The Impact of the agricultural sector on cyclical unemployment and output in EU

K. Lawler, E. Katsouli and D. Pallis*

Abstract

The purpose of this paper was to estimate changes in cyclical unemployment and output in the EU using an Okun's law equation, extended with a new variable, namely, the share of the economically active labour force of the agricultural sector in the total economy. Treating both the NAIRU and the potential output growth rate as time dependent unobserved stochastic processes, a state-space maximum likelihood estimation method - using Kalman filter where the state variables were random walks - was followed in order to estimate the 15 equations. Overall, the estimated equations suggested that the extent and direction of changes of cyclical unemployment and cyclical output over the period 1961-1999 is mixed across the EU. The paper concludes that the introduction of the share of the agricultural labour force in the determination of cyclical unemployment and output is important and therefore the application of "common agricultural policies" across the 15 EU member states may be questionable because of the different expected effects of these policies on the various economies.

Keywords: *Agricultural sector, Okun's law, Kalman filter, Cyclical unemployment, Potential output growth rate, NAIRU, Europe.*

Introduction

It is well accepted that the pace of economic expansion depends inversely to the fluctuations of cyclical unemployment, or alternatively to the deviations of total unemployment from the natural rate of unemployment (U_{NR}), which was later called the 'Non-Accelerating Inflation Rate of Unemployment' (NAIRU). The U_{NR} and U_{NAIRU} are alternative ways of defining the goal of full employment when it is to be pursued with fiscal and monetary policies, and thus, they are alternatively called the 'full employment rate' (U_F)).

This relationship between cyclical unemployment and economic expansion, expressed by fluctuations in Gross Domestic Product, is written by Okun (1962) as the 'Okun's Law' equation

$$g_t = \delta(U_t - U_{NR}) + \varepsilon_t \tag{1}$$

where: U_t = total unemployment rate in period t,
U_{NR} = natural rate of unemployment,
$g_t = (GDP_t - GDP_{t-1})/ GDP_{t-1}$ = growth rate of real output in period t,
GDP_t = real Gross Domestic Product in period t,

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δ = parameter that measures the responsiveness of output to unemployment, where $\delta < 0$.
ε_t = disturbance term in period t.

However, taking into account that total unemployment is the sum of cyclical, frictional and structural unemployment, and that frictional and structural unemployment are the two components of natural unemployment, then, the term (U_t-U_{NR}) in equation (1) measures the cyclical unemployment rate, which responds to fiscal and monetary policies; the natural rate of unemployment depends more on other inherent features within the economy, such as misinformation and mismatches within the labour markets.

Equation (1) was extended latter as follows:

$$g_t = g_t^p + \delta(U_t - U_{NAIRU}) + \varepsilon_t \quad (2)$$

where: g_t^p = potential growth rate of real output in period t.

Recently, and due to the introduction of new methods of estimation in econometrics, the estimation of the NAIRU and of the potential output - using the Okun equation - have drawn attention as important topics of research in economics (Apel and Jansson, 1999). General specification forms of this equation may be the following:

$$g_t = g_t^p + \delta(L)(U_t - U_t^{NAIRU}) + \varepsilon_t \quad (3)$$

with

$$g_t^p = \alpha(L)g_{t-1} + \beta(L)T_t + \gamma(L)S_t \quad (4)$$

where: $\alpha(L)$, $\beta(L)$, $\gamma(L)$, $\delta(L)$ = polynomials in the lag operator,
T_t and S_t = production determination and supply variables
U_t^{NAIRU} = time varying NAIRU.

In estimating equations (3) and (4) the following methodological options may be considered:

1. The time varying NAIRU may alternatively modelled as a deterministic function of time (Staiger *et al,* 1997a, 1997b), as an unobserved stochastic process (Gordon, 1997; Staiger *et al,* 1997b; Laubach, 2001), or as a function of structural economic variables (Weiner, 1993; Staiger *et al,* 1997b).
2. The time varying potential output may alternatively modelled as a deterministic function of time, or as an unobserved stochastic process (Kutner, 1994; Jaeger and Parkinson, 1994; Apel and Jansson, 1999).

From the available options the time dependent NAIRU and potential output unobserved stochastic processes modelling incorporates economic content that it is absent from the deterministic function modelling (Apel and Jansson, 1999).

Summarising the relevant literature, we may say that the main problem in the research referring to the estimation of the relationship between output and unemployment, using an Okun's law specification, is the uncertainty surrounding the estimates of the NAIRU and the potential output growth rates, and therefore, it is important any contribution to this area to be concentrated on new specifications of the equations involved and on new estimating techniques that will add to our knowledge.

Considering the last paragraph, the contribution of this paper is to estimate changes in cyclical unemployment and cyclical output for each of the 15 European Union (EU) member-states, using a new Okun's law specification. For this purpose the NAIRU and potential output to be estimated follow the unobserved stochastic process modelling and are estimated simultaneously. Section 2, presents the specific model to be estimated and explains the new specification of the equations used. The statistical estimates of the model, using the Kalman filter estimation methodology, and discussion of the meaning of these estimates is presented in section 3. Section 4 presents the time varying estimates of the NAIRU and the potential output for the 15 European Union member-states. Finally, section 5 presents the conclusions and policy implications of the paper. All estimates have been carried out using EViews 3.1.

The model employed

The corresponding equations, to equations (3) and (4), employed in this paper are as follows:

$$g_t = g_t^p + \delta(U_t - U_t^{NAIRU}) + \varepsilon_t \quad , \quad \delta < 0 \qquad (5)$$

where:

$$U_t^{NAIRU} = \delta_t U_{t-1} + \eta_{1,t} \qquad (6)$$

$$g_t^p = \alpha_t g_{t-1} + \beta q_t + \gamma s_{t-i} + \eta_{2,t} \quad , \quad \beta \geq 0 \qquad (7)$$

δ_t and α_t are time parameters to be estimated, q_t is labour productivity in time period t, s_t is the share of the economically active population of agriculture with respect to total economy, and $\eta_{1,t}$ and $\eta_{2,t}$ are disturbance terms. Equations (5)-(7) relate cyclical unemployment to cyclical growth rates of real output and allow the estimation of the NAIRU and the potential growth rate. Cyclical unemployment proxies demand pressures and the potential growth rate incorporates two components: an unobserved component ($\alpha_t g_{t-1}$) which refers to the overall pace of economic expansion, and the two structural components (βq_t), which refers to the production technological conditions captured by labour productivity, and (γs_{t-i}) which refers to the supply of labour captured by the share of the economically active population of agriculture with respect to total economy.

Specifically, we believe that the introduction of variable s_t in equation (6) constitutes the novelty of this paper. This is because the agricultural sector was traditionally a source of labour supply to the rest of the economy. Therefore, any labour supply to the non-agricultural sector is depicted by the decreasing level of variable s_t. This is true for all the EU economies under investigation. However, we can distinguish the following cases:

1. Employed labour force in the agricultural sector is now employed in the non-agricultural sector:
   a) If the agricultural output growth rate is less than the non-agricultural output growth rate, any transfer of labour from the agricultural sector to the non-agricultural sector may end in increasing the output growth rate of the economy as a whole. In this case it is $\gamma < 0$.

b) If the agricultural output growth rate is equal to the non-agricultural output growth rate, any transfer of labour from the agricultural sector to the non-agricultural sector may end in unchanging the output growth rate of the economy as a whole. In this case it is $\gamma = 0$.
c) If the agricultural output growth rate is greater than the non-agricultural output growth rate, any transfer of labour from the agricultural sector to the non-agricultural sector may end in decreasing the output growth rate of the economy as a whole. In this case it is $\gamma > 0$.

2. Employed labour force in the agricultural sector is unemployed in the non-agricultural sector. In this case it is $\gamma > 0$.
3. Unemployed labour force in the agricultural sector is still unemployed in the non-agricultural sector. In this case it is $\gamma = 0$.
4. Unemployed labour force in the agricultural sector is now employed in the non-agricultural sector. In this case it is $\gamma < 0$.

Under the observations above it is clear that the sign of parameter γ in equation (6) cannot be determined a priori without any further information. However, the advantage of equations (5) to (7) is that they combine both unobservable variables (α_t, δ_t) and economically meaningful observed information (U_{t-1}, g_{t-1}, q_t and s_t).

The data used in the analysis is annual, cover the period from 1961 to 1999 and are taken from European Economy (1999) and the FAO electronic database. The identification of the variables used is the following:

U = unemployment rate (total; percentage of civilian labour force)
q = labour productivity growth (gross domestic product at 1990 market prices per person employed; annual percentage change from national currency).
g = output growth rate (gross domestic product at 1990 market prices; national currency; annual percentage change)
s = agricultural labour share (economically active population in agriculture by economically active population in total economy; percent).

The model estimations

In order to estimate cyclical unemployment, i.e. estimating first the time dependent NAIRU, and cyclical output growth rate, i.e. estimating first the time varying potential output growth rate, the estimation may be summarised as follows:

- The specification of the model described in the of equations (5)-(7) can be written in a state-space form as follows:

Measurement equation:

$$g_t = \alpha_t g_{t-1} + \beta q_t + \gamma s_{t-i} + \delta(U_t - \delta_t U_{t-1}) + u_t \tag{8}$$

Transition equations:

$$\alpha_t = \phi_1 \alpha_{t-1} + v_{1,t} \tag{9}$$

$$\delta_t = \phi_2 \delta_{t-1} + v_{2,t} \tag{10}$$

where α_t and δ_t are the state variables, φ_1 and φ_2 are parameters and the disturbance terms u_t $v_{1,t}$ and $v_{2,t}$ are assumed to be independent and white noise.

- The parameters of the equations (8)-(10) can be estimated by maximum likelihood using the Kalman filter. The Kalman filter is a recursive algorithm for sequentially updating the state variables given past information. More technically, it is an algorithm for calculating linear least squares forecasts of the state variables given data observed up to date t (Cuthbertson *et al.,* 1992; EViews, 1998).
- The state variables are either random walk (assuming $\varphi_1 = 1$ and $\varphi_2 = 1$; shocks to the random coefficient persist indefinitely) or AR(1) and constant mean (assuming $\varphi_1 \neq 1$ and $\varphi_2 \neq 1$; shocks to the random coefficient have some persistence, but that the coefficient eventually returns to its mean value).
- Because the data is annual, at most two lags in the independent variables of equation (8) are used.

Table 1 presents the estimated Okun equations for each of the 15 EU member-states using Kalman filter. The estimates refer to the state variables following a

Table 1. Estimations of Okun's law equations (dependent variable is g)

	δ: $(U_t - U_t^{NAIRU})$	β: q_t	γ: s_{t-i}	R^2	DW
1. B	-0.341 [2.82]	1.233 [14.64]	-0.364 $[2.82]_{t-1}$	0.969	2.144
2. DK	-0.145 [0.84]	1.329 [8.82]	-0.144 [2.91]	0.906	2.053
3. D	-1.115 [3.38]	1.202 [9.21]	-0.126 $[1.64]_{t-1}$	0.872	1.905
4. EL*	-0.168 [2.77]	0.779 [18.88]		0.928	2.193
5. E	-0.648 [4.10]	1.110 [9.61]	-0.050 [2.01]	0.967	2.693
6. F	-0.254 [1.46]	1.586 [14.61]	-0.305 [6.47]	0.999	2.533
7. IRL	-0.709 [6.33]	1.069 [10.11]		0.982	2.468
8. I	-0.998 [5.67]	1.261 [9.33]		0.986	2.555
9. L	-0.886 [4.24]	1.033 [10.90]		0.870	1.750
10. NL	-0.546 [6.52]	0.921 [8.92]	-0.077 $[0.90]_{t-2}$	0.999	1.704
11. A	-0.909 [2.24]	1.087 [7.35]	-0.165 [3.42]	0.971	2.307
12. P	-0.332 [2.94]	0.858 [8.74]		0.849	2.134
13. FIN	-0.788 [4.54]	1.278 [1.30]	-0.087 [1.74]	0.979	2.005
14. S	-1.694 [6.09]	0.933 [13.40]	0.165 [2.00]	0.991	2.478
15. UK	-0.287 [3.44]	1.032 [10.43]	-0.187 [0.96]	0.781	2.184
16. **EU**	-0.463 [2.40]	1.196 [18.60]	-0.175 $[3.89]_{t-1}$	0.999	2.323

Notes: t-ratios in brackets. *EL = Greece random walk process. Experiments assuming that the state variables follow an AR(1) and constant mean process were also performed but the results were inferior because in most cases the autoregression coefficients were not significant. From the results in Table 1 we may conclude the following:

- In all cases the estimated coefficients have the expected a priori signs. The unemployment gap affects negatively output growth rates; labour productivity affects positively output growth rates; the agricultural labour share affects output growth rates in various ways.
- Most estimates are generally acceptable, according to the usual statistical criteria.
- The specifications of the Okun equations are almost identical between the EU member-states. This ensures comparability of the results.
- Using computed two quartiles of the estimated coefficients in Table 1, the EU member-states may be categorized into the following groups:
  Output growth rate with respect to cyclical unemployment (quartiles: Q_1=-0.837 and Q_2=-0.337): more sensitive (S, D, I, A, L); average sensitive (FIN, IRL, E, NL, B); less sensitive (P, UK, F, EL, DK).
  Output growth rate with respect to labour productivity (quartiles: Q_1=1.0325 and Q_2=1.2175): less sensitive (EL, P, NL, S,UK); average sensitive (L, IRL, A, E, D); more sensitive (B, I, FIN, DK, F).
  Output growth rate with respect to agricultural labour share: negatively sensitive (B, DK, D, E, F, NL, A, FIN, UK); zero sensitive (EL, IRL, I, L, P); positive sensitive (S).

Estimations of the NAIRU and potential output growth rates

Table 2 presents the estimates for the year 1999 of the NAIRU and the potential output growth rates for the EU, derived from the estimated Okun equations presented in Table 1, according to equations (8)-(10). For comparison purposes, in the first two columns of this table the recent OECD (Richardson *et al,* 2000) and Laubach (2001) estimates of the NAIRU are also presented. Furthermore, in the same table the actual rates of unemployment and output growth rates for all the EU member-states are also presented, so the extent and direction of changes in cyclical unemployment and output may realised for the year 1999, i.e. the final year of the estimation period.

The full path of cyclical unemployment (U_t- U_t^{NAIRU}) and cyclical output growth rates (g_t- g_t^p) for the period 1961-199 and for each of the EU member-states are shown in Figures 1 and 2. In the same figures the correlation coefficients between the variables of (U_t- U_t^{NAIRU}) and (g_t- g_t^p) are also reported.

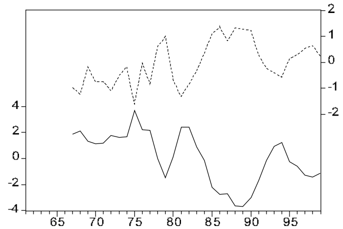
Comparing our estimates of the NAIRU with those of the other researchers it is seen in Table 2 that our estimates are higher than the Richardson *et al* (2000) estimates in 11 out of the 14 member-states, i.e. in 78.5 % of the reported cases. However, our estimates are rather close to the estimates reported by Laubach (2001), the latter being higher than the Richardson *et al* (2000) estimates in 3 out of the 4 member-states, i.e. in 75.0 % of the reported cases. The precision of our estimates – measured by the reported t-ratios – is much higher than the precision of the Laubach estimates. However, we believe that this is due to the fact that our data were annual in contrast to the Laubach data which were quarterly. Broadly speaking, our estimates are in the range of the generally accepted levels of the NAIRU.

From the 1999 values of the actual unemployment rates and actual output growth rates in Table 2, compared to the NAIRU and potential output growth rates, cyclical unemployment and cyclical output may be computed. It is seen that in 10 member-states (B, DK, EL, E, IRL, L, NL, A, FIN, UK) cyclical unemployment is negative, meaning that the NAIRU is greater than the actual unemployment rate, and in 5 member-states (D, F, I, P, S) cyclical unemployment is positive. In contrast, it is seen that cyclical output is positive in almost the same 10 member-states and negative in almost the same 5 member-states. This means that the inverse relationship between cyclical unemployment and cyclical output holds for at least year 1999.

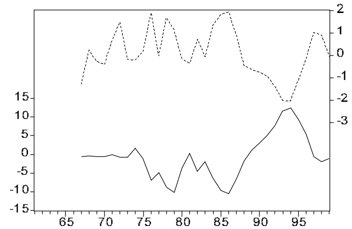
Table 2. Estimates of the NAIRU and potential output growth rate

	OECD[1] estimates of NAIRU:99	**Laubach[2] estimates of NAIRU:98:4; Estimates I**	**and II**	**Our estimates of NAIRU:99**	**Actual U:99**	**Our estimates of Potential g:99**	**Actual g:99**
1. B	8.2			9.44 [5.17]	8.3	1.68 [8.04]	1.9
2. DK	6.3			5.73 [1.27]	4.6	1.76 [9.00]	1.7
3. D	6.9	8.81 [0.80]	7.33 [1.89]	8.68 [7.53]	9.0	1.91 [4.91]	1.7
4. EL	9.5			16.67 [9.71]	9.4	2.05 [7.88]	3.4
5. E	15.1			20.44 [7.93]	17.3	1.33 [4.19]	3.3
6. F	9.5	11.57 [1.41]	10.70 [3.04]	10.93 [2.07]	11.5	2.44 [7.85]	2.3
7. IRL	7.1			8.65 [4.02]	6.0	7.58 [39.65]	9.3
8. I	10.4	12.45 [0.58]	15.58 [9.59]	11.79 [9.51]	12.2	2.03 [4.02]	1.6
9. L				3.48 [11.35]	2.7	3.11 [30.57]	3.2
10. NL	4.7			5.07 [4.11]	3.6	1.49 [7.42]	2.3
11. A	4.9			4.74 [4.13]	4.3	2.00 [7.57]	2.3
12. P	3.9			4.37 [7.24]	4.7	3.74 [13.93]	3.2
13. FIN	9.0			10.53 [5.19]	10.1	3.44 [17.91]	3.7
14. S	5.8			7.55 [9.64]	7.8	2.58 [10.52]	2.2
15. UK	7.0	6.10 [1.28]	6.42 [2.47]	6.52 [6.97]	6.5	1.40 [6.76]	1.1
16. **EU**	8.8			11.09 [4.17]	9.6	3.49 [12.06]	2.1

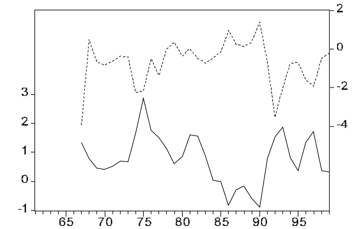
t-ratios in brackets
1. Richardson et al, (2000)
2. Laubach, (2001): Estimates from two specifications



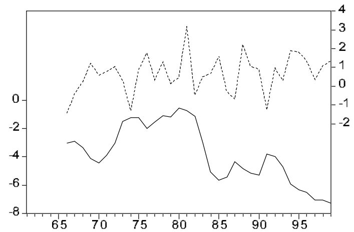
1. Belgium (r=-0.924)



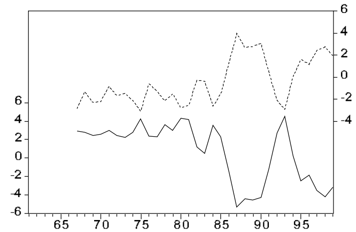
2. Denmark (r=-0.855)



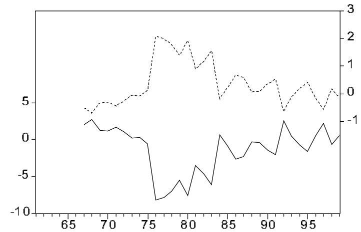
3. Germany (r=-0.688)



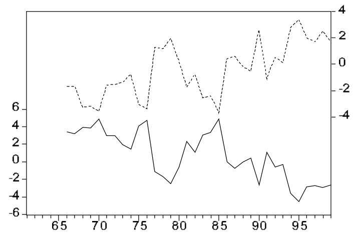
4. Greece (r=-0.205)



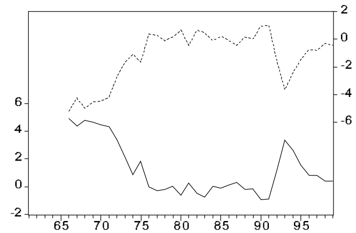
5. Spain (r=-0.980)



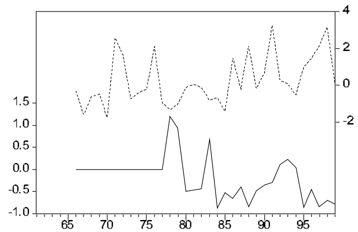
6. France (r=-0.999)



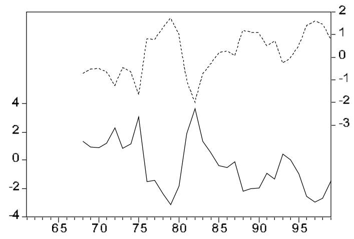
7. Ireland (r=-0.987)



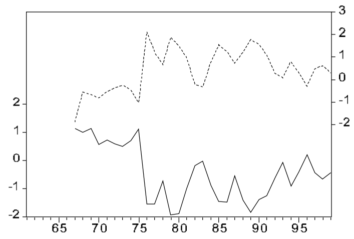
8. Italy (r=-0.993)



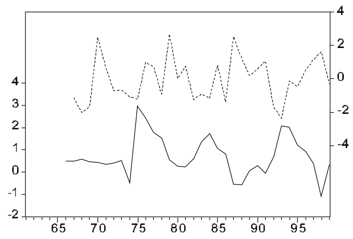
9. Luxembourg (r=-0.430)



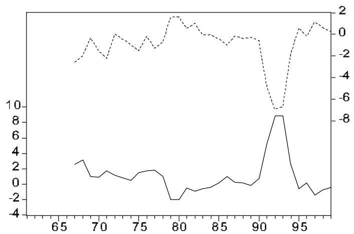
10. Netherlands (r=-0.999)



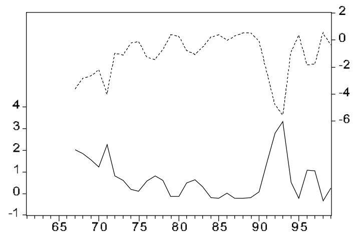
11. Austria (r=-0.958)



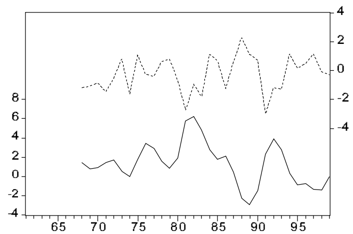
12. Portugal (r=-0.373)



13. Finland (r=-0.974)

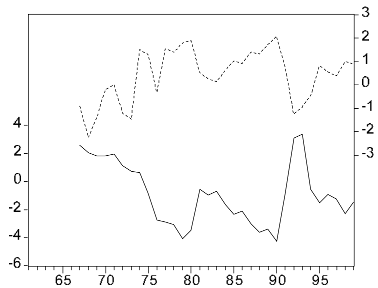


14. Sweden (r=-0.996)



15. United Kingdom (r=-0.607)

Figure 1. Cyclical unemployment (line) and cyclical output (doted)



16. EU (r=-0.824)

Figure 2. Cyclical unemployment (line) and cyclical output (doted)

In terms of the overall path of cyclical unemployment and output, shown in Figures 1 and 2, our estimates suggest that the extent and direction of changes in these two variables over the period 1961-1999 is mixed across the EU member states. Furthermore, it is seen that the higher the cyclical unemployment, the lower cyclical output. The extent of this inverse relationship between cyclical unemployment and output can be verified by the negative correlation coefficients reported in Figures 1 and 2. It is seen that in most cases (B, DK, E, F, IRL, I, NL, A, FIN, S) the correlation coefficients are between -1.000 and -0.800, in two cases (D, UK) is between -0.800 and -0.600, in one case (L) is between -0.600 and -0.400, and in two cases (EL, P) is between -0.400 and -0.200. Generally speaking we could say that if we knew the changes in cyclical output we could predict the changes in cyclical unemployment.

Conclusions

The aim of this paper was to estimate changes in cyclical unemployment and output in the EU. For this purpose an equation making use of an Okun's law type specification, where deviations of the unemployment rate from the NAIRU produce deviations of the output growth rate from its potential level, was estimated. Furthermore, it was assumed that the potential output growth rate may, to some extent, be influenced by the path of the actual output growth rate, the labour productivity rate and the transfer of labour force from the agricultural sector to the rest of the economy.

Treating both the NAIRU and the potential output growth rate as time dependent unobserved stochastic processes, a state-space maximum likelihood estimation method - using Kalman filter where the state variables were random walks - was followed in order to estimate the 15 equations. However, although the Kalman filter estimates are preferred as being economically more meaningful, the variation of the NAIRU needs to be right, too little variation in the NAIRU will result in miss-specified and unreliable equations; too much variation undermines the concept and makes the NAIRU of limited use for policy (Richardson *et al.,* 2000). In our exercise we followed the method of the joint estimation of both the NAIRU and the potential output growth rate by employing the Okun's law equation.

Overall, the estimated equations suggest that the extent and direction of changes of cyclical unemployment and output over the period 1961-1999 is mixed across the EU. Furthermore, it is seen that the higher cyclical unemployment, the lower cyclical output. Thus, the application of "common" policies across the EU may be questionable because of the different effects of these policies on the various economies.

The last observation can be verified from the estimates of the potential output growth rate in the light of equation (7). By using the estimated parameters in equation (7) the potential output growth rate (g_t^p) was estimated, as the figures in Table 2 and in Figures 1 and 2 show. Furthermore, if we assume the scenario that all labour from agricultural sectors were transferred to the rest of the economy (assuming therefore complete industrialisation of the agricultural sector which is depicted by s_{t-i}=0), then a new potential output growth rate may be estimated. Let us call this new estimate as the "overall potential output growth rate" ($g_t^{p,o}$). Comparing g_t^p with $g_t^{p,o}$, we can find the changes in the potential output growth rate due the transfer of the labour force from the agricultural sector to the rest of the economy. The results of this comparison are shown in percent changes in Figure 3.

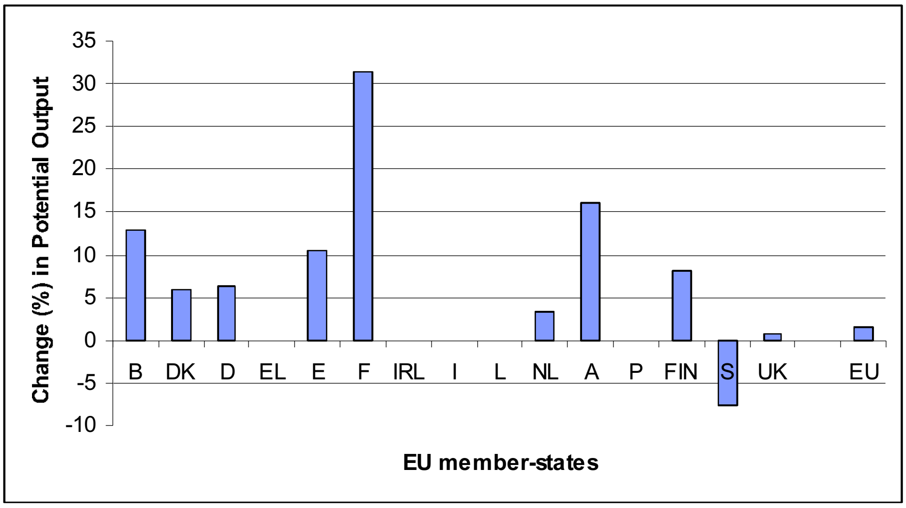


Figure 3. Changes in potential output growth rate due to agricultural industrialisation

It is seen in Figure 3 that there exists a "potential increase" in the potential output growth rate, for example, of France equal to 31.4%. In other words, although the potential output growth rate for France has been estimated for 1999 to be 2.44% (see Table 2) this could be 3.21% if the agricultural sector was completely industrialised. Similarly, although the potential output growth rate has been estimate for 1999 to be 2.58% for Sweden this will be 2.38% if the agricultural sector was completely industrialised. For some economies (EL, IRL, I, L, P) the industrialisation of agriculture will not affect the potential output growth rate. Overall, the potential increase in the potential output growth rate has been estimated to be 1.6% for the European Union from the industrialisation of agriculture.

Finally, it must be noted here that although we tried in this paper to capture some of the problems in the estimation of cyclical unemployment and output, the usual biases in estimating the NAIRU are the miss-specified equations and the non-linearities and asymmetries in the effect of the cyclical unemployment on cyclical output. New specifications in the equations used must be employed, taking into account the limitations (cases) presented in section 2 about the characteristics of the transfer of labour force from the agricultural sector to the rest of the economy. Therefore, further research is needed in this field in the light of specific country experiences (Richardson *et al.,* 2000).

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