{t+1},y_{t+1})D^{t+1}(x_t,y_t)}\right]^{1/2}\left[\frac{D^t(x_t,y_t)D^t(x_{t+1},y_{t+1})}{D^{t+1}(x_{t+1},y_{t+1})D^{t+1}(x_t,y_t)}\right]^{1/2}\frac{D^{t+1}(x_t,y_t)}{D^t(x_{t+1},y_{t+1})}.$$

The first term in brackets is technical progress, and represents shifts of the world production frontier. A value over unity indicates positive technical progress while a value below one is a technical regress. There is a remaining term:

$$\frac{y_{t+1}}{y_t}\left[\frac{D^t(x_t,y_t)D^t(x_{t+1},y_{t+1})}{D^{t+1}(x_{t+1},y_{t+1})D^{t+1}(x_t,y_t)}\right]^{1/2}\frac{D^{t+1}(x_t,y_t)}{D^t(x_{t+1},y_{t+1})}.$$

Dividing by $D^{t+1}(x_t,y_t)$ and $D^t(x_{t+1},y_{t+1})$ the terms in brackets, one gets:

$$\frac{y_{t+1}}{y_t}\left[\frac{D^t(x_t,y_t)D^{t+1}(x_t,y_t)}{D^{t+1}(x_{t+1},y_{t+1})D^t(x_{t+1},y_{t+1})}\right]^{1/2}.$$

To provide as economic interpretation of the expression above, one can restrict the analysis to the case of the standard Cobb-Douglas with constant returns to scale. Then:

$$D_o^t(x_t,y_t) = \inf\{\theta : y_t/\theta \le A_t k_t^{\alpha} \in P^t, 0<\alpha<1\} = \inf\{\theta : y_t/A_t k_t^{\alpha} \le \theta\} = y_t/A_t k_t^{\alpha}.$$

Replacing in the latter expression, one has:

$$\left[\frac{y_{t+1}^2}{y_t^2}\frac{\dfrac{y_t}{A_t k_t^\alpha}\dfrac{y_t}{A_{t+1}k_t^\alpha}}{\dfrac{y_{t+1}}{A_{t+1}k_{t+1}^\alpha}\dfrac{y_{t+1}}{A_t k_{t+1}^\alpha}}\right]^{1/2}=\left(\frac{k_{t+1}}{k_t}\right)^\alpha .$$

Thus, one can see that the last term represent capital deepening. In summary, the change in labor productivity is the product of efficiency change, technical progress and capital deepening.

Technical change can be neutral and non neutral. It is often assumed that technical progess is Hicks neutral, thus corresponding to parallel shifts of the production frontier (e.g. Solow, 1957). When technical change is *capital intensive,* it favors the use of capital via the increase of the capital/output elasticity. Conversely, technical change can be *labor intensive*, that is, it favors the use of labor, via greater increases in the output elasticity of labor relatively to capital (Chen and Yu, 2012). Antonelli and Quatraro (2010) note that the consequences of such inputs' bias are crucial:

"countries with different factors' endowments will take advantage of technological innovations that allow for a more intensive use of locally abundant production factors. It follows that countries better able to introduce technologies that are able to matching the local conditions of factor markets should show better productivity performances than countries that have put less effort in shaping technologies according to the relative scarcity of production factors".

In order to assess the inputs' bias of technical change, the relevant component of labor productivity can be further decomposed as in Fare et al (2001):

$$\left[\frac{D^t(x_t,y_t)D^t(x_{t+1},y_{t+1})}{D^{t+1}(x_{t+1},y_{t+1})D^{t+1}(x_t,y_t)}\right]^{1/2}$$
$$=\left[\frac{D^t(x_t,y_t)}{D^{t+1}(x_t,y_t)}\right]\left[\frac{D^t(x_{t+1},y_{t+1})D^{t+1}(x_{t+1},y_t)}{D^{t+1}(x_{t+1},y_{t+1})D^t(x_{t+1},y_t)}\right]^{1/2}\left[\frac{D^{t+1}(x_t,y_t)D^t(x_{t+1},y_t)}{D^t(x_t,y_t)D^{t+1}(x_{t+1},y_t)}\right]^{1/2}.$$

The first term is the magnitude index, a measure of Hicks neutral technical change, which represents the component of technical change that leaves the inputs' mix unchanged. The second term is the output biased technical change, which represents changes in the bundle of outputs produced. (As in this analysis there is only one output, the output biased technical change is always one - no changes). The last term is the input biased technical change, and indicates the technical change that affect the composition of the bundle of inputs used. Technical change can be capital intensive or labor intensive. For example, in the latter case, output elasticity to labor increases relatively to the output elasticity to capital (Robinson, 1938).

One can see that, if output remains constant in the input bias term, the only variable element is the input mix. As explained in Fare et al (2001), under constant returns to scale each element of the decomposition above is independent from output, and the decomposition can be rewritten as:

$$\left[\frac{D^t(x_t,1)}{D^{t+1}(x_t,1)}\right]\left[\frac{D^t(x_{t+1},1)D^{t+1}(x_{t+1},1)}{D^{t+1}(x_{t+1},1)D^t(x_{t+1},1)}\right]^{1/2}\left[\frac{D^{t+1}(x_t,1)D^t(x_{t+1},1)}{D^t(x_t,1)D^{t+1}(x_{t+1},1)}\right]^{1/2}.$$

The input technical change bias (IBTECH) is:

$$IBTECH=\left[\frac{D^{t+1}(x_t,1)D^t(x_{t+1},1)}{D^t(x_t,1)D^{t+1}(x_{t+1},1)}\right]^{1/2}.$$

If IBTECH is equal to one, there is no bias in technical change:

$$\frac{D^t(x_t,1)}{D^{t+1}(x_t,1)}=\frac{D^t(x_{t+1},1)}{D^{t+1}(x_{t+1},1)}.$$

Thus, with two inputs (labor and capital) and under constant returns to scale, one gets:

$$\frac{D^t(1,1,K_t/L_t)}{D^{t+1}(1,1,K_t/L_t)}=\frac{D^t(1,1,K_{t+1}/L_{t+1})}{D^{t+1}(1,1,K_{t+1}/L_{t+1})}.$$

Fare et al (2001) propose a graphical explanation that is reproduced in this document. Assume that $K^{t+1}/L^{t+1}<K^t/L^t$ (as in figure 1) and technical progress occurs from period t to period t+1. There are four input sets for a unit level of output: $S^t(1),S^{t+1}{}_K(1),S^{t+1}{}_L(1),S^{t+1}{}_n(1)$. Each set represent a type of technical change indexed K for capital intensive, L for labor intensive, and n for Hicks neutral. Looking at figure 1 IBTECH is:

$$IBTECH=\left[\frac{\dfrac{ox^t}{ob}\dfrac{ox^{t+1}}{oe_n}}{\dfrac{ox^t}{oc}\dfrac{ox^{t+1}}{of}}\right]^{1/2}=\left[\frac{oc}{ob}\frac{of}{oe_n}\right]^{1/2}.$$

If IBTECH is equal to one, then:

$$\frac{ob}{oc}=\frac{of}{oe_n}.$$

As a result, the shift of the frontier is homothetic and technical progress is Hicks neutral. If there is a shift to frontier $S^t{}_L(1)$, technical change is labor intensive and IBTECH>1. If there is a shift to frontier $S^t{}_K(1)$, technical change is capital intensive and IBTECH<1.

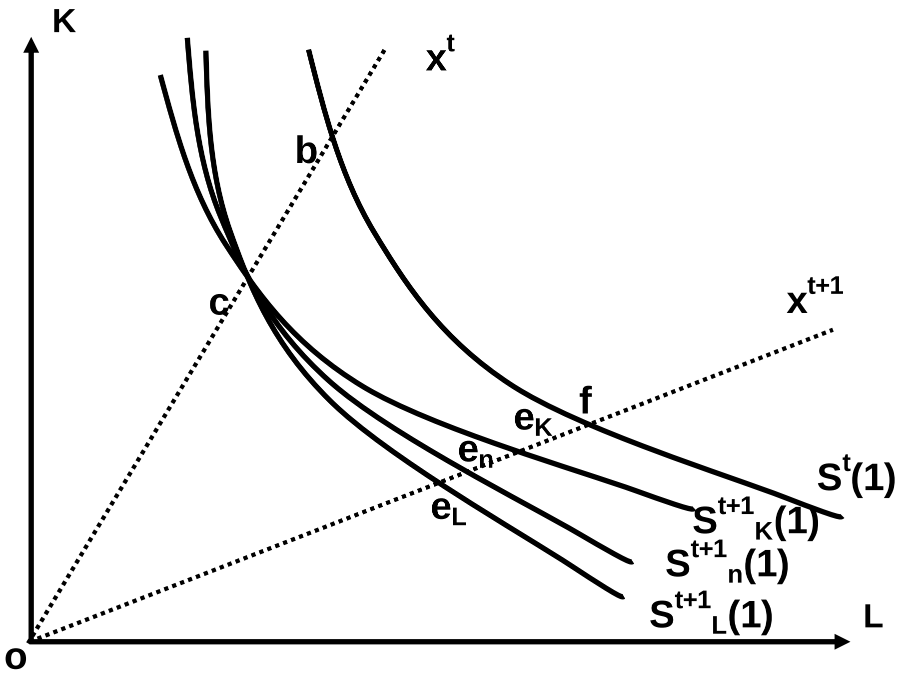

FIGURE 1. Unit output technological frontier

Conversely if $K^{t+1}/L^{t+1} > K^t/L^t$ (as in figure 2) then if IBTECH>1 technical progress is capital using biased, if IBTECH<1 it is labor biased.

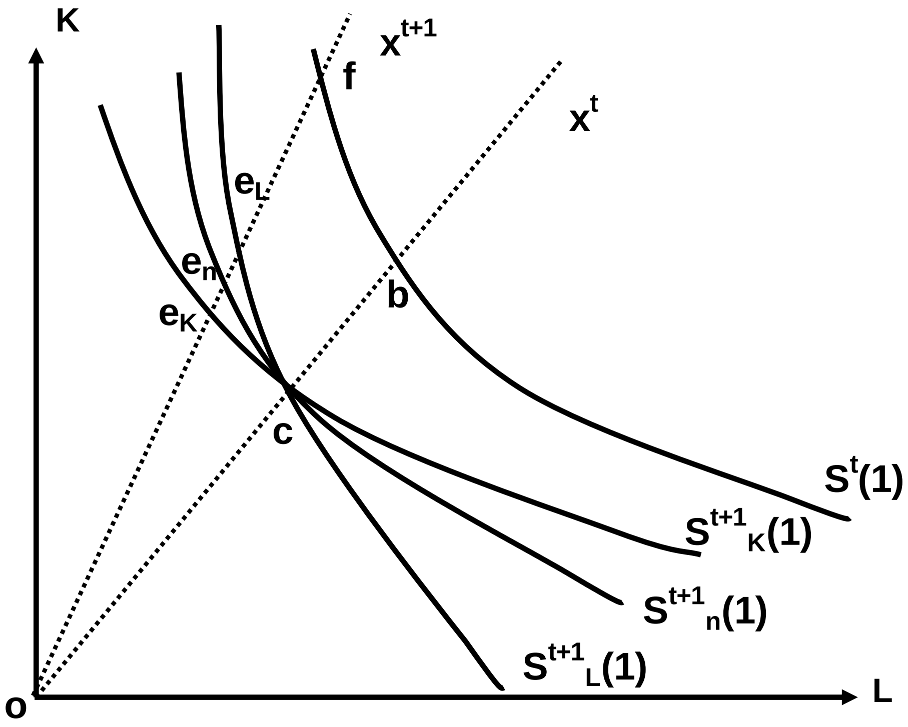

FIGURE 2. Unit output technological frontier

Table 1 summarizes the interpretation of the indicator.

TABLE 1

INTERPRETATION RULES

	IBTECH<1	IBTECH=1	IBTECH>1
$\frac{K^{t+1}/L^{t+1}}{K^t/L^t} < 1$	K using	Neutral	L using
$\frac{K^{t+1}/L^{t+1}}{K^t/L^t} > 1$	L using	Neutral	K using

The final decomposition of labor productivity is:

$$\frac{y_{t+1}}{y_t} = \quad \textit{efficiency change}(EFF) \bullet \textit{magnitude of technical change}(MTC) \bullet \textit{input biased technical change}(IBTECH) \bullet \textit{capital deepening}(CAP)$$

Finally, the unit labor cost (ULC) changes is:

$$d\ln(ULC_{t+1}) = d\ln(\textit{labor compensation}_{t+1}) - \ln(EFF_{t+1}) - [\ln(MTC_{t+1}) + \ln(IBTECH_{t+1})] - \ln(CAP_{t+1}).$$

The term in brackets is the logarithm of technical progress. The equation above shows that an increase in 1% in efficiency (or any other components of labour productivity) lowers unit labour costs by about the same amount. Conversely, any percentage increase in compensation per worker will increase ULC by the same amount. A percent change in efficiency has the same effect than one percent change in technical progress and capital deepening on ULC.

Positive efficiency changes mean that countries moves towards best practices, or maximum feasible production given inputs use. This could be achieved through improvements in managerial practices, firms' decision structure and learning by doing. Such elements, under the control of the management, are among determinants of productivity identified by Syverson (2011).

Technical change measures expansions in feasible production. It results from successful R&D, thus reflects the ability of countries to innovate. Moreover, it evolves with investments in intangible capital. This latter form of capital, however, which denotes the amount of knowledge and organisational capital and firm-specific skills, is also a determinant of the evolution of efficiency (Corrado et al., 2010).

The first two components of labour productivity determine total factor productivity (TFP), which represents those productivity gains resulting from efficiency in combining inputs. TFP changes reflect a complex mix of elements such as increase in knowledge from innovation, investment in intangible, organisational and managerial practises.

Capital deepening, which summarises the contribution of inputs to production, has received various interpretations. Pilat (2004) explains that, when capital deepening increases, new capital is used, which introduces new technologies in the production process. The most interesting explanation of the interpretation of capital deepening is found in Frankel (1962). This author argues that firms accumulate capital in response to market conditions and economic opportunities. As a result, capital deepening increases. This means that the latter term reflects factors external to the firm that explain productivity changes, such as changes in regulatory frameworks or flexible inputs markets.

The ULC decomposition of this section shows that, if the average compensation of workers increases, then competitiveness worsens. Conversely, countries competitiveness improves following improvements in efficiency, the occurrence of technical change and capital intensity increases.

II UNIT LABOUR COST CHANGES

The data are sourced from Eurostat, the OECD and the Statec for Luxembourg. Output is measured by GDP and inputs by domestic employment and capital stock. All figures are expressed in PPP. Unit labour cost (ulc hereafter) is calculated as the ratio of labour compensation to real GDP.

Table 2 shows the evolution of ulc levels normalized at 100 in 1995. One observes the large variation in trends amongst European countries and the United States. The largest increases in ulc were experienced by Greece, Portugal and Ireland, three countries which are currently supported by the European Financial Stability Facility. There are no obvious differences between European Monetary Union members and non members, as the average unit labour cost of Denmark and Sweden followed closely the EMU average (see figure 3). Luxembourg, which has an indexed wage-inflation mechanism, did not have significantly higher unit labour cost than the EU average but was amongst the countries with higher unit labour costs. Germany out-performed all other countries[3].

[3] For reasons of space, only selected years are presented. Complete tables are available upon request from the authors.

TABLE 2

LEVEL OF UNIT LABOUR COST (1995 = 100)

Country		1995	2000	2005	2010
AT	Austria	100	99	101	111
BE	Belgium	100	104	113	127
DE	Germany	100	101	101	105
DK	Denmark	100	110	124	146
ES	Spain	100	111	128	Missing
FI	Finland	100	102	110	124
FR	France	100	104	114	Missing
GR	Greece	100	127	149	173
IE	Ireland	100	106	129	137
IT	Italy	100	107	125	141
LU	Luxembourg	100	105	120	144
NL	The Netherlands	100	110	123	135
PT	Portugal	100	119	139	150
SE	Sweden	100	109	116	126
UK	United Kingdom	100	114	129	151
US	United States	100	111	120	130

Source: OCDE.

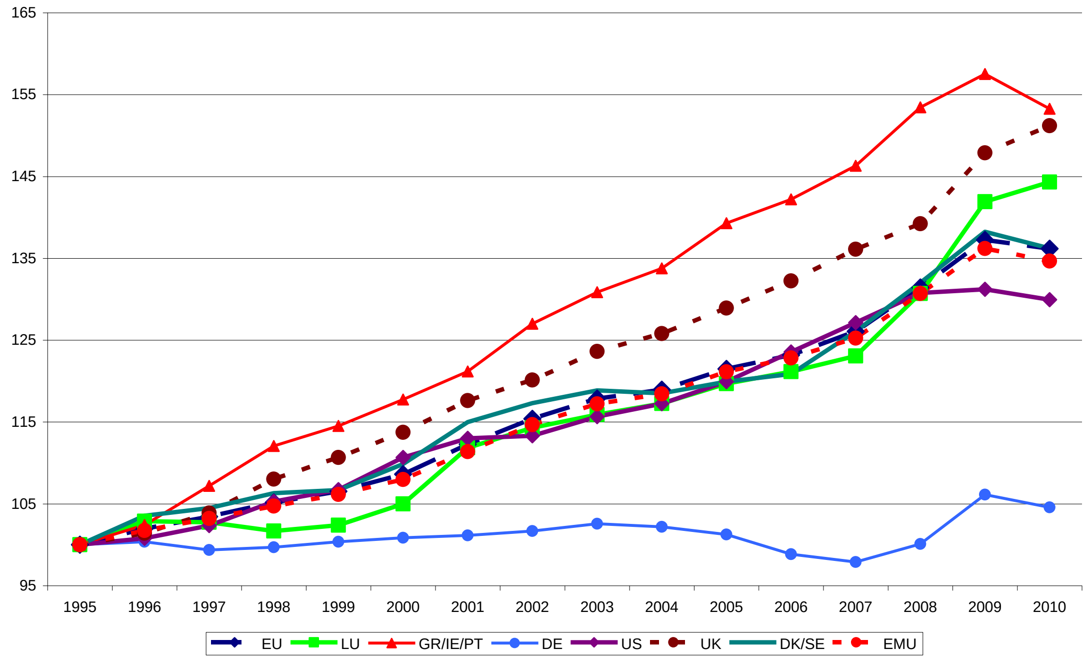

FIGURE 3:
AVERAGE UNIT LABOUR COST VARIOUS COUNTRIES / GEOGRAPHICAL ZONES

There are several explanations for these differing trends. Germany has out-performed other countries because successive governments have mediated wage negotiation and demanded wage moderation (Laski and Podkaminer, 2012), in addition with rises in labour productivity. It is interesting to note that the adoption of similar approaches by other countries has not been as successful. For example, the Belgian Government has gradually reduced the tax wedge on labour and introduced a mechanism (1996) to ensure similar wage developments than in Germany, France and the Netherlands. Despite these facts, wage developments have always exceeded those in the reference countries. The rise in ulc in Greece, relative to the other Eurozone countries has been related to the inherent inability of the Greek trade union movement to accept real wage increases for private-sector workers in line with productivity developments (Katsimi and Moutos, 2010). In response to the relatively high growth rate of labour compensation per worker, in Finland, employers and unions have decided to cap wage increases at slightly above 2% per year (OECD, 2012) but results are not visible yet.

Recall that ulc changes reflect the comparative evolution of total nominal costs per employee to labour productivity (e.g. Van Ark et. al., 2005). In figure 4 any country below the first diagonal line is not able to compensate average labour cost changes with labour productivity gains. One can see that this is the case for all countries. However, the closer to the line a country is, the “better” cost competitiveness changes are, conversely, the worst evolution is for countries farer from the line. This situation is even worst for countries with a negative growth rate of labour productivity. Over the period 1995-2010, Germany gained from moderate increases in average labour compensation and relatively high average productivity gains such as Austria. This contrasts with three countries with negative labour productivity changes and positive labour compensation growth: Italy and Spain, and Greece (the latter characterised by a very high labour compensation growth rate).

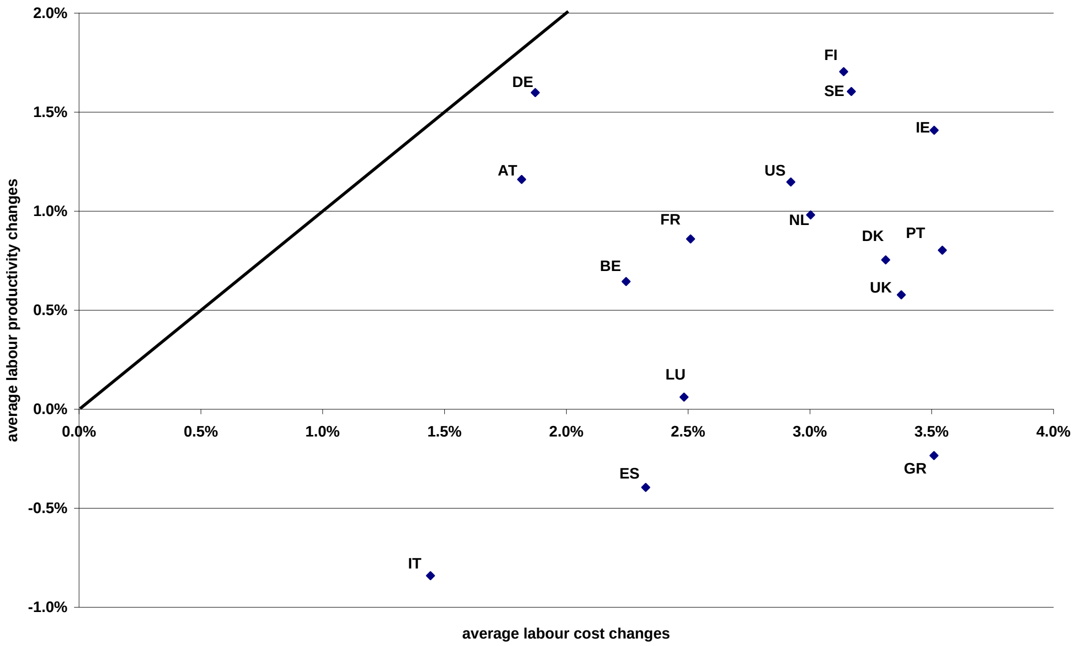

FIGURE 4:
COMPARISON LABOUR PRODUCTIVITY / AVERAGE LABOUR COMPENSATION CHANGES

TABLE 3
LABOUR COMPENSATION / LABOUR PRODUCTIVITY (1995 = 100)

	Labour compensation per worker				Average growth	Labour productivity				Average growth
Country	**1995**	**2000**	**2005**	**2010**		**1995**	**2000**	**2005**	**2010**	
AT	100	117	123	131	1.8%	100	107	105	110	1.2%
BE	100	118	128	139	2.2%	100	108	106	112	0.6%
DE	100	113	127	132	1.9%	100	106	107	114	1.6%
DK	100	125	141	163	3.3%	100	109	108	117	0.8%
ES	100	112	119		2.3%	100	106	109	115	-0.4%
FI	100	119	137	159	3.1%	100	111	110	119	1.7%
FR	100	119	135		2.5%	100	112	111	116	0.9%
GR	100	127	156	166	3.5%	100	114	112	112	-0.2%
IE	100	113	139	167	3.5%	100	111	113	127	1.4%
IT	100	111	115	124	1.4%	100	113	114	116	-0.8%
LU	100	120	133	144	2.5%	100	115	115	119	0.1%
NL	100	124	141	155	3.0%	100	117	116	124	1.0%
PT	100	126	148	168	3.5%	100	116	117	125	0.8%
SE	100	132	147	158	3.2%	100	119	118	127	1.6%
UK	100	131	154	164	3.4%	100	122	119	123	0.6%
US	100	128	146	153	2.9%	100	119	120	129	1.1%

It was noted by the OECD (2012) that Denmark should boost productivity growth (only 0.8%) to restore competitiveness when the average growth rate of labour compensation per worker is on average 3.3%. According to the IMF (2010) this poor productivity performance was caused by low job protection discouraging investment in firm specific human capital. In Italy, several explanations have been provided by the OECD (2009) to explain negative productivity performance, such as low educational attainment and inadequacy in tertiary education and lack of innovation and R&D activities.

In summary, the deterioration of unit labour cost lies simultaneously on relatively high growth rates of labour compensation and low and even negative growth rates of labour productivity. As seen in the first section, labour productivity changes can be decomposed into efficiency changes, technical progress and capital deepening. The following presents the evolution of each labour productivity component over the period analysed. This help to shed light on the variation in ulc performances, and provides interesting policy implications.

TABLE 4
EFFICIENCY LEVEL / CATCHING-UP EFFECT (1995 = 100)

	Efficiency level – Catching up effect				Average growth
Country	1995	2000	2005	2010	
AT	100	101	100	100	1.000
BE	100	99	96	95	0.997
DE	100	98	103	106	1.004
DK	100	102	103	100	1.000
ES	100	88	82	82	0.987
FI	100	103	108	111	1.007
FR	100	100	98	98	0.999
GR	100	95	101	98	0.998
IE	100	100	99	100	1.000
IT	100	90	82	80	0.985
LU	100	100	100	100	1.000
NL	100	99	96	99	0.999
PT	100	83	73	77	0.983
SE	100	109	121	123	1.014
UK	100	101	105	105	1.003
US	100	100	100	100	1.000

Recall that any value over 100 (1 for growth rates) represents efficiency gains; conversely, any value below 100 (1 for growth rates) correspond to efficiency losses. Two countries exhibit a value of 100 and an average growth rate of 1, namely Luxembourg and the United States, meaning that these countries were on the world production frontier. As a result, no further efficiency gains could be realised. Few countries have been catching up: Germany, Finland, Sweden and the United Kingdom. Several countries are lagging behind, especially Spain, Portugal and Italy; this is also the case for Belgium, France, Greece and the Netherlands.

TABLE 5
TECHNICAL PROGRESS / REGRESS (1995 = 100)

	Technical progress / regress				Average growth
Country	1995	2000	2005	2010	
AT	100	113	115	112	1.007
BE	100	113	114	111	1.007
DE	100	108	106	102	1.001
DK	100	100	93	85	0.989
ES	100	112	108	104	1.003
FI	100	112	108	102	1.001
FR	100	112	113	109	1.006
GR	100	98	89	80	0.985
IE	100	99	89	85	0.989
IT	100	111	105	96	0.997
LU	100	113	110	99	1.000
NL	100	112	111	105	1.003
PT	100	88	79	69	0.975
SE	100	105	97	88	0.991
UK	100	93	84	73	0.979
US	100	111	110	104	1.002

Few countries experienced technical progress: Austria, Belgium, Germany, Finland, France, The Netherlands and the United States. Luxembourg is a special case, experiencing no technical progress but also no regress. Some countries were characterized by technical regress: Denmark, Greece, Ireland, Italy, Portugal, Sweden and the United Kingdom. Technical regress, albeit difficult to interpret, can be found in many studies at firm level (e.g. Sena, 2006), industry level (e.g. Tortosa-Ausina, 2012) and country level (e.g. Chen and Yu, 2012). However few authors have attempted to provide plausible causes for this result. Lee and Johnson (2012) attributed technical regress to production issues when in actuality it may result from lack of demand. Bontemps et al. (2012) emphasizes the negative effect of new regulations that generate negative technical progress. Last, for Sena (2006) it is a consequence of sharp recessions. This argument is based on Caballero and Hammour (1994, 1996). During recessions old techniques are substituted by new techniques. It may appear that the process of destruction of old techniques is faster than the creation of new techniques. Thus, the firm, the sector or countries experience technical regress. It is worth noting that all countries have a technical progress level in 2010 below the value observed in 2005.

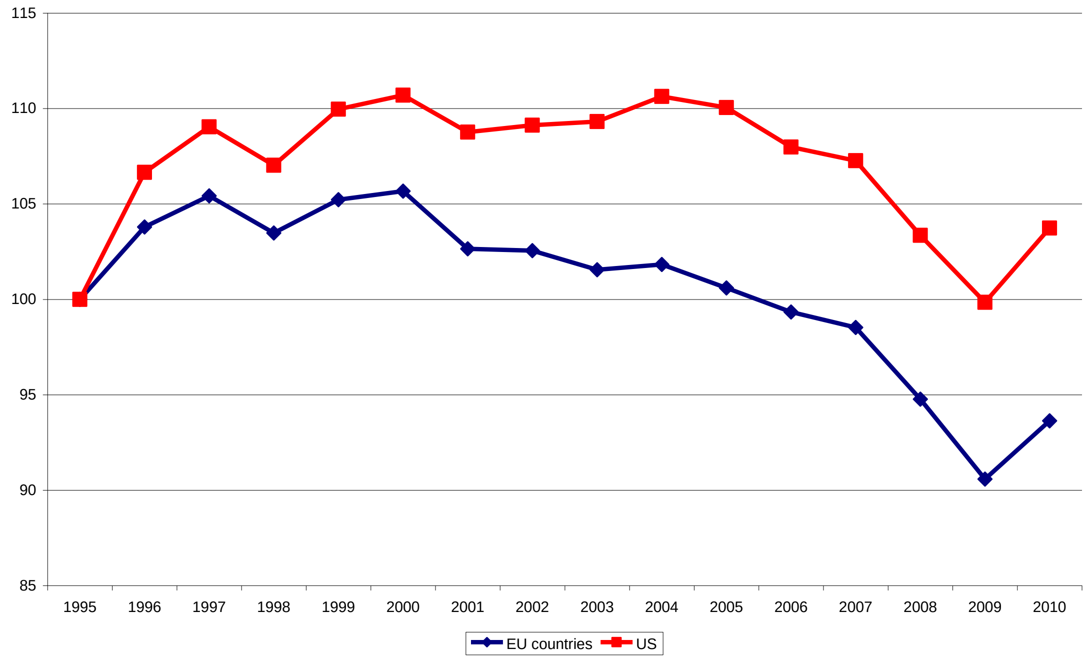

FIGURE 5:
COMPARISON OF TECHNICAL PROGRESS LEVELS.

On average, EU countries and the United States showed similar trends, but EU countries had a lower level of technical progress. One may see that the levels sharply decreased during the recession. The European Commission (2010) emphasizes the need of better and stronger R&D policies that should generate technical progress to lower unit labor cost changes in the Euro Area. For example, the spring 2008 European Council insisted that Luxembourg invested more in knowledge and innovation.

TABLE 6
CAPITAL DEEPENING (1995 = 100)

	Capital deepening				Average growth
Country	1995	2000	2005	2010	
AT	100	104	106	106	1.004
BE	100	103	103	104	1.003
DE	100	106	116	117	1.010
DK	100	111	118	130	1.018
ES	100	102	105	114	1.009
FI	100	101	108	114	1.009
FR	100	103	107	108	1.005
GR	100	108	116	123	1.014
IE	100	107	122	143	1.024
IT	100	104	107	115	1.009
LU	100	101	101	101	1.000
NL	100	102	107	111	1.007
PT	100	145	186	212	1.051
SE	100	105	109	116	1.010
UK	100	122	136	140	1.023
US	100	104	110	113	1.008

All countries experienced capital deepening, with an impressive average growth rate of 5 percent for Portugal. On average, capital deepening increased more rapidly in the European countries than in the United States, which contributed to increases in EU's cost competitiveness.

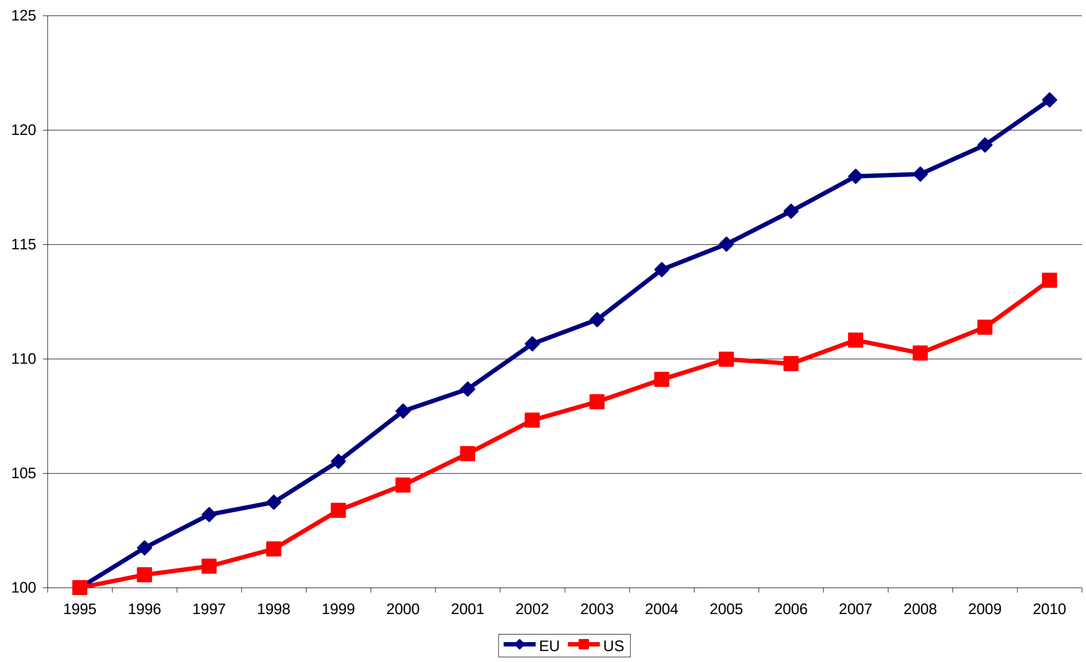

FIGURE 6:
COMPARISON CAPITAL DEEPENING.

The remaining of this section is concerned with the bias in technical progress and its impact on ulc. The technical progress bias was not constant over time some year it is labour intensive while other years it capital intensive; however, countries had about the same bias for a given year (in both cases of capital and labour intensive bias). Technical progress was capital intensive in 1998, 1999, 2003, 2004, 2007 and 2009. It was labour intensive in 1996, 1997, 2000, 2001, 2002 and 2008 (see table in appendix). No countries had Hicks neutral technical change. On average, technical progress is higher and technical regress lower when technical change is capital intensive than in the case of labour intensive technical progress. Conversely, when technical progress is labour intensive then efficiency gains are higher and efficiency losses lower than in the case of capital intensive technical progress. Finally, when technical change is capital intensive rather than labour intensive cost competitiveness losses are lower.

TABLE 6
AVERAGE AND TECHNICAL AND EFFICIENCY CHANGE (1995 = 100)

	Average technical change			Average efficiency change		
	K-using	L-using	ratio	K-using	L-using	ratio
AT	1.022	0.995	1.027	0.991	1.008	0.984
BE	1.021	0.995	1.026	0.991	1.002	0.989
DE	1.014	0.990	1.024	0.999	1.009	0.989
DK	0.998	0.982	1.016	1.001	1.000	1.001
ES	1.013	0.992	1.020	0.978	0.999	0.979
FI	1.002	1.001	1.000	1.003	1.009	0.993
FR	1.011	0.996	1.016	0.998	1.001	0.997
GR	0.988	0.984	1.005	0.992	1.003	0.988
IE	0.995	0.986	1.009	0.997	1.002	0.996
IT	1.000	0.995	1.004	0.989	0.979	1.010
LU	1.006	0.995	1.011	1.000	1.000	1.000
NL	1.008	0.998	1.010	0.997	1.003	0.994
PT	0.974	0.976	0.998	0.990	0.976	1.014
SE	0.989	0.994	0.995	1.022	1.007	1.016
UK	0.980	0.979	1.001	1.003	1.004	1.000
US	1.005	0.999	1.006	0.996	1.007	0.990

TABLE 7
AVERAGE GROWTH OF UNIT LABOUR COST (1995 = 100)

	Average growth of unit labour cost		
	K-using	L-using	Ratio
AT	1.003	1.010	0.993
BE	1.010	1.022	0.989
DE	1.001	1.005	0.997
DK	1.019	1.032	0.987
ES	0.901	1.025	0.879
FI	1.022	1.011	1.011
FR	0.915	1.017	0.899
GR	1.035	1.039	0.996
IE	1.019	1.024	0.996
IT	1.017	1.032	0.985
LU	1.020	1.030	0.990
NL	1.019	1.022	0.997
PT	1.028	1.027	1.001
SE	1.000	1.030	0.970
UK	1.027	1.029	0.998
US	1.014	1.024	0.990

CONCLUSIONS

This article presents a new decomposition of unit labour cost changes to enrich the analysis of cost competitiveness' evolution. The latter is explained in terms of the evolution of labour compensation, efficiency gains, technical changes and capital deepening. In most studies, it is found that cost competitiveness is worsening due to increases in labour compensation and low labour productivity performance. The new decomposition proposed in this article shows, in addition, that low productivity performance are explained by low and even negative technical progress. When technical (inputs) bias is taken into account, it is shown that, when technical progress is capital intensive, cost competitiveness losses are lower than in the case of labour intensive technical change. Moreover, efficiency changes are enhanced when labour intensive technical change occurs and overall technical change is enhanced under capital intensive technical change.

This decomposition sends contradictory messages. Indeed, gains in efficiency due to labour intensive technical progress improve labour productivity, thus lowering unit labour costs. At the same time, efficiency gains put pressure on wages and tend to increase nominal wages, thus increasing unit labour costs. This suggests possible policy responses to deterioration of cost competitiveness. For example, one could favour R&D projects and efforts to develop capital intensive technical progress. However, the latter option could prove unsustainable in the long run in some countries and socially problematic, for example, in Spain and Greece where unemployment rates in 2012 were higher than 20 percent.

There are several avenues for further researches. First, this decomposition can be applied at industry level between and across countries; the problem is availability of data. Formal and conclusive tests of the positive effect of unit labour cost on competitiveness have yet to be developed. Then it should be interesting to test what elements effectively influence technical progress, efficiency and capital deepening.

Biased technical progress															
Country	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
AT	K-using	L-using	L-using	K-using	K-using	L-using	L-using	L-using	K-using	K-using	L-using	L-using	K-using	L-using	K-using
BE	K-using	L-using	L-using	K-using	K-using	L-using	L-using	L-using	K-using	K-using	L-using	L-using	K-using	L-using	K-using
DE	K-using	L-using	L-using	K-using	K-using	L-using	L-using	L-using	K-using	K-using	L-using	L-using	K-using	L-using	K-using
DK	K-using	L-using	L-using	K-using	K-using	L-using	L-using	L-using	K-using	K-using	L-using	L-using	K-using	L-using	K-using
ES	K-using	L-using	L-using	K-using	K-using	K-using	L-using	L-using	K-using	K-using	L-using	L-using	K-using	L-using	K-using
FI	L-using	L-using	L-using	K-using	L-using	K-using	L-using	L-using	L-using	K-using	L-using	L-using	K-using	L-using	K-using
FR	K-using	L-using	K-using	K-using	K-using	K-using	K-using	L-using	K-using	K-using	L-using	L-using	K-using	L-using	K-using
GR	L-using	L-using	L-using	L-using	K-using	L-using	K-using	L-using	K-using	K-using	L-using	L-using	K-using	L-using	K-using
IE	L-using	K-using	K-using	K-using	L-using	L-using	L-using	L-using	L-using	K-using	L-using	L-using	K-using	L-using	K-using
IT	L-using	K-using	K-using	K-using	K-using	L-using	L-using	K-using	K-using	K-using	L-using	L-using	K-using	L-using	K-using
LU	K-using	K-using	K-using	L-using	K-using	L-using	L-using	L-using	K-using	K-using	L-using	L-using	K-using	L-using	L-using
NL	K-using	L-using	L-using	L-using	K-using	K-using	K-using	L-using	K-using	K-using	L-using	L-using	K-using	L-using	K-using
PT	L-using	L-using	L-using	L-using	K-using	K-using	L-using	K-using	K-using	K-using	L-using	L-using	K-using	K-using	K-using
SE	L-using	L-using	K-using	K-using	L-using	L-using	K-using	L-using	K-using	K-using	L-using	L-using	K-using	L-using	K-using
UK	L-using	L-using	K-using	K-using	L-using	L-using	L-using	L-using	L-using	K-using	L-using	L-using	K-using	L-using	K-using
US	K-using	K-using	L-using	L-using	L-using	K-using	L-using	K-using	K-using	K-using	L-using	L-using	K-using	K-using	K-using

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