DISCUSSION PAPER SERIES

IZA DP No. 136

Unemployment and Productivity Growth

An Empirical Analysis within the Augmented Solow Model

published in: Economic Modelling 19, (2002), 105-120

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March 2000

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IZA Discussion Paper No. 136
March 2000

ABSTRACT

Unemployment and Productivity Growth*
An Empirical Analysis within the Augmented Solow Model

Does a country's level of unemployment have an impact on the long-run growth rate? Incorporating unemployment into a generalised augmented Solow-type growth model, yields some answers to this question. In particular, we show that the impact of unemployment on productivity growth heavily depends on the influence of human capital in the production function. In the traditional Solow model, unemployment has neither an influence on long-run productivity growth nor on the long-run level of productivity. However, if human capital matters, unemployment has a long-run effect on the level of productivity. Moreover, if we allow for endogenous growth within our theoretical framework, unemployment has an impact on long-run productivity growth. Using data from 13 OECD countries from 1960 to 1990 within a dynamic panel data framework, we find supportive evidence that an increase in unemployment indeed reduces the long-run level of productivity. Taken at face value our results suggest that if unemployment would have remained at the level of 1960 then productivity today would be roughly 10% higher than it is.

JEL Classification: O40, O57, E24

Keywords: Growth, equilibrium unemployment, panel data.

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* Thanks for helpful comments go to Michael Carlberg, Michael Cyrus and Parvati Trübswetter. A previous version of the paper has been presented at seminars at the universities of Hamburg and Cologne. We thank all participants for valuable comments and suggestions, especially André Drost, Bernhard Felderer, Peter Funk, Bernd Lucke, Regina Noak, and Nikolaus Siegfried. The usual disclaimer applies.

1. Introduction

Does a country's level of unemployment have an impact on the long-run growth rate? Persistently high unemployment rates in Europe over the last two decades indicate that unemployment is, at least to a large extent, not a pure business cycle phenomenon. This implies a continuing waste of labour and of human capital in most European countries. Hence, it seems reasonable to ask, whether given levels of unemployment influence long-run productivity growth or the long-run level of productivity itself.

While unemployment is a severe problem in Europe, but not in the US, the decline in productivity growth has been stronger in the US. Between 1979 and 1997 the average rate of unemployment in the US was 6.7% and the average growth rate of labour productivity was 0.9%. In Europe the average rate of unemployment was 9.3% and the average growth rate of labour productivity was 2.2%. The common explanation given for these facts is the following: high wages lead firms to substitute labour with capital. This leads to increasing unemployment and to increasing productivity since the workers who are still employed become more productive. Hence, it is argued that there is a trade-off between unemployment and productivity growth. However, if we look at simple time series plots, the evidence lends at best mild support to the above mentioned hypothesis. Figure 1 shows the development of unemployment and productivity growth in Europe and in the US between 1960 and 1997. It is striking that there has been an increase in the rate of unemployment that goes along with a decline of productivity growth in Europe as well as in the USA.

Gordon (1997) and Bean (1997) argue that this time series evidence shows a causal link running from unemployment to growth.[1] Section 2 formalises this link by introducing

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[1] The traditional link between unemployment and productivity is represented in Okuns law. However the focus of Okuns law is on short-run demand dynamics, see Gordon (1979). Neither the slowdown of productivity growth nor the increase in unemployment over the last decades can be explained by such short-run business cycle effects.

unemployment into an augmented Solow growth model. The model nests the standard Solow model as well as the endogenous growth model as special cases. Our main argument is that physical and human capital are built up by savings and education. Unemployment reduces savings and expenditures on education. Therefore, unemployment might impinge on productivity and productivity growth. In section 3 and 4 we put our theoretical model to an empirical test, where section 3 discusses the empirical specification and section 4 presents the results of our estimates using a dynamic panel data framework. The main finding is that unemployment indeed reduces the level of productivity: Taken at face value our results suggest that if unemployment would have remained at the level of 1960 than productivity today would be roughly 10% higher than it is. Section 5 discusses some puzzles arising from our empirical results. Section 6 concludes.

2. Unemployment in the Augmented Solow Growth Model

Our focus is on the interaction between long-run (equilibrium) unemployment and productivity growth. Modern labour market theory provides at least three competing models to explain equilibrium unemployment:[2] 1) union models, where wages are determined by a bargain between unions and firms; 2) search models, where the wage is determined by a bargain between individual workers and firms; 3) efficiency wage models, where firms set wages above the competitive level to increase workers efforts. Even though the reasoning behind these models differs, two important results of the models are very similar: first, the equilibrium rate of unemployment is determined by institutional settings, such as the size and power of unions, the bargaining system, and by the generosity of the unemployment insurance system. Second, the equilibrium rate of unemployment is independent of production and

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[2] The classification follows Pissarides (1998).

productivity growth.[3] Both results seem to fit the data pretty well (see Nickell (1998) and Bean (1994)). Since these determinants of equilibrium unemployment are exogenous to our model of production and growth, we take the equilibrium rate of unemployment as exogenously determined.

We start with a short-run model. Labour supply measured in efficiency units is given as N. All workers are assumed to be equally efficient. Unemployment reduces labour input in production: $L = (1 - u)N$. Available capital as well as the technological state of the economy are given. Firms use physical capital K and labour L to produce a homogenous output Y. The production function is assumed to be of Cobb-Douglas type: $Y = K^{\alpha}L^{1-\alpha}$ with $0 < \alpha < 1$. Profit maximisation implies that the marginal product of capital equals the interest rate $r = \alpha Y/K$ and the marginal product of an efficiency unit of labour equals the wage for an efficiency unit of labour $w_l = (1 - \alpha)Y/L$.

Efficiency units of labour are composed of raw labour and of human capital H. Efficiency units of raw labour depend on the size of the workforce $\overline{N}$ and on the technological state of the economy E. Consequently, labour supply in efficiency units is given as: $N = H^{\beta}(E\overline{N})^{1-\beta}$, with $0 \leq \beta \leq 1$. Therefore, the production function is:

$$Y = (1-u)^{1-\alpha} K^{\alpha} H^{\beta(1-\alpha)} (E\overline{N})^{(1-\alpha)(1-\beta)} \tag{1}$$

The production function encompasses three special cases. 1) With $\beta = 0$ human capital is unproductive and efficiency units of labour depend only on the number of workers and on the technological state of the economy, as in the traditional Solow growth model. 2) With $\beta = 1$ raw labour is unproductive and labour supply depends only on human capital and therefore we

[3] Layard et al (1991) explicitly state in the section about efficiency wages: "Note, that as with our union model, productivity changes have no impact on u*"

obtain an endogenous growth model in the spirit of Lucas (1993). 3) In the intermediate case $0 < \beta < 1$ we get the augmented Solow model introduced by Mankiw/Romer/Weil (1992).

Productivity, defined as production per worker, is given as $P = Y/\overline{L}$, where $\overline{L}$ is the number of employed workers. Insert $\overline{L} = (1-u)\overline{N}$ into the production function and divide by $\overline{L}$ to obtain:

$$P = \frac{E}{(1-u)^{\alpha}}\left(\frac{K}{E\overline{N}}\right)^{\alpha}\left(\frac{H}{E\overline{N}}\right)^{\beta(1-\alpha)} \tag{2}$$

To establish the wage of a worker the labour share is divided by the number of workers $w = w_l L/\overline{L}$. Therefore, the wage is proportional to productivity $w = (1-\alpha)P$. Now consider an increase in the rate of unemployment. As an important first result we see that this leads to an increase in productivity and wages and to a reduction of production and of the interest rate.

This result holds for a given capital stock and a given level of labour efficiency. However, labour supply, capital and labour efficiency grow the long-run. The work force grows with the exogenous rate $n = \hat{\overline{N}}$ and exogenous technological progress leads to growing efficiency $e = \hat{E}$. Efficiency units of raw labour supply $E\overline{N}$ therefore grow at an exogenous rate n + e. The equilibrium rate of unemployment stays constant and therefore labour used in production grows with the same rate as labour supply.

In each period physical capital is augmented by investment $\dot{K} = I$, where the dot denotes the time derivative $\dot{K} = dK/dt$. Since we are interested in consequences of long-run unemployment and not in business cycle effects, we assume that all savings are invested I = S. Savings are proportional to income S = sY. Hence we have $\dot{K} = sY$. Divide both sides by K and use (1) to obtain to growth rate of physical capital:

$$\hat{K} = s(1-u)^{1-\alpha}\left(\frac{H}{K}\right)^{\beta(1-\alpha)}\left(\frac{E\overline{N}}{K}\right)^{(1-\alpha)(1-\beta)} \tag{3}$$

Human capital is augmented by education. Spending on education is proportional to income and therefore we have $\dot{H} = zY$, where z is the educational spending rate. Use the production function to substitute Y and divide by H to obtain the growth rate of human capital:

$$\hat{H} = z(1-u)^{1-\alpha}\left(\frac{H}{K}\right)^{-\alpha}\left(\frac{E\overline{N}}{H}\right)^{(1-\alpha)(1-\beta)} \quad (4)$$

From (3) and (4) it becomes clear that an increase in the rate of unemployment reduces the growth rates of physical and human capital.

We are interested in the impact of a discrete jump in the equilibrium rate of unemployment. Productivity growth can be obtained from (2) as $\hat{P} = \hat{E} + \alpha(\hat{K} - (\hat{N} + \hat{E})) + \beta(1-\alpha)(\hat{H} - (\hat{N} + \hat{E}))$. Hence, productivity growth is determined by technical progress and growth of physical and human capital per capita. Since growth rates of physical and human capital are reduced by unemployment, productivity growth is also reduced.

In the long run the economy converges to the steady state, where capital and production grow with equal rates $\hat{Y} = \hat{K}$. Transform the production function into growth rates to see that from the steady state condition $\hat{Y} = \hat{K}$ and $\hat{E} + \hat{\overline{N}} = e + n$ it follows: $\hat{K} = \beta\hat{H} + (1-\beta)(e+n)$. Two cases arise: 1) with $\beta < 1$ the steady state growth rate is determined by the exogenous rate of technological progress and population growth $\hat{Y} = \hat{K} = \hat{H} = n + e$; 2) with $\beta = 1$ we have constant returns to the factors that can be accumulated and therefore a balanced endogenous growth path with $\hat{Y} = \hat{K} = \hat{H}$.

Since $\hat{K} = \hat{H}$ holds in both cases ($\beta < 1$ and $\beta = 1$), the steady state ratio between human and physical capital can be obtained from (3) and (4):

$$\frac{H}{K} = \frac{z}{s} \quad (5)$$

For the long-run analysis of productivity we have to treat the two cases $\beta = 1$ and $\beta < 1$ separately. With $\beta < 1$ the steady state growth rate of output is $\hat{Y} = n + e$ and therefore the growth rate of productivity is $\hat{P} = e$. Hence, unemployment has no influence on the long-run growth rate. However, it might influence the level of productivity. In the steady state K and H grow with the rate $\hat{K} = \hat{H} = e + n$ and therefore physical capital per efficiency unit of raw labour k and human capital per efficiency unit of raw labour h are constant. Insert $k = K/E\overline{N}$ and $h = H/E\overline{N}$ as well as (5) into equation (3) and (4) and use the steady state condition to solve for k and h:

$$k = (1-u)^{\frac{1}{1-\beta}} \left(\frac{s}{e+n}\right)^{\frac{1}{(1-\alpha)(1-\beta)}} \left(\frac{z}{s}\right)^{\frac{\beta}{(1-\beta)}} \tag{6}$$

$$h = (1-u)^{\frac{1}{1-\beta}} \left(\frac{z}{e+n}\right)^{\frac{1}{(1-\alpha)(1-\beta)}} \left(\frac{z}{s}\right)^{\frac{-\alpha}{(1-\alpha)(1-\beta)}} \tag{7}$$

An increase in the rate of unemployment reduces physical and human capital per effective raw labour. Now insert (6) and (7) into (2) to gain:

$$P = E(1-u)^{\frac{\beta}{1-\beta}} \left(\frac{s}{e+n}\right)^{\alpha/[(1-\alpha)(1-\beta)]} \left(\frac{z}{e+n}\right)^{\beta/(1-\beta)} \tag{8}$$

As an important result we see that for $\beta > 0$ unemployment reduces productivity in the long run. In contrast, if $\beta = 0$ there is no effect on the long-run level of productivity.

If $\beta = 1$ holds, the model delivers endogenous growth. Insert $\beta = 1$ into equations (3) and (4) to obtain:

$$\hat{K} = s(1-u)^{1-\alpha} \left(\frac{H}{K}\right)^{(1-\alpha)} \tag{9}$$

$$\hat{H} = z(1-u)^{1-\alpha} \left(\frac{H}{K}\right)^{-\alpha} \tag{10}$$

In steady state we have H/K = z/s and therefore: $\hat{Y} = \hat{K} = \hat{H} = (1-u)^{1-\alpha} s^{\alpha} z^{1-\alpha}$. Productivity grows with the rate $\hat{P} = \hat{Y} - n$ and therefore we have:

$$\hat{P} = (1-u)^{1-\alpha} s^{\alpha} z^{1-\alpha} - n \tag{11}$$

Hence, unemployment reduces productivity growth.

Finally, have a brief look at the process of adjustment induced by an increase in the level of unemployment. In the short run the increase in unemployment leads to an increase in capital per worker. Therefore productivity and wages rise, but income is reduced. This leads to a decline in savings and in educational spending. As a result, the growth rates of physical and human capital are reduced and productivity growth is also reduced. The long-run effect depends on the size of the influence of human capital in the production function. 1) When human capital does not matter, we have a traditional Solow type growth model. In that case growth rates of physical capital and of productivity return to the exogenously given levels. What is more, even the level of productivity is not affected in the long run. 2) When human capital and raw labour are productive, the growth rates of physical and human capital as well as the growth rate of productivity return to their original exogenous levels. However, the transitory decline in productivity growth reduces the level of productivity in the long run. 3) When raw labour is unproductive and labour input depends only on human capital, the growth rate of human and physical capital as well as the growth rate of productivity decline to a new steady state level. Hence, we have a permanent reduction in productivity growth.

3. Empirical Specification and Data

To test for the impact of unemployment on growth we will augment standard growth regressions by levels and changes of the unemployment rate, as motivated by our theoretical model. To capture dynamic as well as long-run effects we exploit a dynamic panel data framework. An advantageous feature of dynamic panel data models is that we do not have to rely on stochastic assumptions about the initial levels of technology, which has to be done in cross-section data regressions.[4] Initial levels of technology as well as other time invariant country effects are captured by fixed effects. Exogenous technological progress and other time specific common shocks are modelled by fixed (deterministic) time effects.

The general specification of our growth regressions as a dynamic two-way fixed effects model is:

$$y_{c,t} = \gamma y_{c,t-1} + \delta u_{c,t-1} + x'_{c,t-1}\theta + \mu_c + \eta_t + \varepsilon_{c,t} \qquad (12)$$

where $y_{c,t}$ is the log of the dependent variable, $u_{c,t-1}$ is the log of the country's lagged unemployment rate, $x'_{c,t-1}$ is a vector of the log of lagged variables controlling for observed time variant country characteristics, γ, δ and θ are the parameter(s) (vector) of interest, μ_c is a fixed country effect, η_t is a fixed time effect and $\varepsilon_{c,t}$ is a standard error term with $\varepsilon_{c,t}$ ~ $N(0,\sigma^2_\varepsilon)$, $E(\varepsilon_{c,t},\varepsilon_{j,s}) = 0$, $c \neq j$ or $t \neq s$, $E(\mu_c,\varepsilon_{j,s}) = 0$ $\forall$ r, j, t and $E(x_{c,t},\varepsilon_{j,s}) = 0$ $\forall$ c, j, s, t. Using lagged values of all explanatory variables, any potential endogeneity should be reduced.[5]

As it is well known from the literature (Nickell 1981, Kiviet 1995), the usual least square dummy variable estimator (LSDV) of equation (12) yields asymptotically biased estimates of the parameters. We therefore additionally use a GMM-estimator proposed by Arellano/Bond (1991). In a first step equation (12) is first-differenced to wipe out μ_c. This allows in a second step to exploit all lagged values of $y_{c,t-i}$ ($i \geq 2$) as instruments in the first-differenced equation. Moreover, if endogeneity of some other regressors like the saving rate is an issue, these

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[4] Standard augmented growth regressions relying on cross-section data have to deal with the problem that the initial level of technical efficiency [E(0)] for each country is unobserved. This introduces an omitted variable bias if one or more regressors are correlated with the initial level of technical efficiency (Caselli et al. 1996, Temple 1999). To solve the problem Mankiw/Romer/Weil (1992) assume that E(0) is a linear function of a stochastic technology shifter, which is independent of all explanatory variables. The dynamic panel data framework has also been used by Islam (1995) and by Caselli et al.(1996).

[5] We will further address endogeneity problems later on.

variables might be instrumented using lagged values of $x_{c,t-i}$ ($i \geq 2$) as well. However, first-differencing introduces a moving average with unit root in the disturbance $\Delta\varepsilon_{c,t}$. The weighting matrix of the GMM-estimator takes the MA form of $\Delta\varepsilon_{c,t}$ into account.[6] Our IV-estimator hinges upon the assumption that there is no second-order serial correlation for the disturbances of the first-differenced equations. Therefore, we employ a robust test of second-order correlation suggested by Arellano and Bond (1991). Moreover, standard tests indicate that heteroscedasticity is an issue in our data. Standard errors and all test statistics are therefore robust to general heteroscedasticity.

Our data set covers 13 OECD countries from three sources. Real GDP per worker as a measure for labour productivity, the investment share of GDP in percentage points as a proxy for the saving rate, capital stock per worker (all three at constant 1985 international prices) and the average population growth are drawn from the Penn World Tables version 5.6.

The unemployment rates are the OECD standardised unemployment rates. Our proxy for the country's stock of human capital is the percentage of secondary school attainment in the total population aged 15 and over, which is drawn from the Barro/Lee (1996) data set. Like most other studies (Temple 1999) we opt for a five year time interval to remove the effects of business cycles, i.e. the explanatory variables are taken as averages over the 5 years preceding t or t – 1, and $y_{c,t} - y_{c,t-1}$ are five year differences [t – (t – 5)]. However, using 5-year averages leaves us with a small data set with respect to the time dimension. As a check of robustness, we therefore additionally run some regressions with annual data within an error correction framework. Since we have standardised unemployment rates starting in 1964 up to 1997, but only information for the secondary school attainment from 1960 to 1990, we exploit

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[6] This is Arellano and Bonds' GMM1-estimator. In most Monte Carlo simulations (Judson/Owen 1999, Kievit 1995) GMM1 outperforms GMM2 if one takes the sample size of our data set into account. All GMM-estimations are carried out using GAUSS and the DPD-tool developed by M. Arellano and S. Bond (Arellano/Bond (1988)).

data from 1960 to 1990.[7] Table A in the Appendix provides descriptive statistics for all variables used in the empirical analysis. In our data the log of averaged unemployment is negatively correlated with productivity growth as indicated by an overall correlation coefficient of $\rho = -0.47$ ($p = 0.001$). Country-specific correlation coefficients of unemployment and productivity growth range from –0.83 (Netherlands) up to 0.10 (UK). Except for the UK all country specific correlation coefficients are negative.

4. Results

We start with a dynamic analysis of the bivariate relation between the level of productivity and unemployment using LSDV- and GMM-estimators. The underlying argument of our theoretical model is that productivity growth might be reduced by an increase of unemployment via reduced savings and educational expenditures (see equations 3 and 4). Therefore, we also analyse bivariate correlations between lagged unemployment and physical capital and lagged unemployment and human capital per worker. The reason for the parsimonious specification is that due to the potential mechanical correlation between the investment share of GDP in percentage points and GDP itself, the signal in the other explanatory variables of interest might be low conditional on investment (see Barro (1997) and Krueger/Lindahl (1998)). Table 1 displays our results.

Columns 1 and 2 of Table 1 show the results of the LSDV- as well as the GMM-estimator for the productivity equation. The estimated parameters for lagged unemployment are both significantly negative. Hence, we find a negative correlation between lagged unemployment and productivity, which is in line with our theoretical model. In addition, the estimated

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[7] This implies that we use the unemployment rate in 1964 as a proxy for the average unemployment rate of the years 1960 to 1964.

parameters of the short-run effect of unemployment are significantly negative. Therefore, within our five-year time span the initially positive effect of an increase in unemployment on productivity is totally purged by the following adjustment process. Columns 3 and 4 show the results for capital per worker. The correlation between lagged unemployment and capital per worker is significantly negative and is greater than the negative correlation between labour productivity and unemployment. This provides supportive evidence for the underlying link that an increase in unemployment goes along with a decrease in capital accumulation. Columns 5 and 6 indicate that we do not find any significant correlation between lagged unemployment and human capital measured by the secondary school attainment rate. Only the estimated parameter for the short-run averaged growth rates of unemployment in the LSDV-model is significantly positive, which is not in line with our simple model, but might be explained by the fact that young people might stay in school in the short run when unemployment increases.

With respect to the different wald statistics (Wald_P, Wald_C, Wald_T) the panel specification of our parsimonious models seems to be appropriate. The BP-statistics indicate that heteroscedasticity is an issue in our data.[8] Considering the m_2 statistics, there is no evidence for serial correlation in the disturbances in our underlying model in levels.

In a second step we estimate our extended version of the standard augmented growth regression introduced by Mankiw/Romer/Weil (1992). The following specification can be derived from equations (6), (7), and (8). Instead of employment rates we use unemployment rates to assess the effect of unemployment directly. In addition to the lagged unemployment rate we introduce somewhat ad hoc the change in the averaged unemployment rate $\Delta u_{c,t}$ and

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[8] In Table 1 we use White estimators to compute robust standard errors. However, the finite sample characteristics of White's estimator are widely unknown (Greene 1997, p. 549). We therefore also compute an alternative estimator recommended by Greene (1997) for the LSDV model. The crucial results with respect to the lagged level of unemployment remain stable but the standard errors are higher, e.g. the estimated standard errors for $u_{c,t-1}$ are in column 1 $s_x = 0.021$ and in column 3 $s_x = 0.023$.

the average annual growth rate of unemployment over the five years preceding t $av(\Delta(u^S))$ to capture short-run dynamics:

$$p_{c,t} = \gamma p_{c,t-1} + \delta_1 u_{c,t-1} + \delta_2 \Delta\, u_{c,t} + \delta_3 av(\Delta(u^S)) + \delta_4[s_k - (n+e+d)] + \delta_5 h + \mu_c + \eta_t + \varepsilon_{c,t} \quad (13)$$

The log of the variable s_k is proxied by the averaged log investment share of GDP over the 5 years preceding t and the variable h is the secondary school attainment rate as provided by Barro/Lee (1996).[9] The variable n is the average rate of population growth in the relevant 5-year interval; e and d represent exogenous technological progress and depreciation respectively. In line with large parts of the literature we take (e + d) to be equal to 0.05. Table 2 shows our results.

Column 1 and 2 report LSDV- and GMM- estimates of equation (13). The estimated parameters for $p_{c,t-1}$ are both significantly positive and clearly unequal from one. Hence, we observe convergence to the exogenous trend captured in the time effects in our data. The implied convergence rate ranges between 0.11 and 0.12 and is in line with results presented by Islam (1995) and Caselli et al (1996). The estimated parameters for $[s_k - (n+e+d)]$ are positive and significant. The implied shares of capital are equal to 0.28 (LSDV) and 0.37 (GMM), which corresponds to other results (Gollin 1998). The estimated parameters for h are never significantly different from zero. This is again in line with results provided by Islam (1995) and Caselli et al. (1996).

The estimated parameters for the lagged level of unemployment are both significantly negative. Hence we observe a negative impact of the lagged level of unemployment on productivity, as suggested by our model. The implied long-run elasticity of productivity with

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[9] Following previous panel data estimates we use this stock measure for human capital. Flow measures used by Mankiw/Romer/Weil (1992) are not available for 5-year intervals.

respect to unemployment is roughly –0.08.[10] This indicates that unemployment does indeed have a remarkable long-run effect on productivity in our data: since unemployment in some countries roughly doubled over the observed period, our estimates imply that their productivity today would be 8% to 10 % higher than it would have been without the increase in unemployment.

Considering the fit of our regressions, all Wald statistics indicate that our panel specification is appropriate. Once again, the test statistic of the Breusch-Pagan test indicates that heteroscedasticity is an issue in our data. Moreover, the m_2 statistics give supportive evidence for the validity of the GMM-procedure.

One might argue that endogeneity of both capital shares and of lagged unemployment is an issue in our data, e.g. rapidly growing countries are able to attract more investment. To check for endogeneity we exploit lagged values of all explanatory variables as instruments in the GMM procedure. Column 3 of Table 2 shows that the results remain stable with respect to the convergence parameter and the estimated parameter for the level of unemployment, but that none of the other estimates is significantly different from zero.

Following the empirical growth literature (Temple 1999) and using five year averages to wipe out any cyclical effects leaves us with a panel data set with a small dimension with respect to T. Recent Monte Carlo studies (Judson/Owen 1999, Bun/Kiviet 1999) have emphasized that the finite sample properties of different inference techniques for dynamic panel data are not well understood. Therefore, we ran some additional regressions using annual data from 1965 up to 1990 to check for the robustness of our results. Since we do not have annual data on human capital, we restrict ourselves to parsimonious specifications like the one documented

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[10] Note that using the above mentioned alternative estimator to compute robust standard errors does not change the results qualitatively. However, the standard error for the estimated parameter of lagged unemployment in the LSDV model is then 0.018, which implies a significance level of only 10%.

in Table 1. We specify ad hoc error correction equations with fixed effects for both labor productivity growth and for growth of capital per worker using the LSDV- and GMM-estimator. To test for cointegration between productivity (capital per worker) and unemployment we compute two residual based tests of the null of no cointegration in panels suggested by Pedroni (1999). With respect to labour productivity both tests reject the null (panel-t:–2.91; group-t:–36.8), with respect to capital per worker only one test rejects the null (panel-t:–0.03; group-t:–2.3).[11] Table 3 displays our results for the ECM estimates.

Column 1 of Table 3 shows that we again observe a significant negative correlation ($\alpha < 0.1$) between lagged unemployment and productivity using the LSDV-estimator.[12] Moreover, with respect to the short-run dynamics we find a positive relationship of productivity growth and the change of unemployment as predicted by our model. The estimated parameter for the lagged level of productivity is significantly negative, which is in line with the results of the cointegration tests. However, column 2 shows that we do not observe any significant relationship between lagged unemployment and productivity growth within the GMM-framework. Hence, based on annual data, we find only partly supportive evidence for a negative long-run correlation of unemployment and productivity.[13] Column 3 and 4 indicate that we observe a significantly negative correlation between lagged unemployment and growth of capital per worker in our data. These results are in line with our estimates presented in Table 1.

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[11] Following Pedroni's (1999) terminology we compute the panel t-statistic (parametric) and the group t-statistic (parametric). Both are analogous to the familiar augmented Dickey-Fuller t-statistics based on the within- respectively the between-dimension of the data. The values of the test statistics have to be compared to the appropriate tail of the normal distribution.

[12] This result holds when we use the above mentioned different robust estimator of the standard error.

[13] Daveri/Tabellini (1997) find a significantly negative relationship between unemployment and productivity growth in their study using five year averages of the data. Note that using productivity growth implies that they impose the restriction $\gamma = 1$ in equation (13).

5. Discussion

Our empirical evidence is partly in line with our theoretical analysis: most importantly we find a negative effect of unemployment on the level of productivity in nearly all specifications. However, we also yield some results, that are at variance with the predictions of our theoretical model. Our results give supportive evidence to the conditional convergence hypothesis and point to a negative impact of the level of unemployment on the level of productivity, but does not provide any evidence on an effect of human capital on productivity. However, in terms of our theoretical model, unproductive human capital implies that the long-run level of productivity is independent of the unemployment rate. One reason for the fact that our empirical results are at odds with the theoretical model if we assume that human capital is unproductive might be that - like other empirical growth studies using cross country data - we underestimate the effect of human capital in our augmented growth regression due to measurement error (Krueger/Lindahl 1998*)*. Secondary school attainment rates are clearly a very poor proxy for human capital, in particular if only OECD countries are considered. However, if we decide to take our results with respect to human capital literally we have to look for another explanation for the negative long-run effect of unemployment on productivity.

Without human capital the production function is $Y = K^{\alpha}L^{1-\alpha}$, with $L = (1-u)E\overline{N}$. A crucial assumption of our model in section 2 is that the saving rate is independent of unemployment. Like Daveri/Tabellini (1997) we will now argue that this need not be the case, if the model takes adequate account of the tax and unemployment insurance system. There are two types of individuals: employed and unemployed. The employed workers receive wage income and the unemployed individuals receive unemployment benefits. To finance unemployment benefits the employed have to pay contributions to the unemployment insurance system. The net wage of the employed is (1 – t)w, where t is the contribution rate and w is the gross wage.

Unemployment benefits B are fixed in relation to the net wage: B = b(1 – t)w, where b is the fixed net replacement rate. Total income is composed of wage income of the employed, benefits paid to the unemployed, and interest income $Y = (1 - u)(1 - t)w\overline{N} + ub(1 - t)w\overline{N} + rK$. With a balanced budget of the unemployment insurance system the contributions of the employed equal benefits paid to the unemployed: $(1 - u)tw\overline{N} = ub(1 - t)w\overline{N}$. Hence total income is $Y = (1 - u)w\overline{N} + rK$. Notice $\overline{L} = (1 - u)\overline{N}$, $w = \beta Y/\overline{L}$ and $r = \alpha Y/K$ to see that the identity holds. The assumption that savings are proportional to income implies that the saving rates from different income sources are the same. In particular this implies that the saving rate from wage income is the same as the saving rate from unemployment benefits. Empirically this is highly unlikely.

For simplicity and to make our point, we will now assume that the unemployed do not save. We will maintain the assumption that saving rates from interest income and from wage income are identical. In that case savings are: $S = s[(1 - u)(1 - t)w\overline{N} + rK]$. Contribution rates to the unemployment insurance depend on the replacement rate and on the level of unemployment: $t = ub/(1 - u + ub)$. An increase in the level of unemployment as well as an increase in the replacement rate increases the contribution rate. Insert the contribution rate into $\dot{K} = S = s[\beta(1 - t) + \alpha]Y$ and divide both sides by K, replace production with the help of (1) and rearrange to obtain:

$$\hat{K} = \frac{s(1 - u + \alpha bu)}{1 - u + bu}\left(\frac{E\overline{N}(1 - u)}{K}\right)^{1-\alpha} \tag{14}$$

Here it becomes obvious that an increase in the rate of unemployment as well as an increase in unemployment benefits reduces the growth rate of capital.

In the long run the economy converges to the steady state, where capital and production grow with equal rates. From the production function we know that in the steady state $\hat{K} = e + n$ holds. Hence, growth rates are not affected by unemployment. To inquire into the level of productivity we will analyse capital per unit of effective labour $k = K/E\overline{N}$. Aggregate capital K grows with the rate $\hat{K}$ = e +n and productivity growth is given by $\hat{P} = e$ in the steady state. Hence, capital per effective labour unit k = is $K/E\overline{N}$ constant. Insert k into (14) and use the steady state condition $\hat{K}$ = e + n to obtain:

$$k = (1-u)\left(\frac{s(1-u+\alpha bu)}{(e+n)(1-u+bu)}\right)^{1/(1-\alpha)} \tag{15}$$

Consequently, an increase in the rate of unemployment reduces capital per effective labour unit more than proportionally. Now insert capital per effective labour unit in (2) to gain:

$$P = E\left(\frac{s(1-u+\alpha bu)}{(e+n)(1-u+bu)}\right)^{\alpha/(1-\alpha)} \tag{16}$$

As (16) shows, an increase in the level of unemployment leads to a decline in productivity. The mechanism is as follows. An increase in unemployment requires higher contributions to unemployment insurance. This reduces savings of the employed. Since this is not compensated by savings of the unemployed, capital accumulation is reduced. In the same way an increase in the replacement rate leads to a decline of productivity.

6. Conclusion

To answer the question whether unemployment influences productivity in the long run we incorporate unemployment into an augmented Solow-type growth model. The model shows that unemployment reduces the level of productivity if human capital is productive. In contrast unemployment has no long-run effect on the level of productivity if human capital is unproductive. Empirically we analyse the relationship between unemployment and productivity in a dynamic panel data framework using data for 13 OECD countries. It turns out that unemployment indeed has a negative impact on the level of productivity. However, we do not find a significant impact of human capital on productivity. Besides pointing out substantial measurement error in cross-country education data, we also offer an alternative explanation for the negative impact of unemployment on productivity. If we incorporate an unemployment insurance system in our theoretical model, we observe an impact of unemployment on savings. As a result the extended model shows that unemployment reduces productivity even if human capital is unproductive.

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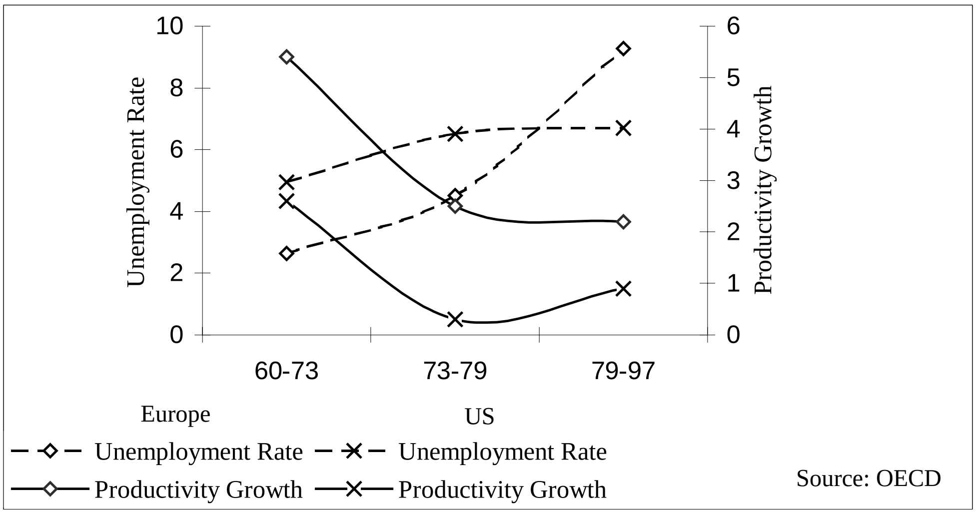

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Figure 1: Unemployment and Productivity Growth

Table 1: Parsimonious Specifications

	Productivity ($ln(P_{ct})=p_{ct}$)			Capital per worker ($ln(K/L)_{ct}=k/l_{ct}$)			Human Capital ($ln(h)_{ct}=h_{ct}$)	
	LSDV	GMM		LSDV	GMM		LSDV	GMM
$p_{c,t-1}$	0.578**	0.600**	$k/l_{c,t-1}$	0.731**	0.794**	$h_{c,t-1}$	0.406**	0.652**
	(0.062)	(0.048)		(0.043)	(0.044)		(0.104)	(0.107)
$u_{c,t-1}$	-0.040*	-0.040*	$u_{c,t-1}$	-0.081**	-0.058*	$u_{c,t-1}$	-0.029	-0.170
	(0.016)	(0.018)		(0.019)	(0.023)		(0.060)	(0.150)
$\Delta u_{c,t}$	-0.005	-0.001	$\Delta u_{c,t}$	-0.102**	-0.117**	$\Delta u_{c,t}$	0.088	-0.048
	(0.024)	(0.026)		(0.031)	(0.037)		(0.058)	(0.092)
$av(\Delta u^s)$	-0.139*	-0.152*	$av(\Delta u^s)$	-0.067	-0.022	$av(\Delta u^s)$	0.606**	-0.022
	(0.065)	(0.065)		(0.083)	(0.066)		(0.221)	(0.308)
$R^2_{adj.}$	0.97	--		0.98	--		0.89	--
BP (df)	7.4 (2)	--		16.7 (3)	--		15.6 (3)	--
Wald_P (df)	264.8 (13)	--		419.0 (13)	--		87.8 (13)	--
Wald_C (df)	48.8 (12)	--		85.4 (12)	--		56.0 (12)	--
Wald_X (df)	155.69 (4)	233.4 (4)		503.3 (4)	677.0 (4)		27.1 (4)	60.6 (4)
Wald_T (df)	236.10 (5)	52.6 (4)		137.8 (5)	58.6 (4)		53.9 (5)	11.4 (4)
m_1	--	-2.1		--	-1.7		--	-1.9
m_2	--	-0.1		--	-1.6		--	-0.8

Notes: N(LSDV) = 65 (13 countries * 5 intervals), N(GMM)=52.

Robust standard errors in parentheses. * ($\alpha < 0.05$) ; ** ($\alpha < 0.01$). Test statistics are robust to heteroscedasticity.

Time dummies included in all regression.

BP: Breusch-Pagan test for heteroscedasticity using within residuals.

Wald_P: Wald test of joint significance of country effects; Wald_C: Wald test of identical country effects; Wald_X: Wald test of joint significance of all independent variables (excluding time dummies), Wald_T: Wald test of joint significance of time dummies. Degrees of freedom for χ^2-statistics are reported in parentheses.

m_1: Test of first-order correlation of disturbances; m_2: Test of second-order correlation of disturbances. Both tests are distributed N(0,1).

Instruments used in the GMM-estimates are all available lagged (t-i, i≥2) values of $y_{c,t}$, all time dummies and all other explanatory variables.

Table 2: Standard Growth Regressions

	LSDV	GMM [a]	GMM [b]
$p_{c,t-1}$	0.562**	0.577**	0.546**
	(0.047)	(0.039)	(0.052)
$u_{c,t-1}$	-0.031*	-0.030*	-0.037*
	(0.016)	(0.014)	(0.014)
$\Delta u_{c,t}$	-0.006	-0.0003	-0.015
	(0.025)	(0.029)	(0.030)
$av(\Delta u^s)$	-0.143*	-0.136*	-0.125
	(0.062)	(0.068)	(0.073)
$s_k - (n + e + d)$	0.174*	0.246*	0.216
	(0.074)	(0.101)	(0.143)
h	0.013	0.011	0.019
	(0.029)	(0.032)	(0.023)
$R^2_{adj.}$	0.97	--	--
BP (df)	8.4 (3)	--	--
Wald_P (df)	105.7 (13)	--	--
Wald_C (df)	69.5 (12)	--	--
Wald_X (df)	181.4 (6)	729.0 (6)	455.4 (6)
Wald_T (df)	96.1 (5)	60.9 (4)	55.7 (4)
m_1	--	-2.0	-2.1
m_2	--	0.6	0.8

Notes: N(LSDV) = 65 (13 countries * 5 intervals). N(GMM)=52.

Robust standard errors in parentheses. * ($\alpha < 0.05$) ; ** ($\alpha < 0.01$). Test statistics are robust to heteroscedasticity.

Time dummies included in all regression.

BP: Breusch-Pagan test for heteroscedasticity using within residuals.

Wald_P: Wald test of joint significance of country effects; Wald_C: Wald test of identical country effects; Wald_X: Wald test of joint significance of all independent variables (excluding time dummies). Wald_T: Wald test of joint significance of time dummies. Degrees of freedom for χ^2-statistics are reported in parentheses.

m_1: Test of first-order correlation of disturbances; m_2: Test of second-order correlation of disturbances. Both tests are distributed N(0,1).

(a) Instruments used in the GMM-estimates are all available lagged (t-k, k≥2) values of $y_{c,t}$, all time dummies and all other explanatory variables. (b) Additionally instrumenting unemployment and both capital shares by lagged values t-2 and t-k, k=2,3 respectively.

Table 3: Parsimonious Specifications (annual data)

	Productivity Growth (Δp_{ct})			Capital per worker Growth ($\Delta k/l_{ct}$)	
	LSDV	GMM		LSDV	GMM
$\Delta p_{c,t-1}$	--	--	$\Delta k/l_{c,t-1}$	0.100 (0.111)	0.029 (0.067)
$p_{c,t-1}$	-0.118** (0.016)	-0.371** (0.126)	$k/l_{c,t-1}$	-0.089** (0.027)	-0.116** (0.019)
$u_{c,t-1}$	-0.006+ (0.003)	-0.022 (0.045)	$u_{c,t-1}$	-0.019** (0.007)	-0.024** (0.008)
$\Delta u_{c,t-1}$	0.015+ (0.008)	0.044 (0.031)	$\Delta u_{c,t-1}$	-0.008 (0.005)	0.005 (0.010)
$\Delta u_{c,t-2}$	0.020** (0.006)	0.034 (0.024)	$\Delta u_{c,t-2}$	--	--
$\Delta u_{c,t-3}$	0.018** (0.004)	0.028+ (0.015)	$\Delta u_{c,t-3}$	--	--
$\Delta u_{c,t-4}$	0.021** (0.005)	0.028** (0.010)	$\Delta u_{c,t-4}$	--	--
$R^2_{adj.}$	0.60	--		0.67	--
BP (df)	102.6 (6)	--		418.4 (2)	--
Wald_P (df)	144.1 (13)	--		176.4 (13)	--
Wald_C (df)	41.1 (12)	--		93.1 (12)	--
Wald_X (df)	87.6 (6)	74.8 (4)		39.3 (4)	186.5 (4)
m_1	--	-2.72		--	-1.7
m_2	--	0.122		--	-1.6

Notes: N(LSDV) = 286 (13 countries * 22 intervals). N(GMM)=273.
All variables are deviations from period means.
Robust standard errors in parentheses. +($\alpha < 0.1$);* ($\alpha < 0.05$); ** ($\alpha < 0.01$). Test statistics are robust to heteroscedasticity.
BP: Breusch-Pagan test for heteroscedasticity using within residuals.
Wald_P: Wald test of joint significance of country effects; Wald_C: Wald test of identical country effects;
Wald_X: Wald test of joint significance of all independent variables.
Degrees of freedom for χ^2-statistics are reported in parentheses.
m_1: Test of first-order correlation of disturbances; m_2: Test of second-order correlation of disturbances.
Both tests are distributed N(0,1).
Instruments used in the GMM-estimates are all available lagged (t-i, i≥3) values of $y_{c,t}$ and all other explanatory variables.

Appendix

Table A: Descriptive Statistics

variable	mean	std.-dev.
P_c	10.11	0.22
$u_{c,t-1}$	1.16	0.78
$\Delta u_{c,t}$	0.29	0.34
$av(\Delta u^s)$	0.05	0.10
$s_k - (n + e + d)$	6.12	0.19
h	3.60	0.43
$k/l_{c,t}$	10.18	0.42

Note: N = 65 (13 countries * 5 intervals) as in LSDV-procedures.

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