Unemployment in Europe:

Swimming against the Tide of Skill-Biased Technical Progress

without Relative Wage Adjustment

by

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Abstract
The hypothesis that European unemployment is the rigid relative wage mirror-image of increased wage dispersion in the US is explored. The framework is a two sector – manufacturing and services- model with skilled and unskilled labor. A proxy for skill-biased technical progress (SBTP) is constructed from data on total factor productivity (TFP). Econometric analysis of the relationship between SBTP and aggregate unemployment shows that SBTP explains some 50% of the unemployment increase in major European countries since the early 1970s, but it does not explain US unemployment. The hypothesis is robust in that it is not rendered void by inclusion of alternative, mostly macroeconomic, explanatory variables.

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1. Introduction

The findings in the beginning of the 1990s that wage differences among workers had increased significantly in the US since the early 1980s (Juhn, Murphy and Pierce (1993), Katz and Murphy (1992) and Gottschalk (1997)) have triggered two interesting research topics. The first is to identify the cause, or possibly causes, of the change. Increased trade with less developed countries and skill-biased technical progress (SBTP) have been, and still are, the main contenders (see Woods (1994) and Leamer (1996) on trade and Krugman (2000) and Krusell, Ohanian, Ríos-Rull and Violante (2000) on SBTP). Currently, SBTP is regarded as the quantitatively more important of the two explanations. The second topic can be called the "mirror-image" hypothesis. It suggests that the trend increase in European unemployment is partly a result of similar technical change to that in the US and rigid relative wages, which are presumed to be the result of institutional factors, such as collective wage bargaining, trade union policies, unemployment benefits and social security.[2] Hence, while in the US, technical progress in combination with market determined wages has led to increased wage differences, in Europe it has together with rigid relative wages "priced out" low-skilled or "fringe" workers from the labor market and contributed to European unemployment.[3] This seems to be consistent with observations on which groups of workers are the hardest hit by unemployment.

However, although the mirror-image hypothesis has both a theoretical and casual empirical appeal, it is not possible to find unambiguous evidence to support it. See Nickell and Bell (1995), Nickell (1997), Card, Kramartz and Lemieux (1999) and

[2] Although many share the presumption that these factors result in rigid relative wages the relative importance of these different factors, the interaction between them and how they differ between countries is still not clear. The relative importance of these different factors, the interaction between them and how they differ between countries is still not clear. See Ljungqvist and Sargent (1998) for an analysis where wage rigidities come from labor supply.

[3] Davis (1998) provides an argument for that trade between the US and Europe may reinforce European unemployment.

Manacorda and Petrongolo (1999) on non-support and Fitzenberger and Franz (1997) for more supporting evidence for the case of Germany.[4] The lack of empirical evidence might result from that the relative wage rigidity has only small effects on unemployment and that these are overshadowed by unemployment caused by other factors such as macroeconomic shocks.[5] This implies that the empirical and the policy relevance of the hypothesis may be limited. On the other hand, if relative wage rigidity contributes significantly to European unemployment, which we argue in this paper, employment policies in Europe need to address this issue.

However, there are also other potential explanations as to why the hypothesis has not got unambiguous support. One reason may lie in a less than perfect relation between wage deciles and worker skill. The facts regarding the US are that differences among different wage deciles**,** workers with or without tertiary education and also within fairly narrow education and experience groups, have increased.[6] In both the Nickell and Bell and the Card *et al.* studies workers are classified according to years spent in education.[7] That proxy certainly does not coincide perfectly with wage deciles and is probably unrelated to inequality within groups. It may therefore give rise to measurement errors. The relations between education groups and wage deciles may be too vague or years spent in education may be too crude a measure of on-the-job skill. It may also be that institutions affect the proxy. Less generous US unemployment benefits may, for example, force an unemployed US worker with high level but obsolete education to accept an unskilled position. He would then drop out of the unemployment statistics (there is no information in the data as to whether a well-educated worker has a skilled work or not). In Europe, he would remain unemployed. Such a factor might inflate the European skilled unemployment figures

[4] Some authors take the hypothesis almost as self-evident, see Krugman (2000). However, the question about empirical relevance remains.
[5] European unemployment is hardly caused by rigid relative wages alone.
[6] The “college premium” has also increased.
[7] In the Card *et al.* study some additional criterion such as age and gender are also used.

relative to US ones, and hide potentially biased unemployment effects from SBTP and rigid relative wages.

Given potential problems with the studies, it seems premature to reject the relevance of the hypothesis altogether. However, further testing along the very same lines seems pointless since the data problems appear unresolvable. In this paper we therefore pursue an alternative strategy, namely to analyze the link between a measure of SBTP and aggregate unemployment directly. Hence, if SBTP has contributed significantly to low skilled or fringe worker unemployment then this effect should show up in aggregate unemployment if one controls for other explanatory factors.

To follow this approach it is necessary to obtain time series information on SBTP. However, although it is not controversial in the literature that technical progress has been skill-biased (see, for example Berman, Bound and Machin (1997)) it is nevertheless not possible to find direct time series indicators of SBTP. Our strategy therefore is to construct a measure of SBTP from productivity trends in manufacturing and services in EU countries and the US. Rough inspection of the data immediately gives the result that most TFP growth over the period 1970-95 has taken place in manufacturing (see Graph 1). We therefore use TFP in manufacturing as our proxy of SBTP. This of course requires first that the TFP growth is the result of technical progress and second that there is a monotonic relation between SBTP and TFP. As will be shown below, with rigid relative wages the second requirement is unambiguously true. On the first requirement, changed composition of manufacturing industries can increase the TFP measure without there being any technical progress, for example through imports of “low productive” manufacturing from NICs or outsourcing of low productive service activities. While both these factors have probably contributed to the observed TFP growth in manufacturing they are not likely to alter the observation that TFP growth has been stronger in manufacturing than in services.[8]

Moreover, TFP is essentially a factor neutral concept, not necessarily associated with SBTP. Under the assumption that there is no SBTP involved, relative wage changes caused by sector differences in TFP growth would come through changed commodity prices and changed balance between sectors of different skill intensities. However, from the fact that the per worker wage is higher in manufacturing than in services we infer that manufacturing is the more skill-intensive sector. Therefore the observed change towards the service economy would rather tend to reduce the wage difference between skilled and unskilled workers than to increase it. This indicates that technical progress entails a skill-biased element.[9] Finally, Kahn and Lim (1998) provide direct evidence for a strong empirical relationship between TFP and various measures of SBTP in US manufacturing, starting in the early 70's.

However, since the TFP measures change over the business cycle, for reasons that are unrelated to technical progress, the measure is distorted and the estimates may be biased downwards.[10] To mitigate this effect we use the observed co-movement of sectoral activity at business cycle frequencies and divide with TFP in services which reduce common business cycle components. It is important to notice that this explanation of the unemployment trend is in sharp contrast to popular alternative explanations, as suggested, for example, by Phelps (1994), which blame the downturn in productivity for the increase in unemployment.

Given the observed sectoral heterogeneity of TFP trends, it is appropriate to explore the relation between SBTP in manufacturing and unskilled unemployment within the framework of a two-sector two-skill-type of skills model. The two sectors

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[8] See ten-Raa and Wolff (2000) on US TFP growth in manufacturing and outsourcing in the 1980s. Ameco (a European Commission data base) shows that the import share from LDCs (excluding OPEC) has fallen since the 1960s.

[9] Lawrence and Slaughter (1993) argue that although the education premium has increased since the 1970s the share of college-educated workers has increased in almost all industries and indeed also the economy as a whole. The implication is that technical progress has been skill-biased.

are manufacturing and services and the two types of labor are skilled and unskilled workers. However, there are also theoretical reasons for developing the argument in a two-sector model. First, if the hypothesis is that SBTP and rigid relative wages price-out unskilled workers from the market, an aggregate analysis does not provide an answer as to why sectors that use unskilled workers intensively do not develop and eliminate unemployment. Second, aggregation of heterogeneous production technologies may make the distinction between skill biased and neutral technical progress meaningless.[11] Third, the stylized fact regarding the US, namely a fall in unskilled real wages, cannot be obtained in an aggregate model without assuming that technical progress lowers low-skilled marginal productivity.[12]

The paper makes a significant theoretical contribution by deriving, analytically, restrictions on technology required to generate changes in wage dispersions and unemployment as well as a fall in real wages of low skilled workers.[13] The empirical contribution is to provide a comparison of the explanatory power of the SBTP- wage rigidity hypothesis with other potential explanations, of which there are several, mostly derived from macroeconomics (see Bean (1994)). There has been a certain separation between purely macroeconomic hypotheses and the relative wage rigidity hypothesis. To our knowledge, no attempts to confront both explanations with each other exist, probably largely due to non-availability of long enough time series on employment, wages and unemployment by skill categories for EU countries.

The analysis proceeds as follows. Within the framework of the theoretical model we obtain a number of comparative static results for different types of technical progress and for different values of technology parameters. The SBTP-unemployment relationship is then tested econometrically. The empirical result is that the SBTP

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[10] It is also the case that TFP is procyclical while unemployment is countercyclical which also introduces a downward bias on the estimates.

[11] This would occur when technical progress is labor augmenting, the aggregate technology is Cobb-Douglas, while sector technologies are not.

[12] For the time period in question, the early 1970s and onwards, we find that a less attractive assumption.

measure is indeed an explanatory factor for unemployment in several European countries while, as predicted by the theoretical model, it has no explanatory power *vis-à-vis* the US. Moreover, it is a vital element in any explanation of European unemployment.

The paper is organized as follows. Section 2 contains the theoretical model. We describe the elements of the model and then discuss the production sector parameter conditions under which technical progress, together with flexible wages, gives rise to increased wage dispersion. Further restricting the parameters, the model produces falling real wages for unskilled workers. We then examine SBTP under rigid relative wages. We show that the model generates unemployment when it would have generated increased wage dispersion were relative wages flexible. That is the mirror-image hypothesis. However, the mirror image is not exact. Section 3 discusses the SBTP measure and tests the empirical hypothesis. Data and competing macroeconomic hypotheses are also described here. We elaborate on the econometric conditions required for reaching the conclusion on the empirical hypothesis. Section 4 summarizes and outlines some policy conclusions.

[13] In this area only numerical results on the basis of CGE models are obtained (see e.g.,Schimmelpfennig (1999).

2. The Model

a. Technology and Demand.

We consider a model where the roles of production factors other than labor are disregarded and labor supply is exogenous. Each worker supplies one unit of labor. In the flexible wages case the labor market clears for both types of workers and in the rigid relative wage case it clears for skilled labor. The numbers of unskilled and skilled workers are L_u and L_s, respectively.

The two commodities produced are manufactured goods and services, denoted *M** and *S**, respectively. The production functions in the two sectors are assumed to be CES and we write them as follows. $M^* = \left[(1-d_m)(q_{um}L_{um})^r + d_m(q_{sm}L_{sm})^r\right]^{\frac{1}{r}}$, $S^* = \left[(1-d_s)(q_{us}L_{us})^n + d_s(q_{ss}L_{ss})^n\right]^{\frac{1}{n}}$, where $r < 1$ and $n < 1$, and where L_{ij} is labor of type *i*, skilled or unskilled, in sector *j*, manufacturing or services. The augmentation factor of labor of type *i* in sector *j* is q_{ij} while d_m and d_s are the distribution parameters in the production functions. r and n are the parameters for the elasticity of substitution. Hence, the elasticity of substitution between unskilled and skilled labor in manufacturing is $s_M = 1/(1-r)$ and in services, $s_S = 1/(1-n)$.

The corresponding cost functions are:

(1)

$$c_m(w_u, w_s, d_m, q_{um}, q_{sm})M^* = M^*\left[(1-d_m)^{\frac{1}{1-r}}\left(\frac{w_u}{q_{um}}\right)^{\frac{r}{r-1}} + d_m^{\frac{1}{1-r}}\left(\frac{w_s}{q_{sm}}\right)^{\frac{r}{r-1}}\right]^{\frac{r-1}{r}}$$ and

(2)

$$c_s(w_u, w_s, d_s, q_{us}, q_{ss})S^* = S^*\left[(1-d_s)^{\frac{1}{1-n}}\left(\frac{w_u}{q_{us}}\right)^{\frac{n}{n-1}} + d_s^{\frac{1}{1-n}}\left(\frac{w_s}{q_{ss}}\right)^{\frac{n}{n-1}}\right]^{\frac{n-1}{n}}$$

where w_u and w_s are the wages of unskilled and skilled workers, respectively.

On the demand side we assume that workers have identical homothetic preferences. This implies that the distribution of income does not affect aggregate commodity demand. We write aggregate demand for manufacturing as follows $M = h(p_m, p_s)\lfloor w_u(L_u - u) + w\ L_s \rfloor$, where p_m and p_s are the commodity prices of manufacturing and services, respectively, u is the number of unemployed unskilled workers and $[w_u(L_u - u) + w_s L_s]$ is the aggregate income. It follows that demand for services is $S = \left[\frac{1 - h(p_m, p_s)p_m}{p_s}\right][w_u(L_u - u) + w_s L_s]$

b. Equilibrium.

Assuming that firms take commodity and factor prices as given, we have the following equilibrium relationship between commodity and factor prices, $p_m = c_m(w_u, w_s, \boldsymbol{d}_m, q_{um}, q_{sm})$ and $p_s = c_s(w_u, w_s, \boldsymbol{d}_s, q_{us}, q_{ss})$. That is, commodity prices equal marginal costs.

Through Shephard's lemma we obtain the following equilibrium conditions for the two labor markets. First, the unskilled labor.

(3) $$\frac{\partial c_m(w_u, w_s, \boldsymbol{d}_m, q_{um}, q_{sm})}{\partial w_u} M^* + \frac{\partial c_s(w_u, w_s, \boldsymbol{d}_s, q_{us}, q_{ss})}{\partial w_u} S^* = L_u - u\,.$$

Second, the skilled labor.

(4) $$\frac{\partial c_m(w_u, w_s, \boldsymbol{d}_m, q_{um}, q_{sm})}{\partial w_s} M^* + \frac{\partial c_s(w_u, w_s, \boldsymbol{d}_s, q_{us}, q_{ss})}{\partial w_s} S^* = L_s\,.$$

Equilibrium on commodity markets implies that $M^* = M$ and $S^* = S$.

Note that without loss of generality one wage or one price can be normalized to one. We choose to set the wage of unskilled workers equal to one and to denote the wage of skilled workers *w*. In equilibrium the essential two endogenous variables, *w* and *u* are related as follows.

(5)

$$\left\{\left[\frac{c_{mw}(1,w,\boldsymbol{d}_m,q_{um},q_{sm})}{c_m(1,w,\boldsymbol{d}_m,q_{um},q_{sm})} - \frac{c_{sw}(1,w,\boldsymbol{d}_s,q_{us},q_{ss})}{c_s(1,w,\boldsymbol{d}_s,q_{us},q_{ss})}\right] h(c_m,c_s)c_m + \frac{c_{sw}(1,w,\boldsymbol{d}_s,q_{us},q_{ss})}{c_s(1,w,\boldsymbol{d}_s,q_{us},q_{ss})}\right\}\left[L_u - u + wL_s\right] = L_s$$

where $c_{mw} = \frac{\partial c_m}{\partial w_s}$ and $c_{sw} = \frac{\partial c_s}{\partial w_s}$.

Note also that with a flexible wage, *w,* there exist an equilibrium with no unemployment, that is $u = 0$.

c. Skill-Neutral Technical Progress and Flexible Wages

Skill-neutral technical progress implies that either $q_{sm} = q_{um}$ or $q_{ss} = q_{us}$ or both. It is now easy to verify that the general equilibrium effect on the wage dispersion of skill-neutral technical progress is as follows when production of commodity *i* is more skill intensive than production of the other commodity and $\boldsymbol{h}_i$ is the absolute value of the price elasticity of commodity *i* (for derivation see Appendix a).

(6) $$\frac{dw}{dn_i}\begin{cases} > 0 \\ = 0 \\ < 0 \end{cases} \text{as} \begin{cases} \boldsymbol{h}_i > 1 \\ \boldsymbol{h}_i = 1 \\ \boldsymbol{h}_i < 1 \end{cases}$$, where n_i is the neutral technical progress.

Hence, in the case where manufacturing is the more skill intensive commodity, wage dispersion increases (decreases) when the price elasticity is (in absolute value) larger (smaller) than one.[14] The mechanism is that technical progress lowers marginal cost and the price of manufacturing which increases or decreases the size of the manufacturing production depending on whether the price elasticity is larger or smaller than one. In the case manufacturing production increases the relative demand for skilled worker increases which increases the wage difference. When preferences are Cobb-Douglas, wage dispersion is unaffected by neutral technical progress, irrespectively of the relative skill-intensities in the two sectors.

Considering the development towards the service economy in both the US and the EU, which within the framework of our sectoral aggregation, taken alone would imply a reduced wage difference, we do not want to emphasize the role of commodity demand. In the following we therefore assume Cobb-Douglas preferences.

d. SBTP and Flexible Relative Wage

Our framework potentially covers two types of SBTP. One is where technical progress changes the distribution parameters, $\boldsymbol{d}_i$, $i = m, s$, and the other where it changes the efficiency parameters, q_{ij}, $i = m, s$ and $j = u, s$. In the latter case we consider only increases since decreases are associated with technical regress which we regard to be an implausible hypothesis for the time period in question. From the outset it is clear that SBTP that give rise to increased wage dispersion has to increase demand for skilled labor relative to that of unskilled labor. An increase of the share parameter of skilled labor, in any of the two sectors, would under some parameter constellations both increase skill intensity and lower cost, at given wages. That would imply a relation between productivity change and relative wages. Such a relation can also be generated with the labor augmenting SBTP. It is therefore not very restrictive to deal only with the latter form of SBTP.

The first issue considered is how SBTP affects wage dispersion. From (5) we immediately obtain the following equation.

$$\text{(6)} \qquad \frac{dw}{dq_{sm}} = \frac{-\dfrac{\partial}{\partial q_{sm}}\left[\boldsymbol{a}\dfrac{c_{mw}}{c_m}\right](L_u + wL_s)}{\dfrac{\partial}{\partial w}\left[\left\{\boldsymbol{a}\dfrac{c_{mw}(1, w, \boldsymbol{d}_m, q_{um}, q_{hm})}{c_m(1, w, \boldsymbol{d}_m, q_{um}, q_{hm})} + (1-\boldsymbol{a})\dfrac{c_{sw}(1, w, \boldsymbol{d}_s, q_{us}, q_{hs})}{c_s(1, w, \boldsymbol{d}_s, q_{us}, q_{hs})}\right\}(L_u + wL_s)\right]}$$

where $\boldsymbol{a}$ is the constant budget share of manufacturing. Note that at a stable equilibrium, the denominator is negative. Since SBTP essentially reduces the price of

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[14] The wage per employee is higher in manufacturing than in services which indicates that the share of skilled workers is higher in manufacturing.

factors, in this case skilled labor, SBTP increases (decreases) the wage dispersion as the elasticity of substitution is larger (smaller) than one, that is, $r > (<) 0$. Note that the relative skill-intensity between the two sectors does not affect the qualitative result. From a theoretical point of view it is therefore not essential that SBTP occurs in manufacturing.

However, at this level of generality it does not seem possible to analytically explore how sector heterogeneity with regard to elasticity of substitution affects the magnitude of the relative and real wage change. To explore these issues, we further specialize the model. Hence, we make the following specific assumptions. The production function for services is $2L_{us}^{1/2} L_{ss}^{1/2}$, that is $n = 0$.[15] The share parameter in the utility function is ½. The share parameter, d_m is 1/2. All the labor-augmenting factors are 1 at the outset. The supply of skilled labor equals that of unskilled labor, normalized to one.

With the above simplifications, we write the market clearing conditions on the commodity markets as follows.

(7) $$M = \frac{1}{2}\frac{[1+w]}{c_m}$$

(8) $$S = \frac{1}{2}\frac{[1+w]}{c_s}$$

The market clearing condition for skilled labor is

(9) $$\frac{\partial c_m}{\partial w_s} M + \frac{\partial c_s}{\partial w_s} S = 1$$

Inserting (7) and (8) into (9), and making use of the particular functional forms on production functions give us the following relation among the relative wage, unskilled unemployment and SBTP.

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[15] The cost function in the service sector then is $c_s = \sqrt{w} * S$.

(10) $$\frac{1}{2}\left(\frac{\left(\frac{w}{q_{sm}}\right)^{\frac{r}{r-1}}}{w+w\left(\frac{w}{q_{sm}}\right)^{\frac{r}{r-1}}}+\frac{1}{2}\frac{1}{w}\right)(1+w)=1$$

It is easy to see that for $q_{sm}=1,\ w=1$ satisfies (10) for all r. Differentiation of (10) with respect to the labor-augmenting factor while maintaining market clearing yields the following response of wage dispersion.

(11) $$\left.\frac{dw}{dq_{sm}}\right|_{\substack{q_{sm}=1\\ w=1}}=\frac{-r}{r-2}=\frac{s_M-1}{1+s_M}$$

Hence, the wage dispersion is clearly increasing in the elasticity of substitution in manufacturing. The intuition for this result is that when the elasticity of substitution is larger than one in manufacturing, the productivity shock will create excess demand for skilled labor, which will be eliminated through an increase in the relative wage. In the case where the elasticity of substitution small in the service sector, a large wage increase would be needed to eliminate excess since demand for skilled labor from the service sector would in that case be unresponsive to the wage increases.[16] In the case where the elasticity of substitution is high in the service sector the wage increase can be smaller since the demand for skilled labor from that sector would be responsive to wage increases.

Having explored the relation between the elasticity of substitution in manufacturing and the responsiveness of the relative wage to SBTP we now turn to the real wage or utility. How individual utility responds to such technological development depends on how commodity prices and income change.

For any indirect utility function, $V=V(p_m(q_{sm}),p_s(q_{sm}),w(q_{sm}))$, we can write the change in utility as follows.

(12) $$\frac{dV}{dq_{sm}} = -\frac{\partial V}{\partial w} w \left[\theta_m \frac{\frac{dp_m}{dq_{sm}}}{p_m} + \theta_s \frac{\frac{dp_s}{dq_{sm}}}{p_s} - \frac{\frac{dw}{dq_{sm}}}{w} \right],$$

where θ_m and θ_s are the budget shares. Using the equilibrium value of w and evaluating at $q_{sm} = 1,$ we have that the sign of the utility change of the low skilled is determined by the following condition.

(13) $$sign\left(\frac{dV^u}{dq_{sm}}\right) = -sign\left(2\frac{dw}{dq_{sm}} - 1\right) = -sign\left(2\frac{-\rho}{\rho - 2} - 1\right)$$

The implications of (13) is that the utility of the unskilled will be positively affected by SBTP for □ *<2/3* and negatively affected whenever □ *>2/3.* In terms of elasticities of substitution, unskilled real income increases when $\sigma_S = 1$ and $\sigma_M < 3$ and decreases when $\sigma_S = 1$ and $\sigma_M > 3$. The utility effect on the skilled workers of the SBTP is always positive.

Hence, the labor augmenting SBTP generates larger increases in wage dispersion the larger is the dispersion of substitution elasticities between the two sectors. A low elasticity of substitution in services has the effect that the price of services increases strongly since the relative wage of skilled labor increases more strongly and skilled labor cannot easily be substituted. This tends to decrease utility of both types of workers. A lower price of manufacturing compensates for this effect for both types of workers but the former effect may dominate the latter and make unskilled workers worse off. Skilled workers will always be better off since they will also get a higher wage. The conclusion is that the model is in principle able to produce the observed increased wage differences and the fall in unskilled real wages

[16] This intuition can be verified through alteration of the technology in the service sector. Hence, a Leontieff technology gives the largest wage response.

in the US, without assuming that technical progress lowers unskilled marginal productivity.

e. Unemployment, SBTP and Rigid Relative Wage.

From the analysis it is obvious that, for Cobb-Douglas preferences, skill neutral technical progress would lead to a reallocation of factors between sectors. It follows that equilibrium can be sustained with the relative wage unchanged. It follows that it would not cause unemployment. Therefore we consider only SBTP.

From (5), with the Cobb-Douglas preferences assumption and fixed relative wage we obtain.

(14) $$u = (1+w) - \left[\mathbf{a}\frac{c_{mw}}{c_m} + (1-\mathbf{a})\frac{c_{sw}}{c_s} \right]^{-1}$$

Taking a linear approximation, around the current wage, w^*, and $q_{sm} = 1$, of the second term on the R.H.S. of (14) yeilds.

(15)

$$\left[\mathbf{a}\frac{c_{mw}}{c_m} + (1-\mathbf{a})\frac{c_{sw}}{c_s} \right]^{-1} \approx \left[\mathbf{a}\frac{c_{mw}}{c_m} + (1-\mathbf{a})\frac{c_{sw}}{c_s} \right]^{-1} \Bigg|_{\substack{q_{sm}=1 \\ w=w^*}} - \left[\mathbf{a}\frac{c_{mw}}{c_m} + (1-\mathbf{a})\frac{c_{sw}}{c_s} \right]^{-2} \mathbf{a} \left[\frac{\partial \frac{c_{mw}}{c_m}}{\partial q_{sm}} \right] (q_{sm} - 1)$$

Inserted into (14) we obtain the following relationship between unemployment and technical progress.

(16) $$u = \mathbf{b} + \mathbf{g}\, q_{sm}$$

where $\mathbf{b} = u^* + \left[\mathbf{a}\frac{c_{mw}}{c_m} + (1-\mathbf{a})\frac{c_{sw}}{c_s} \right]^{-2} \mathbf{a} \left[\frac{\partial \frac{c_{mw}}{c_m}}{\partial q_{sm}} \right]$ ($u*$ is the observed unemployment) and

$$g = \left[a \frac{c_{mw}}{c_m} + (1-a) \frac{c_{sw}}{c_s} \right]^{-2} a \left[\frac{\partial \frac{c_{mw}}{c_m}}{\partial q_{sm}} \right]$$ (see, Appendix b for an explicit equation for

$\frac{\partial \frac{c_{mw}}{c_m}}{\partial q_{sm}}$)

Hence, when there is SBTP in manufacturing, or in fact any sector where the elasticity of substitution between skilled and unskilled labor is larger than one, the model predicts a positive relation between unemployment and SBTP. Hamermesh (1993) estimates a substitution elasticity of around 3 for US manufacturing.[17]

3. Empirical Evidence

As shown in the last section, the relative wage rigidity hypothesis (RWR) makes two important predictions. First, skill biased technical progress together with relative wage rigidity implies a positive correlation between SBTP in a sector where the substitution elasticity is larger than one and the aggregate unemployment rate, provided developments in the other sector are not counteracting this effect. Second, if relative wages are flexible, skill biased technical progress does not affect the trend unemployment rate. Given the empirical evidence on wage dispersion in the US and Europe (see, for example Freeman and Katz (1995)) we would therefore expect a significant relationship between unemployment and SBTP in manufacturing in EU countries, and the absence of such a relationship for US data. However, to our knowledge, there are no directly available data on SBTP. We therefore exploit the relationship between SBTP and the usual Solow TFP (total factor productivity) measure. Two requirements must be met for TFP to be a reasonable proxy variable for

[17] Note that should we not have assumed Cobb-Douglas preferences, a price elasticity of demand for manufacturing below one would have reduced the increase in unemployment from SBTP. When that effect dominates the effect via the production technology, SBTP with flexible wages would have produced reduced wage differences. Considering the US development we do not pay attention to this possibility.

SBTP. First, TFP must be positively correlated with SBTP. Second, in order to minimize the measurement error the influence of other factors that are unrelated to SBTP must be small. As discussed in the introduction there are two other potential sources than SBTP which could influence TFP, namely changes in the composition of employment and either neutral or general labor augmenting technical progress. In the following we discuss the relation between SBTP and TFP.

Under the assumption that the technology can be approximated by a Cobb Douglas production function[18] in aggregate labor and capital an index for TFP as conventionally defined is given by

(17) $$TFP = \frac{\left(\left[(1-\boldsymbol{d}_m)(q_{um}L_{um})^r + \boldsymbol{d}_m(q_{sm}L_{sm})^r\right]^{\frac{1}{r}}\right)^a K^{1-a}\Gamma}{\left(L_{um}+L_{sm}\right)^a K^{1-a}}.$$

Note that no distinction is made between skilled and unskilled employment in the denominator of the TFP measure; only total employment is used. K is the capital stock and Γ stands for neutral technical change.[19] Γ not only captures technology trends but also cyclical variations of productivity, which are due to fluctuations in capacity utilization. Note that (17) can be rewritten as follows.

(18) $$TFP = LP^a\Gamma, \text{ where}$$

(19) $$LP = \frac{\left[(1-\boldsymbol{d}_m)(q_{um}L_{um})^r + \boldsymbol{d}_m(q_{sm}L_{sm})^r\right]^{\frac{1}{r}}}{L_{um}+L_{sm}}.$$

By using the cost function (1) we write (19) as follows.

$$LP = \frac{\left[(1-\boldsymbol{d}_m)(q_{um}\frac{\partial c_m}{\partial w_u}M)^r + \boldsymbol{d}_m(q_{sm}\frac{\partial c_m}{\partial w_s}M)^r\right]^{\frac{1}{r}}}{\frac{\partial c_m}{\partial w_u}M + \frac{\partial c_m}{\partial w_s}M} = \frac{1}{\frac{\partial c_m}{\partial w_u}+\frac{\partial c_m}{\partial w_s}}.$$ By

[18] Given the near constancy of the wage share in output the Cobb Douglas assumption seems to be justified as an approximation.
[19] With a Cobb Douglas specification a distinction between neutral and labor augmenting technical progress is not necessary.

differentiating with respect to q_{sm} we obtain $\frac{dLP}{dq_{sm}} = \frac{-\frac{d}{dq_{sm}}\left(\frac{\partial c_m}{\partial w_u} + \frac{\partial c_m}{\partial w_s}\right)}{\left(\frac{\partial c_m}{\partial w_u} + \frac{\partial c_m}{\partial w_s}\right)^2}$ where the numerator always is positive[20]

It is interesting to note that with rigid relative wages, the trend in TFP does only depend on changes in the two labor augmenting factors and Γ since the composition of employment also only depends on the labor augmenting factors. TFP is unambiguously positively correlated with Γ and q_{sm}. With flexible wages such a monotonic relationship between TFP and factor biased technical progress would not necessarily hold.

Thus, to the extent to which technical progress in manufacturing is skill biased, TFP as measured conventionally should be a reasonable indicator of SBTP. Of course we cannot exclude the possibility of neutral technical progress, which would induce a downward bias on our estimates. However, there are three reasons why Γ is likely to play only a minor role in the regressions. The first is empirical. As the paper by Kahn and Lim shows, there has been positive neutral technical progress in the 60's. However, starting in the early 70's, growth of neutral technical progress has ceased. Second, to the extent that Γ captures utilization rates of labor and capital it is a stationary variable since it only captures business cycle fluctuations and therefore it cannot explain the trend increase in the unemployment rate. Third, we use the ratio of TFP in manufacturing (TFP^M) and services (TFP^S), to eliminate neutral technical changes which are common to both sectors. This implies that changes in prices of intermediate inputs, improvements in infrastructure etc., will at least partly be

[20] In the case where $q_{um} = q_{sm} = 1$, it is

$$\frac{-1}{1-r}\left(d_m^{\frac{1}{1-r}} w^{\frac{1}{r-1}} \left((1-d_m)^{\frac{1}{1-r}} + d_m^{\frac{1}{1-r}} w^{\frac{r}{r-1}}\right)^{\frac{r-1}{r}} \left((1-d_m)^{\frac{1}{1-r}}(r-w) + d_m^{\frac{1}{1-r}}(r-1) w^{\frac{r}{r-1}}\right)\right) > 0$$

, since $r < 1$ and $w \geq 1$.

eliminated. In order to test the effect of SBTP we formulate the following regression equation

$$LUR = \pi \frac{TFP^M}{TFP^S} + \gamma' X + \varepsilon \qquad (20)$$

where LUR is the total unemployment rate and X is a vector of other possible explanatory variables and ε is an error term.

Controlling for other explanatory factors when estimating the relationship between TFP and the unemployment rate seems advisable since there are many different theories that seek to explain the high unemployment and especially its trend increase since the beginning of the 70s in EU countries. Testing the RWR hypothesis while controlling for other potentially relevant factors is also useful since the explanation provided by the RWR hypothesis does not claim to be exhaustive. Other independent causes for the rise in unemployment stressed by the various macroeconomic explanations may exist and complement this hypothesis. In fact, it may very well be that the explanation of unemployment put forward in this paper may not stand up against standard macroeconomic explanations. This suggests that it is useful to pay particular attention to the robustness of our estimation results, by including sets of explanatory factors implied by alternative theories in the regression analysis. For this purpose we broadly classify the alternative explanations into three groups and list the favorite explanatory variables suggested by these views.

The first group of explanations is based on other imperfections on the labor market than relative wage rigidity. The sources for these imperfections can broadly be the following. They can arise from bargaining power of workers and trade unions (see, for example, Nickell and Andrews (1983), Lindbeck and Snower (1988) and Blanchard (1991)), from search and labor adjustment frictions (see, for example, Pissarides (1990) and Bentolila and Bertola (1990)) or from efficiency wages (see, for example, Shapiro and Stiglitz (1984) and Weiss (1991)). In a recent paper, Pissarides (1998) has presented these alternatives in a common framework and has shown that in all three variants, the net replacement ratio is a major explanatory factor for the unemployment rate. In a number of recent papers this hypothesis has been tested (see, for example, Daveri and Tabellini (1995)).

Another group of explanations, mainly advanced by Phelps (1994) but also by Manning (1992), can be called ‘Structuralist’ approach. It puts emphasis on wider economic conditions such as the decline in the rate of productivity growth and/or the rise of real interest rates - though it does not exclude explanations such as the welfare state and tax pressure. Thus, the observed decline in the growth rate of technical progress and the increase in real interest rates are prime suspects for an explanation of unemployment in Europe. Hoon and Phelps (1997) provide an explanation of Europe’s unemployment along these lines as well as some empirical evidence in support of this view. Examples of this position also appear in the traditional Philips curve literature where it is often claimed that the slow-down in productivity growth could be responsible for an increase in unemployment (see, for example, Bean (1994)). According to the Structuralist view, favorite explanatory variables are the growth rate of technical progress approximated by TFP or growth rate of GDP and real interest rate.

Yet another group of explanations which is popular among European economists can be labeled ‘Capital Shortage’ hypothesis (see, for example Burda (1989) for an exposition and some empirical evidence). This theory argues that the increase in unemployment in Europe is related to a lack of investment, i. e., an insufficient provision of work places, which complement physical investment. The hypothesis leaves unspecified the reasons for the decline in investment, though among its proponents (e. g. Malinvaud (1980)) the decline in profitability is generally regarded as the most significant reason. In that sense it may not be completely independent from the previous two explanations. For example, the decline in profitability may be due to tax induced wage pressure but it could also arise from a slow-down in technical progress or an increase in real interest rate. This view implies that the unemployment rate should be significantly correlated with the investment to output ratio or the growth rate of GDP. There exists some controversy as to whether slower growth can be regarded as a causal factor for Europe's unemployment problem. Olson (1995), for example see slower growth and unemployment as jointly determined by sclerotic economic institutions.

To make the relative wage rigidity hypothesis and the alternatives operational, we construct the following variables. Relative TFP (TFPMS) between manufacturing and services is calculated as a weighted average of TFP in manufacturing, electricity, gas, water, transport and communication divided by a weighted average of TFP in wholesale & retail trade, financial institutions and insurance, community social and personal services. The time series are taken from OECD's International Sectoral Database (ISDB). As a proxy for the net replacement rate (NETREP) we use the OECD gross replacement rate adjusted for labor taxes. (European Commission, DG II Tax Database). As a measure for technical progress we use the growth rate of business sector TFP. Real interest rates are calculated *ex-post* by subtracting the rate of consumer price inflation from the nominal long-term interest rate. Finally we use the business sector investment ratio to represent the capital shortage hypothesis.

Before turning to the empirical results we discuss issues of data adequacy and measurement error. None of the explanatory variables (this is also true to some extent for the unemployment rate itself) represents the theoretical hypothesis adequately. Our definition of relative productivity growth implies, for example, that we have identified low growth and high productivity growth sectors correctly and that there is no change in this classification over time. While it is probably correct that at the beginning of our sample period, productivity growth primarily took place in manufacturing industries, modern computer technology now also leads to large technical advances in some service sectors. Therefore our simple classification into manufacturing and services at a high level of aggregation may not be completely adequate and a more sophisticated classification, using information from the 3-digit level may be desirable. We also use the standard definition of TFP to measure technical progress. Here it must be noted that the concept underlying this measurement is neutral technical progress. To measure skill biased technical progress the standard TFP measure should be divided with the factor share of the input that is subject to productivity improvements. In the absence of adequate data we must assume that there is a relatively smooth evolution of factor shares over time. For standard aggregate production technologies this does not seem to be too strong an assumption, nevertheless it induces some measurement error.

Also the fiscal measures and here especially the net replacement rate are plagued by measurement errors and simultaneity problems. For example, the net replacement rate can be low when unemployment is high because of a composition effect. If the increase in unemployment is concentrated among low skilled workers, then the average wage may increase. It is also difficult to select the wage level to which unemployment benefits should be compared to and finally unemployment benefits only capture part of the social benefits unemployed households may be entitled to. All these factors can exert major downward biases on the estimate.

As shown in Table 1, all these alternative explanations do have some empirical appeal in the sense that the suggested explanatory variables have moved in directions, which are broadly consistent with an increase in the unemployment rate. For example, there is a significant increase in the long-term real interest rate especially in EU countries. The net replacement ratio and labor taxes have risen in all countries except the UK. The investment to output ratio as well as the growth rate of GDP and of technical progress has fallen in all countries. Also, in all countries we observe a strong relative increase in the level of total factor productivity of the manufacturing sector relative to services.

Insert table 1 here

Testing the Order of Integration:

A further preliminary statistical check of the adequacy of the selected variables consists in checking the order of integration of the unemployment rate and the one hand and the individual regressors by running ADF tests over the period 1970 to 1992/95. As shown in Table 2, we find that except for the US, the unit root hypothesis cannot be rejected for the unemployment rate at the 5% level, suggesting that the unemployment rate exhibits a stochastic trend in Europe. A necessary condition for the selected explanatory variables to provide an explanation for the trend increase of the unemployment rate is that they are integrated as well. We find that this condition is met for relative TFP, the investment to output ratio, the real interest rate and the net replacement ratio. There is mixed evidence on the presence of unit roots for the growth rate of TFP. The growth rate of GDP seems to be a stationary variable, except for France. Stochastic properties of the data differ somewhat for the US, where also the net replacement ratio and the investment to output ratio are stationary variables.

This data analysis suggests that TFPMS, IY, R, NETREP, and GTFP are potential candidates for an explanation of the long run trend of European unemployment in our data set. The results for the US provide a first confirmation of the prediction of our model, namely that with relative wage flexibility, there does not seem to be a link between the trend in the unemployment rate and sectoral divergences in technical progress. In the US case, potential candidates for an explanation of fluctuations in the unemployment rate are therefore the net replacement ratio and the investment to output ratio.

Insert table 2 here

Regression Results:

This section provides a more systematic comparison of the explanatory power of the RWR hypothesis in relation to the alternatives. In order to check the robustness of the RWR hypothesis we run regressions between the unemployment rate and relative TFP under alternative conditioning sets of variables (we restrict ourselves to 3 variables per regression). We regard the RWR hypothesis as a robust explanation of the change in the unemployment rate if the TFPMS variable meets the following conditions: First, there exists a combination of explanatory variables such that unemployment and TFPMS are cointegrated for EU countries and TFPMS is significant. Second, if there exist other cointegrating relationships, excluding TFPMS, then TFPMS remains significant when added to that list of regressors. Third, conditional on passing the cointegration test, TFPMS is significant and has the correct sign. Finally we do not expect the US unemployment rate to be significantly affected by TFPMS or in other words, the three conditions postulated for TFPMS in the case of Europe should not hold for the US.

As can be seen from Table 3, the three conditions for TFPMS are fairly well met for the large continental EU countries. We obtain a very striking result for Italy, where TFPMS is cointegrated with the unemployment rate for all conditioning variables. In the case of, West Germany and France cointegration holds at least for one combination of variables which includes TFPMS. For France, this combination consists of the variables TFPMS, IY and R, while in the case of Germany, this combination of variables is given by TFPMS, R and NETREP.[21] Cointegration cannot be found at the usual significance levels for the set of combinations of variables excluding TFPMS, except in the case of Italy where the combination of IY, R and NETREP also suggests a cointegrating relationship with the unemployment rate. In this case the regression can, however be improved by adding TFPMS. In this case, the

[21] The critical values for the cointegration tests are taken from MacKinnon (1991). The 5% and 10% critical values for a regression with three variables is –3.74 and –3.49 respectively .

net replacement ratio becomes insignificant. For the UK the results of the cointegration tests are less convincing. However, even in this case one should notice that cointegration can be rejected more strongly if one excludes TFPMS.

The regression results for France, Germany and Italy also suggest that this effect is quantitatively important. Skill biased technical progress could explain an increase of the aggregate unemployment rate in these countries between 3.5 and 5 percentage points. In the case of the US we observe that it is mostly the net replacement ratio which exerts an effect on the US unemployment rate, while TFPMS is not significant and changes sign. Also, compared to Europe the regression coefficient is substantially smaller. Our result concerning the significance of the net replacement ratio for US unemployment seems to be somewhat in contrast to other results obtained for the US (see, for example Daveri and Tabellini (1995)). [22] Finally, it is interesting to look at the other explanatory variables. It seems that IY also is a fairly robust regressor for Europe, since it is significant in most appearances. This is especially the case for France and Italy while this variable is marginally significant in the case of Germany and the UK. About 4 percentage points of the increase in French unemployment could be due to a decline in the investment to output ratio. Similarly, the decline in the investment to GDP ratio could be responsible for a 1.6 percentage point increase of the Italian unemployment rate. The interest rate is also robust concerning the sign and also appears in cointegrating regressions as explanatory variable in the case of France, Germany and Italy. It is nearly cointegrated with the unemployment rate, together with IY and TFPMS in the UK. However, the regression results also suggest that it has played a minor role. Only an increase in the interval between 0.1 and 1 percentage point could be explained

[22] It is often argued that the presence of tax effects for the US labor market would be inconsistent with the US labor market being competitive. This is, however, not necessarily the correct interpretation. Such statements are rather based on the assumptions that labor supply is very elastic in the US. In fact, bargaining models of the labor market would predict the opposite, namely that unemployment in labor markets with little or no bargaining strength for workers should be more sensitive to variations in the net replacement rate because firms are able to set wages closer to the reservation wage.

from the estimated coefficients. The net replacement ratio is most significant in France, a more fragile regressor in the other EU countries and exhibiting the wrong sign in Germany. As noted above, measurement error could be an explanation. It is also interesting that the growth rate of technical progress changes sign depending on the combination of regressors and thus cannot be regarded as a robust explanatory factor for EU unemployment

Insert table 3 here

4. Concluding Comments

This paper has looked at the effects of skill biased technical progress in a two sector, two skill model. Skilled-biased technical progress, together with rigid relative wages, is shown to cause unemployment under conditions where wage dispersion would have increased were relative wages flexible. The model shows a positive relation between the ratio of productivity growth in the two sectors and aggregate unemployment when relative wages are rigid, and that the two variables are unrelated when they are flexible. Econometric testing shows that TFP growth differentials between the manufacturing and services sectors can explain an increase of the unemployment rate in the large continental EU countries of up to 5 percentage points. This result is fairly robust in that the hypothesis is not rendered void by inclusion of alternative explaining variables such as the net replacement ratio, the real interest rate, the investment to output ratio or the growth rate of GDP.

The implications for European employment policy are threefold. Firstly, if it is deemed desirable to avoid letting the wage dispersion increase, two types of policies are potentially efficient. The first is to change the workforce composition. Measures such as education, skill upgrading and, possibly, early retirement are familiar to the EU-countries. Early retirement is probably the more extensively used although the least attractive policy. With regard to education and skill upgrading, there are some important issues. One is the balance between measures that are preventive to unemployment and measures that take workers out of unemployment. Another is to what extent education should be geared to the unemployed and to what extent it should be geared to skill upgrading of employed workers who are virtually without risk of becoming unemployed but who's skill upgrading indirectly creates employment opportunities for the less skilled. The second type of policy would be to alter the balance of commodity demand in favor of those sectors with a potential to absorb the unemployed workers, such as the services sector. Such a policy requires either that the use of inputs in the employment-intensive sectors or their outputs be subsidized (or less taxed). The latter method explains in part how Sweden avoided unemployment for such a long time; public production of services increased strongly in Sweden in the 1970s and 1980s. It should be noted that these policies, while mitigating the unemployment problem, also entail efficiency losses. Should it be deemed desirable and feasible to increase the dispersion of wage costs, reductions or increases of payroll taxes on certain types of labor may be useful, but it should be balanced against the cost of increased progressivity of the tax systems implied by relatively lower payroll or income tax rates for low income earners.[23] Considering that the elasticity of substitution between skilled and unskilled workers is likely to be higher in manufacturing than in services, such a policy would, without large sector size changes, create more unskilled jobs in manufacturing. Thirdly, a plain increase in income dispersion is also a possibility. In Europe such a policy would certainly create significant social tensions since it would probably have to be achieved through labor market organization reforms. However, it would also entail several efficiency-enhancing aspects such as strengthening incentives to obtain valuable skills and education, and to supply valuable labor to the market.

While the policies outlined above may mitigate the problem, it is useful to consider which of them would be potentially viable in the long-term, if SBTP continues as before. Our belief is that the tax and subsidy policies, least painful in the short-run, may be the least suitable in the long-term as they imply increasing efficiency losses. Should such efficiency losses be considered too high a price for reduced unemployment, the remaining alternatives would be some combination of increased income dispersion on the one hand, and education and skill-upgrading on the other. The former would increase the personal incentives for the latter and education and skill-upgrading would hold back increases in wage dispersion.

[23] See Sørensen (1997) for a discussion about tax solutions to the unemployment problem.

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Appendix

(a)

Setting $q_{sm} = q_{um} = q$, from equation (5) we obtain

$$\frac{dw}{dq} = \frac{-\left\{\left[\frac{c_{mw}}{c_m} - \frac{c_{sw}}{c_s}\right]\left(\frac{\partial h}{\partial c_m}\frac{\partial c_m}{\partial q}c_m + h\frac{\partial c_m}{\partial q}\right)[L_u + wL_s]\right\}}{\frac{\partial}{\partial w}\left\{\left\{\left[\frac{c_{mw}}{c_m} - \frac{c_{sw}}{c_s}\right]h(c_m, c_s)c_m + \frac{c_{sw}}{c_s}\right\}[L_u + wL_s]\right\}}$$

or

$$\frac{dw}{dq} = \frac{-\left\{\left[\frac{c_{mw}}{c_m} - \frac{c_{sw}}{c_s}\right]\left(\frac{\partial h}{\partial c_m}\frac{c_m}{h} + 1\right)h\frac{\partial c_m}{\partial q}[L_u + wL_s]\right\}}{\frac{\partial}{\partial w}\left\{\left\{\left[\frac{c_{mw}}{c_m} - \frac{c_{sw}}{c_s}\right]h(c_m, c_s)c_m + \frac{c_{sw}}{c_s}\right\}[L_u + wL_s]\right\}}$$

where $-\frac{\partial h}{\partial c_m}\frac{c_m}{h} = \boldsymbol{h}_m$. Since an increase in q increases the productivity of both factors, it is obvious that $\frac{\partial c_m}{\partial q} < 0$.

(b)

For the case where $w_s = w, w_u = 1, q_{sm} = 1$ and $q_{um} = 1$, we have

$$\frac{\partial \frac{c_{mw}}{c_m}}{\partial q_{sm}} = \frac{\boldsymbol{r}((1-\boldsymbol{d}_m)\boldsymbol{d}_m)^{\frac{1}{1-r}} w^{\frac{1}{r-1}}}{(1-\boldsymbol{r})\left[(1-\boldsymbol{d}_m)^{\frac{1}{1-r}} + \boldsymbol{d}_m^{\frac{1}{1-r}} w^{\frac{r}{r-1}}\right]^2} > (<) 0$$ as $\boldsymbol{r} > (<) 0$. Hence the cost share of skilled labor increases (decreases) if the elasticity of substitution is larger (smaller) than one.

TABLE 1: Trends

	FRANCE	WEST GERMANY	ITALY	UNITED KINGDOM	UNITED STATES
LUR	8.97	5.08	6.15	4.25	1.03
TFPMS	44.27	18.05	50.23	42.05	33.62
GTFP	-2.29	-0.62	-0.84	-2.71	-1.43
GY	-4.38	-3.21	-2.89	-1.59	-0.66
IY	-5.41	-5.53	-8.26	-3.11	-0.44
R	2.90	2.30	2.90	2.20	1.40
NETREP	28.24	3.25	3.24	-7.59	1.75

(Period: 1970-1995 and 1970-1992 for Germany)

TABLE 2: Unit Root Tests

	FRANCE		GERMANY		ITALY		UNITED KINGDOM		UNITED STATES	
	t-Coint	DW	t-Coint	DW	t-Coint	DW	t-Coint	DW	t-Coint	DW
LUR	-0.99	1.89	-1.62	1.57	-0.17	1.82	-1.99	1.46	-3.50	1.84
TFPMS	-1.82*	1.90	-2.11	2.04	-1.74*	2.02	-0.60	1.88	-0.64	1.93
GTFP	-2.83	2.12	-4.21	2.02	-3.78	2.00	-3.70	2.08	-4.09	1.96
GY	-2.40	2.12	-3.96	2.04	-5.42	1.83	-3.80	2.05	-5.31	2.09
IY	-1.66	1.79	-1.85	1.77	-1.80	1.55	-2.57	1.96	-4.47	1.93
R	-1.31	1.81	-2.50	1.97	-1.45	1.96	-2.00	1.99	-2.25	1.79
NETREP	-0.79	1.61	-2.12	1.69	-0.44	1.56	-1.42	1.70	-2.86	1.61

(*): time trend included
5%:-3.0; 10%:-2.62 with constant and 25 observations
5%:-3;6;10%:-3.24 with constant, trend and 25 observations

TABLE 3a: Regression Results - France

(1)	tfpms	gtfp	netrep	RSQ
coef	0,04	0,14	0,24	0,90
t-Stat	0,85	0,54	3,37	
t-Coint	-2,76			
(2)	**tfpms**	**gy**	**netrep**	
coef	0,05	-0,12	0,22	0,91
t-Stat	1,07	-0,66	3,61	
t-Coint	-2,97			
(3)	**tfpms**	**r**	**netrep**	
coef	0,05	-0,62	0,14	0,97
t-Stat	1,87	-4,99	3,77	
t-Coint	-3,03			
(4)	**tfpms**	**r**	**netrep**	
coef	0,05	0,12	0,21	0,91
t-Stat	1,05	0,78	3,66	
t-Coint	-3,23			
(5)	**tfpms**	**gtfp**	**r**	
coef	0,11	-0,42	0,55	0,84
t-Stat	2,21	-1,30	2,42	
t-Coint	-2,95			
(6)	**tfpms**	**gy**	**r**	
coef	0,12	-0,51	0,50	0,89
t-Stat	2,84	-2,51	2,74	
t-Coint	-2,70			
(7)	**tfpms**	**iy**	**r**	
coef	0,10	-0,79	0,20	0,95
t-Stat	5,62	-7,37	2,37	
t-Coint	-4,01			
(8)	**gtfp**	**gy**	**netrep**	
coef	1,18	-0,91	0,27	0,94
t-Stat	3,67	-3,61	14,12	
t-Coint	-2,76			
(9)	**gtfp**	**iy**	**netrep**	
coef	0,20	-0,63	0,20	0,97
t-Stat	1,11	-3,64	5,96	
t-Coint	-2,12			
(10)	**gtfp**	**r**	**netrep**	
coef	-0,01	0,19	0,24	0,90
t-Stat	-0,03	0,99	4,50	
t-Coint	-3,39			
(11)	**gtrfp**	**gy**	**r**	
coef	0,34	-0,95	0,87	0,82
t-Stat	0,54	-2,02	6,89	
t-Coint	-3,16			
(12)	**gtfp**	**iy**	**r**	
coef	-0,35	-0,83	0,54	0,90
t-Stat	-1,60	-4,22	4,00	
t-Coint	-3,05			
(13)	**gtfp**	**gy**	**iy**	
coef	-0,42	0,33	-1,46	0,79
t-Stat	-0,26	0,24	-2,70	
t-Coint	-1,61			
(14)	**iy**	**r**	**netrep**	
coef	-0,610,1	0,17	0,96	0,72
t-Stat	-5,37	1,27	6,63	
t-Coint	-3,19			

t statistics are calculated on the basis of an autocorrelation corrected covariance matrix. They must be interpreted with care since the distribution of coefficient estimates is only standard in the absence of a correlation between the residual of the cointegrating relationship and the residuals of the process driving the explanatory variables.

TABLE 3b: Regression Results - Germany

(1)	**tfpms**	**gtfp**	**netrep**	**RSQ**
coef	0,36	0,01	-0,48	0,78
t-Stat	6,97	0,04	-1,43	
t-Coint	-3,23			
(2)	**tfpms**	**gy**	**netrep**	
coef	0,34	-0,05	-0,42	0,81
t-Stat	6,28	-0,40	-1,12	
t-Coint	-3,02			
(3)	**tfpms**	**r**	**netrep**	
coef	0,21	-0,44	-0,39	0,83
t-Stat	1,74	-1,29	-0,98	
t-Coint	-2,66			
(4)	**tfpms**	**r**	**netrep**	
coef	0,30	0,39	-0,39	0,84
t-Stat	7,07	2,25	-1,58	
t-Coint	-3,70			
(5)	**tfpms**	**gtfp**	**r**	
coef	0,21	-0,02	0,61	0,81
t-Stat	3,72	-0,16	2,06	
t-Coint	-2,88			
(6)	**tfpms**	**gy**	**r**	
coef	0,23	-0,16	0,53	0,84
t-Stat	5,69	-1,46	2,31	
t-Coint	-3,18			
(7)	**tfpms**	**iy**	**r**	
coef	0,09	-0,54	0,47	0,86
t-Stat	0,87	-1,87	1,98	
t-Coint	-2,69			
(8)	**gtfp**	**gy**	**netrep**	
coef	0,53	-0,56	1,32	0,24
t-Stat	0,43	-0,54	1,17	
t-Coint	-1,57			
(9)	**gtfp**	**iy**	**netrep**	
coef	0,08	-0,99	-0,11	0,76
t-Stat	0,27	-3,23	-0,17	
t-Coint	-1,80			
(10)	**gtfp**	**r**	**netrep**	
coef	-0,06	1,30	0,46	0,67
t-Stat	-0,32	4,65	1,31	
t-Coint	-2,59			
(11)	**gtrfp**	**gy**	**r**	
coef	0,61	-0,67	1,58	0,75
t-Stat	2,47	-3,20	8,63	
t-Coint	-2,79			
(12)	**gtfp**	**iy**	**r**	
coef	0,03	-0,66	0,70	0,85
t-Stat	0,19	-3,93	2,54	
t-Coint	-2,46			
(13)	**gtfp**	**gy**	**iy**	
coef	-0,07	0,15	-0,97	0,76
t-Stat	-0,15	0,36	-4,43	
t-Coint	-2,04			
(14)	**iy**	**r**	**netrep**	
coef	-0,79	0,55	-0,12	0,86
t-Stat	-5,41	2,53	-0,4	
t-Coint	-2,73			

TABLE 3c: Regression Results - Italy

(1)	**tfpms**	**gtfp**	**netrep**	**RSQ**
coef	0,10	0,09	0,00	0,09
t-Stat	14,40	1,53	-0,03	
t-Coint	-3,68			
(2)	**tfpms**	**gy**	**netrep**	
coef	0,11	-0,19	0,00	0,94
t-Stat	20,92	-4,50	0,03	
t-Coint	-4,23			
(3)	**tfpms**	**r**	**netrep**	
coef	0,07	-0,23	0,06	0,92
t-Stat	5,43	-2,71	0,73	
t-Coint	-3,97			
(4)	**tfpms**	**r**	**netrep**	
coef	0,10	0,03	-0,02	0,90
t-Stat	12,30	1,02	-0,33	
t-Coint	-4,73			
(5)	**tfpms**	**gtfp**	**r**	
coef	0,09	0,08	0,05	0,90
t-Stat	8,61	1,53	1,34	
t-Coint	-3,36			
(6)	**tfpms**	**gy**	**r**	
coef	0,11	-0,19	0,00	0,94
t-Stat	14,51	-4,39	-0,05	
t-Coint	-4,25			
(7)	**tfpms**	**iy**	**r**	
coef	0,07	-0,22	0,04	0,92
t-Stat	5,14	-3,12	1,47	
t-Coint	-4,09			
(8)	**gtfp**	**gy**	**netrep**	
coef	0,06	0,10	0,42	0,02
t-Stat	0,12	0,21	0,66	
t-Coint	-1,71			
(9)	**gtfp**	**iy**	**netrep**	
coef	0,10	-0,65	0,29	0,84
t-Stat	0,65	-4,75	1,62	
t-Coint	-2,08			
(10)	**gtfp**	**r**	**netrep**	
coef	0,09	0,27	0,31	0,67
t-Stat	0,69	5,28	2,22	
t-Coint	-4,16			
(11)	**gtrfp**	**gy**	**r**	
coef	0,08	0,10	0,28	0,60
t-Stat	0,49	0,67	4,61	
t-Coint	-3,22			
(12)	**gtfp**	**iy**	**r**	
coef	0,11	-0,52	0,13	0,84
t-Stat	0,92	-3,82	2,02	
t-Coint	-2,31			
(13)	**gtfp**	**gy**	**iy**	
coef	0,09	0,03	-0,67	0,76
t-Stat	0,30	0,09	-2,55	
t-Coint	-1,23			
(14)	**iy**	**r**	**netrep**	
coef	-0,52	0,1	0,25	0,89
t-Stat	-7,49	2,77	2,97	
t-Coint	-3,62			

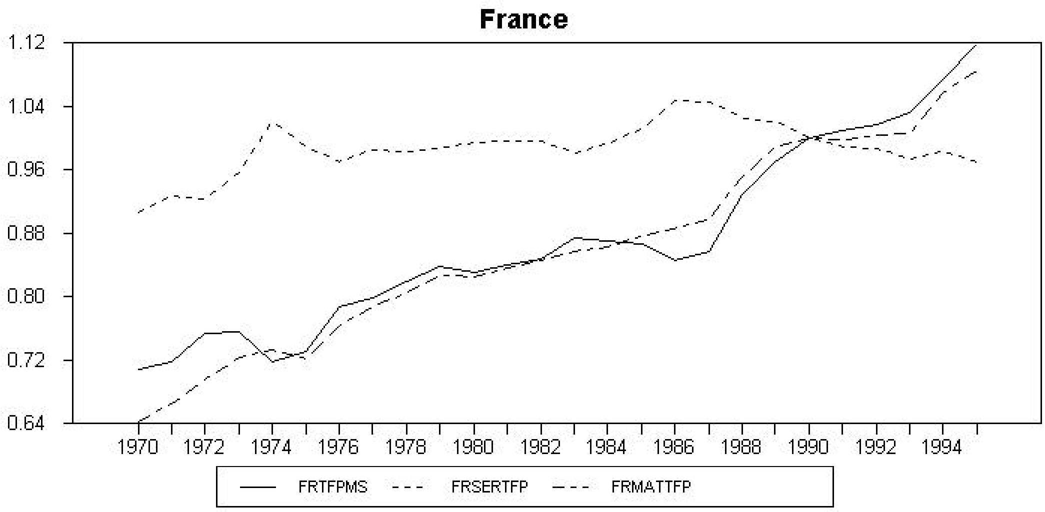
TABLE 3d: Regression Results - United Kingdom

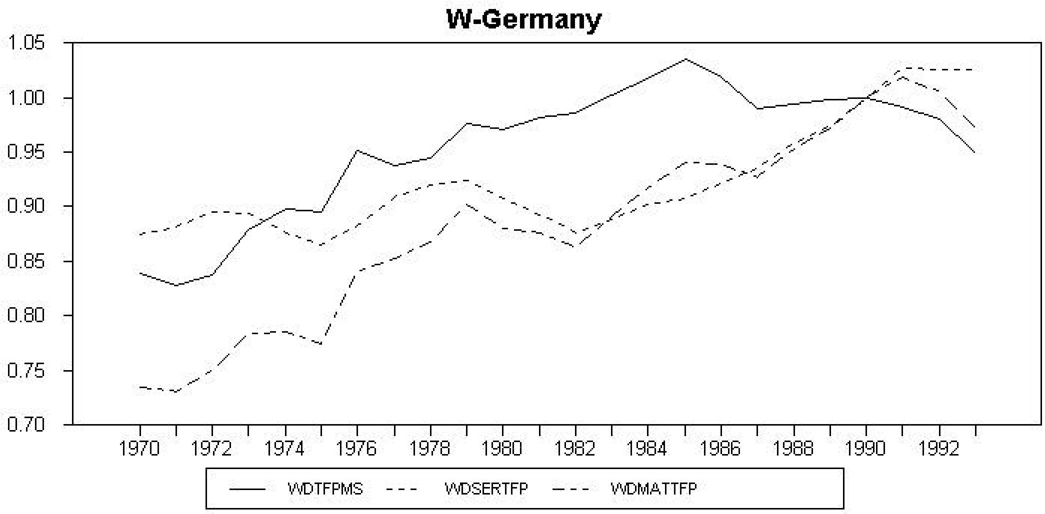
(1)	**tfpms**	**gtfp**	**netrep**	**RSQ**
coef	0,30	0,51	0,50	0,52
t-Stat	1,72	1,41	0,68	
t-Coint	-2,00			
(2)	**tfpms**	**gy**	**netrep**	
coef	0,33	0,16	0,71	0,43
t-Stat	2,01	0,40	0,98	
t-Coint	-2,33			
(3)	**tfpms**	**r**	**netrep**	
coef	0,32	-1,44	0,27	0,55
t-Stat	2,49	-1,65	0,44	
t-Coint	-2,61			
(4)	**tfpms**	**r**	**netrep**	
coef	0,23	0,36	0,42	0,58
t-Stat	1,82	2,12	0,80	
t-Coint	-2,66			
(5)	**tfpms**	**gtfp**	**r**	
coef	0,13	0,24	0,32	0,56
t-Stat	1,36	0,49	0,96	
t-Coint	-2,00			
(6)	**tfpms**	**gy**	**r**	
coef	0,14	-0,29	0,48	0,59
t-Stat	1,77	-0,64	1,79	
t-Coint	-1,79			
(7)	**tfpms**	**iy**	**r**	
coef	0,22	-1,22	0,31	0,66
t-Stat	3,50	-1,94	2,15	
t-Coint	-2,91			
(8)	**gtfp**	**gy**	**netrep**	
coef	1,08	-0,66	-0,71	0,45
t-Stat	1,27	-0,77	-1,44	
t-Coint	-1,54			
(9)	**gtfp**	**iy**	**netrep**	
coef	0,53	-0,87	-0,87	0,38
t-Stat	0,80	-0,43	-1,18	
t-Coint	-1,47			
(10)	**gtfp**	**r**	**netrep**	
coef	0,13	0,46	-0,34	0,52
t-Stat	0,24	1,40	-0,84	
t-Coint	-2,03			
(11)	**gtrfp**	**gy**	**r**	
coef	0,26	-0,47	0,61	0,51
t-Stat	0,44	-0,85	2,36	
t-Coint	-2,08			
(12)	**gtfp**	**iy**	**r**	
coef	-0,04	0,26	0,60	0,46
t-Stat	-0,08	0,29	2,29	
t-Coint	-2,28			
(13)	**gtfp**	**gy**	**iy**	
coef	1,16	-0,79	1,18	0,16
t-Stat	1,15	-0,79	0,75	
t-Coint	-1,79			
(14)	**iy**	**r**	**netrep**	
coef	-0,35	0,44	-0,43	0,55
t-Stat	-0,35	1,54	-1,14	
t-Coint	-1,83			

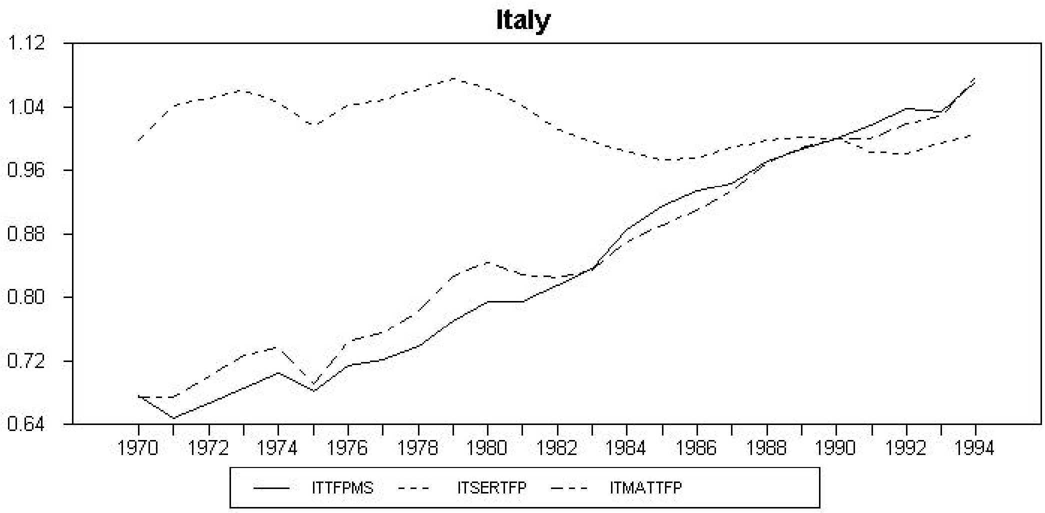
TABLE 3e: Regression Results - United States

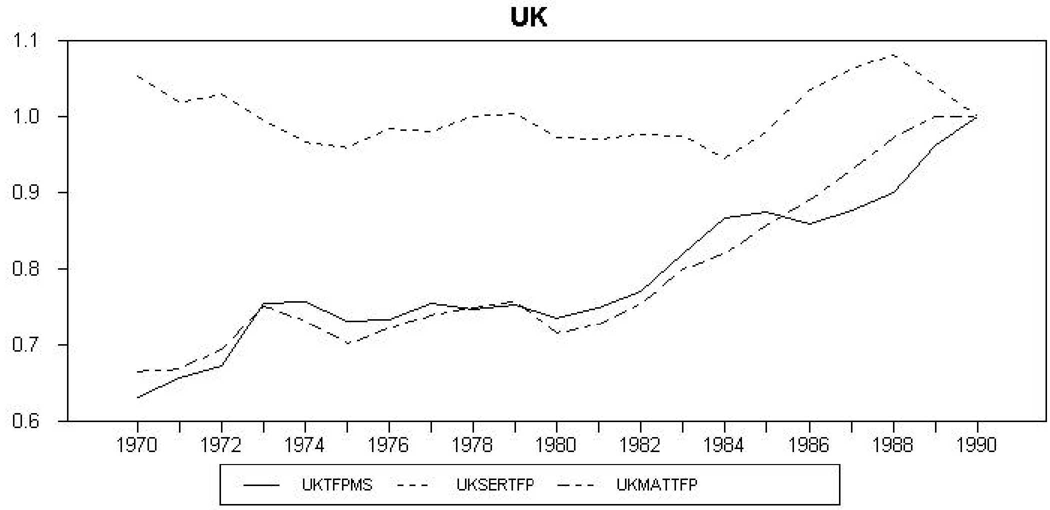
(1)	**tfpms**	**gtfp**	**netrep**	**RSQ**
coef	0,01	-0,02	0,49	0,37
t-Stat	0,80	-0,17	5,81	
t-Coint	-5,05			
(2)	**tfpms**	**gy**	**netrep**	
coef	0,02	-0,17	0,58	0,74
t-Stat	2,33	-4,44	11,39	
t-Coint	-6,12			
(3)	**tfpms**	**r**	**netrep**	
coef	0,01	-0,61	0,67	0,78
t-Stat	0,83	-4,59	10,85	
t-Coint	-5,33			
(4)	**tfpms**	**r**	**netrep**	
coef	0,02	0,01	0,57	0,66
t-Stat	1,80	0,35	9,38	
t-Coint	-6,13			
(5)	**tfpms**	**gtfp**	**r**	
coef	-0,04	-0,33	0,28	0,12
t-Stat	-1,02	-1,27	2,09	
t-Coint	-3,33			
(6)	**tfpms**	**gy**	**r**	
coef	0,04	-0,21	0,16	0,27
t-Stat	0,91	-0,99	0,83	
t-Coint	-2,40			
(7)	**tfpms**	**iy**	**r**	
coef	0,06	0,04	0,09	0,19
t-Stat	1,30	0,08	0,50	
t-Coint	-2,60			
(8)	**gtfp**	**gy**	**netrep**	
coef	0,61	-0,45	0,52	0,74
t-Stat	6,59	-8,43	10,49	
t-Coint	-5,76			
(9)	**gtfp**	**iy**	**netrep**	
coef	-0,01	-0,72	0,57	0,68
t-Stat	-0,18	-5,69	8,22	
t-Coint	-4,48			
(10)	**gtfp**	**r**	**netrep**	
coef	-0,15	0,10	0,43	0,41
t-Stat	-1,18	1,78	4,73	
t-Coint	-4,98			
(11)	**gtrfp**	**gy**	**r**	
coef	0,29	-0,33	0,14	0,24
t-Stat	0,53	-1,26	0,89	
t-Coint	-2,50			
(12)	**gtfp**	**iy**	**r**	
coef	-0,20	-0,36	0,17	0,14
t-Stat	-0,50	-0,69	0,90	
t-Coint	-2,19			
(13)	**gtfp**	**gy**	**iy**	
coef	0,69	-0,48	0,16	0,16
t-Stat	1,05	-1,11	0,21	
t-Coint	-2,60			
(14)	**iy**	**r**	**netrep**	
coef	-0,7	0	0,6	0,7
t-Stat	-5,78	-0,16	8,99	
t-Coint	-4,68			

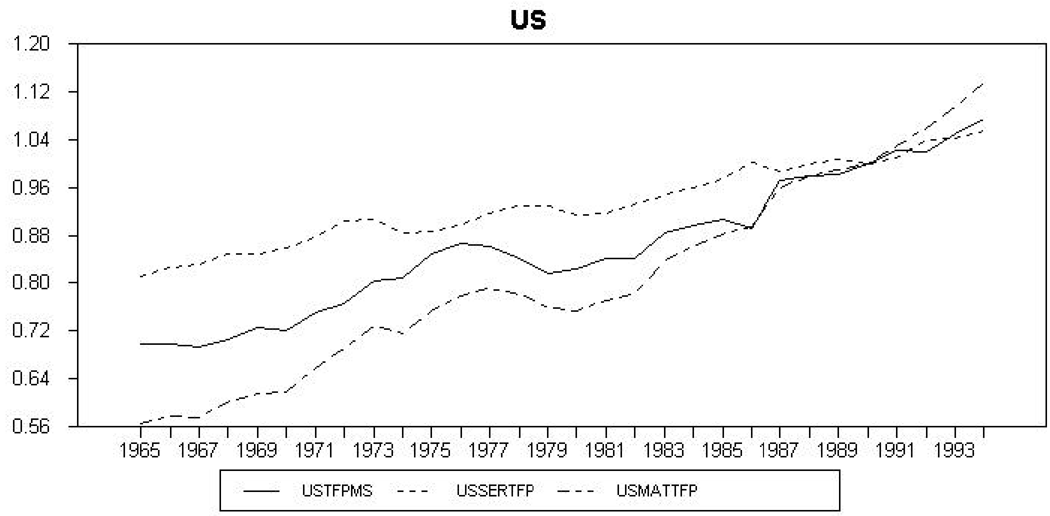
Figure: 1 Sectoral TFP in EU Member States and the US








UK
1.1
1.0
0.9
0.8
0.7
0.6
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
UKTFPMS
UKSERTFP
UKMATTFP


US
1.20
1.12
1.04
0.96
0.88
0.80
0.72
0.64
0.56
1965
1967
1969
1971
1973
1975
1977
1979
1981
1983
1985
1987
1989
1991
1993
USTFPMS
USSERTFP
USMATTFP