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Unemployment, wage bargaining and capital–labour substitution

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Many economists believe that capital accumulation, technical progress and labour force expansion have no lasting effect on unemployment. This view rests on the empirically doubtful assumption that the elasticity of substitution between labour and capital is equal to unity (i.e., production is Cobb–Douglas). Using a simple model based on the work of Layard, Nickell and Jackman, this paper demonstrates that, with a lower elasticity of substitution, the equilibrium unemployment rate is affected by all of the above factors. It considers briefly how capital accumulation may be endogenised and what long-run implications this has for unemployment.

Key words: Unemployment, Capital, Elasticity of substitution, Bargaining, Technical progress.
JEL classifications: E23, E24, E25.

Introduction

Over the past twenty years, unemployment has risen dramatically in Europe. Most of the literature on this development has focused on labour market issues, such as wage-fixing institutions, the role of welfare benefits, and the quality and motivation of the workforce. Other potentially important issues, such as the impact of capital formation on employment, have been rather neglected.[1] Indeed, many economists believe that investment has little or no long-run effect on employment, and that the problem of job creation is primarily a matter of encouraging more employment on whatever capital stock happens to exist at the time. This is the view taken in the highly influential work of Layard and Nickell. In their well-known 1986 study of British unemployment, the cross-equation restrictions in their econometric analysis imply that investment has no permanent effect on unemployment. The same is true of the economic theory presented in their later book on European unemployment (Layard, Nickell and Jackman, 1991).

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[1] Among the exceptions who have written on capital stock and employment are Bean (1989, 1994), Bean and Gavosto (1990), Carlin and Soskice (1990), Drèze (1988), Drèze and Bean (1990), Malinvaud (1980, 1985), Minford and Riley (1994), Rowthorn (1977, 1995). Most of these writings have a different focus from the present article, being mainly concerned with the role of capacity utilisation on inflation. The emphasis here is on capital–labour substitution.

In this book, the authors (LNJ) make a major effort to provide micro-foundations for their macroeconomic views. Wage bargaining and unemployment are modelled within a stochastic framework, using a combination of cooperative and non-cooperative game theory. This impressive model generates extremely powerful results. Suppose that unemployment benefits are always raised or lowered in line with wages, so as to keep the replacement ratio constant. Then, according to their model, the equilibrium unemployment rate (NAIRU) is completely unaffected by variations in aggregate capital stock, aggregate labour supply or technical progress. If there is investment in new physical capital, trade unions will respond by forcing wages up to the point where the loss of jobs on existing equipment is exactly equal to the extra jobs created on the new equipment. If the labour supply is increased through population growth or higher labour-force participation, then bargainers will adjust wages downwards to ensure that enough additional workers are absorbed into employment to keep the unemployment rate constant. The same is true if there is technical progress. These results imply that employment policy should focus exclusively on the labour market, above all on the behaviour of trade unions and the wage–benefit nexus. To the extent that policies to stimulate capital investment are useful, their role is not to create employment, but to raise output growth and living standards.

The model used by LNJ suffers from a potential weakness, which is acknowledged briefly in passing by the authors (p.107), but is ignored elsewhere in their work and has been overlooked by others. It is assumed that labour and physical capital are close substitutes, so that variations in wages have a large effect on employment. This helps to explain why investment in new capital stock leads to no net job creation in the LNJ model. Because the demand for labour is so elastic, the wage increase generated by investment in new capital stock leads to a loss of employment on existing equipment which is enough to offset entirely the extra jobs created on new equipment. Production functions in the LNJ model are of the Cobb–Douglas variety in which σ, the elasticity of substitution between labour and capital, is equal to unity. We argue below that this is an unrealistic assumption. If it is replaced by the more realistic assumption that σ is well below unity, then *none* of their major conclusions with regard to unemployment is valid. In this case, capital investment *does* create employment even when benefits are indexed to wages; while growth in the labour supply, or technical progress with a labour augmenting bias will cause a permanent rise in unemployment unless they are offset by additional investment. The policy implication is that measures to stimulate investment may have an important role to play in reducing unemployment. Moreover, measures to improve the quantity or quality of the labour force, or efficiency in the use of labour, will lead to a higher unemployment rate unless they are accompanied by more investment in physical capital.

To derive these results the present paper uses a version of the LNJ model which has been modified in three respects. The elasticity of substitution σ is less than unity. Demand functions facing individual firms are non-stochastic, whereas in LNJ they are stochastic. This assumption greatly simplifies the analysis without sacrificing anything fundamental. In addition, our model specifically allows for technical progress, which plays only a shadowy role in LNJ, but is of central importance in our approach.

The structure of the paper is as follows. Since the magnitude of σ plays such an important role in the subsequent analysis, the first section contains a survey of the relevant econometric evidence. This is followed by a brief exposition of our modified version of the LNJ model and an examination of how changes in the key macroeconomic variables influence equilibrium unemployment. For ease of exposition, the mathematical workings are kept to a minimum.[2] There is then a discussion of how investment, and thereby unemployment, may be endogenised. The paper concludes with a few general observations.

Elasticity of substitution: the evidence

Rowthorn (1996) reports the results of 33 econometric studies which have estimated the value of σ, or from which estimates of this parameter can be derived. Most of these studies contain a variety of estimates referring to different industries, regions or countries, or to alternative equation specifications.[3] Their findings are summarised by means of employment-weighted averages or medians. Out of a total of 33 studies, in only 7 cases does the summary value exceed 0.8, and the overall median of the summary values (median of the medians) is equal to 0.58.

Additional evidence can be gleaned from econometric studies which estimate labour demand equations. With given capital stock, suppose that a 1% increase in the real wage rate leads to a long-run reduction of σ% in employment. Suppose, also, that the production function is CES and that wages are equal to the marginal revenue product of labour.It is shown in the Appendix that

$$\epsilon = \frac{\sigma(1 - 1/\eta)}{(s - 1/\eta)} \geqslant \frac{\sigma}{s} \tag{1}$$

where σ is the elasticity of substitution between capital and labour, s is the share of profits in output, and η is the price elasticity of demand facing the individual firm. This relationship has implications which are not widely recognised. With the values of σ normally assumed by economists, it implies that a small reduction in wages will lead to a huge increase in employment. For example, economists commonly assume that $\sigma = 1$ and $s = 0.3$. Given just a modest degree of imperfection in the product market, so that η is equal to 1.0, the implied value of ϵ is 7.4. With perfect competition in the product market, η is equal to infinity, and the implied value of ϵ is 3.3. Such values are totally implausible and are many times larger than the estimates derived from econometric studies of labour demand. They imply that a reduction in the real wage rate of only 2%–3% would be enough to eliminate the whole of European unemployment using the existing amount of capital and existing technology.

Table 1 presents estimates of ϵ which are derived from three major econometric studies of OECD employment that are reported by Layard, Nickell and Jackman (1991). Using assumed values for s and η, we can convert these into estimates of σ by means of the following formula:

$$\sigma = \frac{\epsilon(s - 1/\eta)}{(1 - 1/\eta)} \leqslant \epsilon s \tag{2}$$

Table 2 shows the result of this calculation. Two sets of estimates are shown, one of which assumes that $s = 0.4$ and $\eta = \infty$, and the other that $s = 0.3$ and $\eta = 10$. In each case,

[2] Mathematical derivations of the key equations and formulae are given in Rowthorn (1996).

[3] Details of these studies are given in Rowthorn (1996). Note that substitution between capital and labour may occur indirectly because consumers switch between goods whose techniques of production have different capital-intensities. Such a switch may be induced because relative output prices alter when factor prices change. The possibility of indirect substitution between capital and labour should mean that the economy-wide elasticity of substitution is greater than is suggested by disaggregated studies. However, even highly aggregated studies normally reveal an elasticity of substitution which is well below unity.

Table 1. *Estimates of the elasticity of labour demand (ϵ)*

	LNJ	NS	BLN
Australia	0.62	0.59	0.77
Austria	0.27	0.75	0.73
Belgium	0.59	2.38	0.88
Canada	5.00	2.11	0.42
Denmark	0.69		0.61
Finland	0.06	0.56	–0.71
France	0.28	0.50	0.61
Germany	1.71	2.17	0.83
Ireland	0.53	0.35	1.03
Italy	0.30	0.35	0.37
Japan	0.73	0.88	1.03
Netherlands	0.60	0.78	1.10
New Zealand	0.87		
Norway	0.43	0.07	0.19
Spain	1.38		
Sweden	0.17	1.36	0.65
Switzerland	1.68	3.41	0.63
United Kingdom	0.97	1.50	0.63
United States	0.32	0.70	0.48
Median	*0.60*	*0.76*	*0.63*

Note: Elasticities are calculated from the estimated marginal revenue product equations reported in the Appendix to Chapter 9 of Layard, Nickell and Jackman (1991). These equations are of the form

$$\log(N/K)_t = constant - \sum_{i=0}^{m} \hat{a}_i \log(W/P)_{t-i} + \sum_{j=1}^{n} \hat{b}_j \log(N/K)_{t-j} + \sum_{k=1}^{s} \hat{c}_k Z_k$$

where N, K, and W/P are employment, capital and the real wage rate, respectively, and the Zs are other variables; the symbol '^' indicates that coefficients are estimated. The 'other variables' are time, the deviation of output from trend, and the acceleration rate of nominal wages. Holding K constant, the above equation implies that an increase of 1 unit in log(W/P) will lead to an estimated long-run reduction of ϵ units in log(N), where

$$\epsilon = \frac{\Sigma \hat{a}_i}{1 - \Sigma \hat{b}_j}$$

Key: LNJ = Layard, Nickell and Jackman (1991); NS = Newell and Symons (1985); BLN = Bean, Layard and Nickell (1986).

the values of σ are extremely low. In the first panel, only three out of 52 estimates of σ exceed 0.5 and in the second panel only nine exceed this figure. It is possible that these estimates are biased downwards, but the error would have to be truly gigantic to justify the assumption that σ is equal to unity.

The model

This section describes our modified version of the LNJ model of unemployment determination in the presence of trade unions and monopolistic product markets. The economy consists of a large number m of identical firms using equal amounts of physical capital. The output in firm i is equal to

$$Y_i = \left(\alpha(\Lambda_N N_i)^{\frac{\sigma-1}{\sigma}} + (1-\alpha(\Lambda_K K_i)^{\frac{\sigma-1}{\sigma}}\right)^{\frac{\sigma}{\sigma-1}} \qquad \sigma < 1 \tag{3}$$

Table 2. *Implied values of σ*

	(a)			(b)		
	LNJ	NS	BLN	LNJ	NS	BLN
Australia	0.14	0.13	0.17	0.25	0.24	0.31
Austria	0.06	0.17	0.16	0.11	0.30	0.29
Belgium	0.13	0.53	0.20	0.24	0.95	0.35
Canada	1.11	0.47	0.09	2.00	0.84	0.17
Denmark	0.15		0.14	0.28		0.24
Finland	0.01	0.12	–0.16	0.02	0.22	–0.28
France	0.06	0.11	0.14	0.11	0.20	0.24
Germany	0.38	0.48	0.18	0.68	0.87	0.33
Ireland	0.12	0.08	0.23	0.21	0.14	0.41
Italy	0.07	0.08	0.08	0.12	0.14	0.15
Japan	0.16	0.20	0.23	0.29	0.35	0.41
Netherlands	0.13	0.17	0.24	0.24	0.31	0.44
New Zealand	0.19			0.35		
Norway	0.12	0.02	0.04	0.21	0.03	0.08
Spain	0.31			0.55		
Sweden	0.04	0.30	0.14	0.07	0.54	0.26
Switzerland	0.37	0.76	0.14	0.67	1.36	0.25
UnitedKingdom	0.22	0.33	0.14	0.39	0.60	0.25
United States	0.07	0.16	0.11	0.13	0.28	0.19
Median	*0.13*	*0.17*	*0.14*	*0.24*	*0.30*	*0.25*

Note: The estimates in this table are derived from Table 1 using the following parameter values:

	panel (a)	panel (b)
profit share (s)	0.3	0.4
price elasticity (η)	10	infinite

where N_i is employment, K_i is capital, and Λ_N and Λ_K are indices of productive efficiency. Labour-augmenting and capital-augmenting technical progress are indicated by an increase in Λ_N and Λ_K respectively. The elasticity of substitution between labour and capital is $\sigma < 1$, so that technical progress has a labour-augmenting bias if Λ_N increases faster than Λ_K, and a capital-augmenting bias if the reverse is the case. As $\sigma \rightarrow 1$ the production function converges to the Cobb–Douglas case considered by LNJ,

$$Y_i = \Lambda N_i^{\alpha} K_i^{1-\alpha} \tag{4}$$

where $\Lambda = \Lambda_N^{\alpha} \Lambda_K^{(1-\alpha)}$.

Demand for the output of firm i is equal to

$$Y_i = (\mathrm{P}_i)^{-\eta} Y_{d_i} \qquad \eta > 1 \tag{5}$$

where P is the relative price of output and Y_{di} is an index of market conditions facing the firm. This is a non-stochastic version of the demand function used by LNJ.

For each firm there is a separate trade union, and the wage rate is the outcome of a bargain between this union and the firm. Once the wage rate has been fixed, the firm then decides what amount of labour to employ. Both parties to the bargain can foresee accurately the employment consequences of any wage settlement.

The union in firm i seeks to maximise the average income of ‘insiders’ which is equal to

$$V_i = S_i W_i + (1 - S_i) A \tag{6}$$

where S_i is the proportion of insiders who will keep their jobs following the wage settlement, W_i is the wage rate and A is the expected income available to those who lose their jobs. Note that S_i may depend on the wage rate. Following LNJ, we assume that expected income available outside the firm is given by

$$A = (1 - \phi u) W^e + \phi u B \tag{7}$$

where W^e is the average wage in other firms, B is unemployment benefit, u is the unemployment rate, and ϕ is a constant.

The firm seeks to maximise profits which are equal to

$$\Pi_i = P_i Y_i - W_i N_i \tag{8}$$

Since employment is decided after wages are fixed, profit maximisation implies that

$$\frac{\partial (P_i Y_i)}{\partial N_i} = W_i \tag{9}$$

Wages are the outcome of a bargain which maximises the asymmetric Nash product

$$\Omega_i = (V_i - \bar{V}_i)^{\beta} (\Pi_i - \bar{\Pi}_i) \tag{10}$$

where β is an index of relative bargaining power, and $\bar{V}_i$ and $\bar{\Pi}_i$ are the outside options available to the two parties if negotiations collapse and the firm ceases to operate. It is assumed that

$$\bar{V}_i = A, \quad \bar{\Pi}_i = 0 \tag{11}$$

The above equations are sufficient to determine output and employment in firm i given the value of external variables such as A, W^e, B and u.

Economy-wide equilibrium

Since all firms are identical, there will be an economy-wide equilibrium in which $W_i = W = W^e$, $P_i = 1$, $S_i = S$, $N_i = N/m$, $Y_i = Y/m$ and $K_i = K/m$, where the absence of subscript denotes an economy-wide variable. Define

$$v = \frac{\Lambda_K K}{Y} \tag{12}$$

This can be interpreted as the capital–output ratio measured in efficiency units. It can be shown that the equilibrium value of this variable satisfies the following implicit equation[4]

$$[v^{\rho} - (1 - \alpha)]\,[1 - f(v)]^{\rho} = \alpha \left[\frac{\Lambda_K K}{\Lambda_N L}\right]^{\rho} \tag{13}$$

where $\rho = (1 - \sigma)/\sigma > 0$ and $f(v)$ is the function shown in Table 1.

It can also be shown that the equilibrium unemployment rate (the NAIRU) is given by

$$\begin{aligned} u &= 1 - \frac{N}{L} \\ &= f(v) \end{aligned} \tag{14}$$

The main features of this macroeconomic equilibrium are summarised in Table 3. For comparison, the table also shows the limiting values as $\sigma \rightarrow 1$, which coincide with the formulae derived by LNJ.

[4] For the derivation of this and other key equations, see Rowthorn (1996).

Table 3. *Key formulae*

	$\sigma < 1$	limit as $\sigma \to 1$
Π/Y	$(1-\kappa) + (1-\alpha)\kappa\nu^{-\rho}$	$1-\alpha\kappa$
$\pi = \Pi/K$	$\Lambda_K[1-\kappa) + (1-\alpha)\kappa\nu^{-\rho}]\nu^{-1}$	$\Lambda_K(1-\alpha\kappa)\nu^{-1}$
u	$f(\nu) = \dfrac{1-\kappa}{(1-b)\phi\left[\epsilon_{SN}\left[1 - \dfrac{(\kappa+\rho)(1-\alpha)}{(1-\kappa)\nu^{\rho} + (\kappa+\rho)(1-\alpha)}\right] + \dfrac{\kappa}{\beta}\left[1 - \dfrac{(1-\alpha)}{(1-\kappa)\nu^{\rho} + \kappa(1-\alpha)}\right]\right]}$	$\dfrac{1-\alpha\kappa}{(1-b)[\epsilon_{SN} + \alpha\kappa/\beta]}$

Note: $\rho = \dfrac{1-\sigma}{\sigma} > 0, \quad \nu = \dfrac{\Lambda_K K}{Y}, \quad \kappa = 1 - \dfrac{1}{\eta} > 0, \quad \epsilon_{SN} = \dfrac{N}{S}\dfrac{dS}{dN} \geqslant 0, \quad b = \dfrac{B}{W}.$

Investment, labour force growth and technical progress

Following LNJ, assume that benefits are indexed to wages, and that the elasticity of S with respect to N ($= \epsilon_{SN}$) is constant.[5] Table 3 indicates how, under these conditions, unemployment and profits are affected by variations in the ratio $\Lambda_K K/\Lambda_N L$.

Since $\sigma < 1$, it is clear from Table 3 that $f'(v) < 0$, and hence from equation (14) it follows that

$$\frac{dv}{d(\Lambda_K K/\Lambda_N L)} > 0 \tag{15}$$

From the formulae given in Table 3, it follows that

$$\frac{d(\Pi/Y)}{d(\Lambda_K K/\Lambda_N L)}, \quad \frac{d(\Pi/K)}{d(\Lambda_K K/\Lambda_N L)}, \quad \frac{du}{d(\Lambda_K K/\Lambda_N L)} < 0 \tag{16}$$

Thus, an increase in $\Lambda_K K/\Lambda_N L$ reduces both the share and rate of profits, and also the unemployment rate. These findings have been established on the assumption that unemployment benefits are indexed to wages so as to keep the replacement ratio b ($= B/W$) constant. If benefits are not indexed, then the decline in unemployment will be even greater after an increase in $\Lambda_K K/\Lambda_N L$.

In the limit, as $\sigma \to 1$,

$$\frac{d(\Pi/Y)}{d(\Lambda_K K/\Lambda_N L)} = \frac{du}{d(\Lambda_K K/\Lambda_N L)} = 0 \tag{17}$$

This confirms the finding of LNJ that, for the case of unit elasticity of substitution, neither investment, nor variations in the aggregate labour supply, nor technical progress affect the equilibrium unemployment rate or the profit share.[6] However, if the elasticity of substitution is less than unity, then such variations *do* influence both equilibrium unemployment and the distribution of factor income. This conclusion has been established in the present paper using a non-stochastic model, but it remains valid in the stochastic case.

The ratio Λ_K K/Λ_N L may rise for one of two reasons. Either K/L may increase, indicating that physical capital has become more plentiful in relation to the labour supply; or Λ_K/Λ_N may increase, indicating that technical progress has a capital-saving bias. In either case, the effect is to reduce unemployment. The intuition for this result is as follows. An increase in $\Lambda_K K/\Lambda_N L$ leads to a higher share of wages in output. With such a higher wage share, less unemployment is required to keep union wage demands in check, and so the economy can function with permanently less unemployment than before.

Following the same logic, suppose that trade unions become stronger or that benefits become more generous. In the present model, either of these developments will cause the unions to press for a higher wage share, and in the normal course of events additional unemployment would be required to keep their demands in check. However, if greater union pressure is accompanied by a sufficiently large increase in $\Lambda_K K/\Lambda_N L$, these demands will be absorbed by squeezing the profit share so that no additional unemployment is required.

The above results depend crucially on the fact that $\sigma < 1$, for it is only in this case that

[5] Under plausible assumptions, it can be shown that ϵ_{SN} is equal to 0 or 1 in the present non-stochastic model (see Rowthorn, 1996). In the stochastic case, this parameter can take intermediate values between 0 and 1 (see LNJ, p. 106).

[6] LNJ, p. 107.

higher capital intensity will squeeze the profit share and allow the equilibrium wage share to rise. LNJ assume that $\sigma = 1$, thereby ensuring that the equilibrium distribution of income is independent of capital intensity; as a result, variations in the profit share cannot act as a cushion to absorb increased wage pressure from trade unions. In their analysis, the equilibrium wage share is determined by only two factors: technology as reflected in the exponent α, and product market competition as reflected in the elasticity η. The function of unemployment is to make the unions accept this share, for if they do not the result will be accelerating and, ultimately, unsustainable inflation. Anything which strengthens workers' bargaining position (such as greater union power or higher unemployment benefits in relation to wages) must be offset by additional unemployment to keep wage demands in check and force unions to accept the preordained wage share.

LNJ claim, on page 107, that 'unemployment in the long-run is independent of capital accumulation and technical progress'. This follows directly from the following assumptions: (1) $\sigma = 1$, and (2) b = constant (i.e., benefits are upgraded in line with wages). The former assumption ensures that, although capital accumulation and technical progress will increase the absolute level of wages, they will have no impact on the equilibrium wage *share*. Since benefits are upgraded in line with wages, the *relative* cost of unemployment is unaffected by variations in the absolute level of wages, so the unemployment rate required to make unions accept the (unchanged) equilibrium wage *share* is also unaffected.

Behaviour of *u* (the NAIRU) through time

To investigate behaviour of u through time, note that

$$\frac{du}{dt} = \frac{du}{d(\Lambda_K K/\Lambda_N L)} \frac{d(\Lambda_K K/\Lambda_N L)}{dt} \tag{18}$$

Define

$$\begin{aligned} k &= \frac{1}{K}\frac{dK}{dt} \\ \ell &= \frac{1}{L}\frac{dL}{dt} \\ \lambda_K &= \frac{1}{\Lambda_K}\frac{d\Lambda_K}{dt} \\ \lambda_N &= \frac{1}{\Lambda_N}\frac{d\Lambda_N}{dt} \end{aligned} \tag{19}$$

We know that $du/d(\Lambda_K K/\Lambda_L L) < 0$. From equation (18) it follows that

$$\frac{du}{dt} \gtrless 0 \quad \text{as} \quad k \lesseqgtr \ell + \lambda_N + \lambda_K \tag{20}$$

The difference $\lambda_N - \lambda_K$ indicates the labour-augmenting bias in technical progress. Thus, $\ell + \lambda_N - \lambda_K$ is the growth rate of capital stock required to offset the combined effects of labour supply growth and biased technical progress. Equilibrium unemployment (the NAIRU) remains constant if capital grows at this rate.[7] We shall call this the 'natural' rate of growth.

[7] This statement assumes that $b\ (= B/W)$ and that the parameters of the model remain constant.

These findings throw an interesting light on the vexed question of productivity growth and employment. Suppose that benefits are indexed to wages, so the replacement ratio b remains constant. Then rising labour productivity will be accompanied by rising unemployment if capital grows more slowly than the natural rate. Conversely, unemployment will fall if the capital grows more rapidly than this rate. Over the broad sweep of history, labour productivity has been on a long rising trend, while unemployment has fluctuated with no discernible trend either up or down. Such an outcome has been cited as evidence that productivity and unemployment are unrelated and, by implication, that neither capital investment nor technical progress affect equilibrium unemployment. Our analysis suggests that such a conclusion is unwarranted. The fact that labour productivity is trended upwards, while unemployment is untrended, could be owing to the fact that investment has been on average just sufficient to keep pace with expansion in the labour supply and any bias in technical progress. In the following section we shall consider what mechanism might account for this apparent coincidence.

Endogenous investment

The preceding discussion assumed that investment is exogenous, with no feedback from unemployment to capital formation. Investment can be endogenised in a variety of ways.[8] Consider, for example, the following investment function,

$$k = \frac{1}{K}\frac{dK}{dt} = g(\pi, r, z) \qquad g_\pi > 0,\ g_r < 0 \tag{21}$$

where π and r are the real profit and interest rates, respectively, and z is a vector of other variables, such as tax rates. Suppose that benefits are indexed to wages, so that b is constant. Suppose also that r, z, ℓ, λ_L and λ_K are constant. Define k^*, π^*, v^* and u^* by means of the following set of equations which are derived from (21) and Table 3,

$$\begin{aligned} k^* &= \ell + \lambda_N - \lambda_K \\ k^* &= g(\pi, r, z) \\ \pi^* &= \Lambda_K[1 - \kappa + (1-\alpha)\kappa\nu^{*-\rho}]\nu^{*-1} \\ u^* &= f(\nu^*) \end{aligned} \tag{22}$$

From the preceding discussion we see that k^* is the natural rate of growth, and by analogy we shall call u^* the natural rate of unemployment.

If $u > u^*$, it is easily shown that $v < v^*$, $\pi > \pi^*$, $k > k^*$, and hence that $du/dt < 0$. Thus, when unemployment (the NAIRU) is above the natural rate, profits will be above 'normal', capital will accumulate rapidly and unemployment will fall. Conversely, when unemployment is below the natural rate, profits will be low, accumulation will slow and unemployment will rise. Thus, the the natural rate defines a stable growth path along which the profit rate and the unemployment rate are both constant.

In the present model, the trend growth path is stable and the economy converges uniformly back towards this path following a displacement. However, if the response functions are lagged the result may be fluctuations around the long-run trend. There may even be a limit cycle of the type explored by Goodwin (1967).

With the above investment function, the real interest rate influences the absolute level of capital stock, but has no effect on the long-run growth rate of capital. If there is a reduction in the interest rate, the profit rate will eventually fall by an equivalent amount,

[8] For empirical evidence on the determinants of investment, see Glyn (1997).

so that capital stock will once again grow at the natural rate. Corresponding to this new profit rate, there will be a lower share of profits in output, a higher capital intensity in production, and less unemployment. During the transition to the new equilibrium, capital accumulation accelerates and the unemployment rate falls. When economic growth eventually returns to the natural rate, unemployment once again stabilises, but at a lower rate than before. Thus, a permanent reduction in the real interest rate leads to only a temporary acceleration in economic growth but a permanent fall in unemployment. Conversely, an increase in the real interest rate leads to a temporary deceleration in growth and a permanent rise in unemployment. The policy implications of this are obvious.

An interesting feature of the investment function (21) is the response of unemployment to faster labour supply growth or faster labour-augmenting technical progress. Either of these will increase the natural growth rate of the economy, and investment will eventually rise to ensure that capital stock grows at this higher natural rate. Other things being equal, more investment requires a higher profit rate, and more unemployment is required to induce workers to accept such a shift in the distribution of income. Note that unemployment will eventually return to its old level following a once and for all increase in the labour supply or a one-off improvement in production methods. However, this will not occur if there is a permanent acceleration in labour force growth or labour-augmenting technical progress. In such a case, a permanent increase in unemployment is required, because of the need to make the unions accept a permanently higher profit rate.

Concluding remarks

This article was originally motivated by a desire to understand why European unemployment has remained so persistently high since the oil shocks of the 1970s. Most explanations blame rigidities in the labour market or a shift in the skill composition of labour demand. As a result, their policy recommendations focus mainly on measures to increase labour market flexibility or improve the skills of the labour force. Our theoretical analysis does not reject such proposals, but it does suggest that a major factor behind persistent unemployment may also be inadequate growth in capital stock. Such a conclusion is in line with empirical evidence on the link between investment and job creation, which indicates that employment performance has deteriorated most since 1973 in those OECD countries which have experienced the greatest fall in their investment rate (Rowthorn, 1995; Glyn, 1998). The policy implication is that measures to stimulate investment could play an important role in helping to reduce unemployment, and that the present emphasis on labour market policies is exaggerated.

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Appendix: formulae linking σ and ϵ

Suppose that the output of the representative firm is given by the following CES production function

$$Y = \left(\alpha N^{\frac{\sigma-1}{\sigma}} + (1-\alpha)K^{\frac{\sigma-1}{\sigma}}\right)^{\frac{\sigma}{\sigma-1}} \tag{A1}$$

where N and K are employment and capital, σ is the elasticity of substitution between labour and capital, and α is a constant.

Differentiating the above equation, we obtain

$$\frac{\partial Y}{\partial N} = \alpha\left(\frac{Y}{N}\right)^{\frac{1}{\sigma}} \tag{A2}$$

Let η be the absolute price elasticity of demand for the representative firm, and suppose that workers are paid their marginal revenue product. Then the real wage rate (measured in terms of the firm's own product) is equal to

$$W = \left(1 - \frac{1}{\eta}\right)\frac{\partial Y}{\partial N} \tag{A3}$$

Thus

$$W = \alpha\left(1 - \frac{1}{\eta}\right)\left(\frac{Y}{N}\right)^{\frac{1}{\sigma}} \tag{A4}$$

and

$$\frac{WN}{Y} = \alpha\left(1 - \frac{1}{\eta}\right)\left(\frac{Y}{N}\right)^{\frac{1}{\sigma}-1} \tag{A5}$$

Differentiating (A4) yields

$$\frac{N}{W}\frac{\partial W}{\partial N} = \frac{1}{\sigma}\left[\frac{N}{Y}\frac{\partial Y}{\partial N} - 1\right]$$

$$= \frac{1}{\sigma}\left[\alpha\left(\frac{Y}{N}\right)^{\frac{1}{\sigma}-1} - 1\right]$$

$$= \frac{1}{\sigma}\left[\frac{\left(\dfrac{WN}{Y}\right)}{\left(1-\dfrac{1}{\eta}\right)} - 1\right] \tag{A6}$$

Let

$$\epsilon = -\frac{W}{N}\frac{\partial N}{\partial W}$$

$$s = 1 - \frac{WN}{Y} \tag{A7}$$

Substituting in (A6) yields

$$\epsilon = \frac{\sigma\left[1-\dfrac{1}{\eta}\right]}{\left[s-\dfrac{1}{\eta}\right]} \tag{A8}$$

$$\sigma = \frac{\epsilon\left[s-\dfrac{1}{\eta}\right]}{\left[1-\dfrac{1}{\eta}\right]} \tag{A9}$$

These are the required formulae linking ϵ and σ.