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Unemployment and Deterioration of Human Capital

A Labour Market Model with Hysteresis Implications

By J. Möller[1]

Abstract: The paper deals with the deterioration of human capital during spells of unemployment. In our model the probability of leaving the unemployment pool decreases with the duration of unemployment. It can be shown that with a linear deterioration function and a simple distribution function for the reservation productivity of firms, unemployment duration is suitably described by a distribution of the Gompertz-Makeham type. In a numerical simulation it could be demonstrated that deterioration of human capital during unemployment affects the relation between vacancies and unemployment in a specific way: in the case of labour market slackness the steady-state Beveridge curve bends away markedly from the standard u-v-curve in an outward direction while in a situation of almost full employment the effects are negligible. For higher deterioration parameters the Beveridge curve may even be upward sloping in a situation of excess supply on the labour market, implying the existence of multiple equilibria. Empirical estimation of the distribution function with German labour market data 1984–1987 reveals that the multiple equilibrium case is likely to be relevant in reality.

1 Introduction

In their famous article about 'Hysteresis and the European Unemployment Problem', Blanchard and Summers list three different approaches which can be adduced to explain why shocks that cause unemployment might have long-term effects: shortage of physical capital, the insider-outsider approach and human capital theories. The first two theories have been elaborated by several authors [see, for example, Blanchard, Summers (1986), Lindbeck, Snower (1986b, 1987a,b), Gottfries, Horn (1987) for the insider-outsider models, Burda (1988) for the capital shortage approach]. The human capital approach, however, has attracted much less theoretical interest, despite the contributions of Phelps (1972) and Hargraves Heap (1980), pointing out that unemployment may have important effects on the skills

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and motivation of the unemployed which affect the matching process and labour supply in general.

One argument against the relevance of the insider-outsider story is the observation that hysteresis seems to be a phenomenon of 'bad times' rather than of 'good times', i.e. persistent effects of adverse shocks are more likely to occur in an environement where a tendency to overall excess supply on the labour market prevails rather than in an economy which is geared to full employment. For example, why should insiders have acted completly different in the (severe, but short-lived) German recession of 1966/67 than in 1974/75 or in 1980/81 where much more persistent effects on unemployment were observed? An approach which concentrates on wage-setting behaviour in response to shocks has little to say with respect to this important discrepancy, so the insider-outsider aspect is not the complete story. Burda (1988) stresses another point which also is important for the understanding of the specific German situation: between 1980 and 1983 real wage income has been *declining* while unemployment has been rising. He presents a theoretical model which reconciles this empirical observation with an optimising model of wage-setting behavior in the presence of capital shortage. In our view, human capital aspects are equally important.

It is a well-established empirical fact that the probability of leaving the unemployment pool falls essentially with longer duration of unemployment. Basically there are two – in our view complementary – lines of argument to rationalise this phenomenon. The first approach [see for example Budd, Levine, Smith (1987, 1988) and Tötsch (1988)] stresses the role of heterogeneity between workers: During periods of high unemployment a sorting mechanism is at work which leaves behind the less qualified so that groups with unfavourable characteristics appear to be over-represented in the unemployment pool. The second approach assumes a depreciation process for human capital during spells of unemployment, because the 'workers who are unemployed lose the opportunity to maintain and update their skills by working' [Blanchard, Summers (1986, p. 28)]. From the standpoint of hysteresis theory both approaches lead to consequences which are more or less equivalent: in case of the sorting effect, persistent slackness of labour markets causes social costs in the form of generating problem groups on the labour market and in case of the depreciation effect social costs arise from the loss of human capital. Also, since from the two different approaches very similar effects on the matching process can be expected, no attempt is made in the present paper to disentangle sorting and duration effects empirically. But in the theoretical model an explicit deterioration process of human capital is assumed.

The paper is organised as follows: In the next section a probabilistic model of the matching process is developed. We then derive the steady-state Beveridge curve and analyse the effects of an increasing 'depreciation rate of human capital' by means of a numerical simulation. The final section provides some estimation results for German labour market data.

2 A Probabilistic Model of the Matching Process

In order to keep the model tractable, several simplifications are made. First of all it is assumed that the working force of a representative labour market is homogeneous in the status of employment but inhomogeneous in the status of unemployment since human capital deteriorates during unemployment. The deterioration only concerns those components of human capital which are perishable (for example those aquired by experience rating) but do not affect basic skills.

Since we are primarily interested in analysing a situation of excess supply on the labour market the failure of an unemployed person to get a job is considered in more detail than the failure of a vacancy to be filled. Let us simply assume that vacancies which are unfilled after one period are independently re-announced in the next. The total number of vacancies per period is taken as exogenous to our model.

Firms differ in the extent to which the perishable components of human capital play a role for the productivity of their employees. Thus, each vacancy is associated with a specific qualification standard, expressed as a maximum tolerable duration of unemployment of the candidate.[2] A contact between an employer and an applicant is successful (leads to an employment contract) if the applicant meets this standard.

Applicants for a job are randomly drawn from the unemployment register. It is possible that an unemployed person gets more than one chance per period, i.e. a probabilistic model with repetition is applied. For the search process of the worker a very simple stopping rule is chosen, which might be regarded as realistic in slack labour markets: the first possibility of getting a job is accepted. If a firm contacts a person who was in the unemployment register at the beginning of the time period but in the meantime has been successful, the corresponding vacancy remains unfilled.

The probability that a specific unemployed person is contacted for a specific vacancy is $1/U$, where U is the total number of the unemployed. Thus, the probability that an unemployed person has no contact if there are V vacancies in the period under consideration is $(1-1/U)^V$. Since $1/U$ is a small number, this probability can be rewritten by using the approximation $\ln(1-1/U) \approx -1/U$ as

$$\left(1-\frac{1}{U}\right)^V \approx e^{-k} \tag{1}$$

where k denotes the ratio between vacancies and unemployment which characterises the labour market situation. If the unemployed – as has been assumed in traditional

[2] This assumption could also be justified by the argument that employers take the length of the unemployment period as a negative screening device, because they suppose that a selection mechanism is at work which leaves behind the less qualified.

matching models – are homogeneous, the probability λ for a specific person of leaving the unemployment register depends on k only

$$\lambda = 1 - e^k, \tag{2}$$

with $\partial\lambda/\partial k = e^{-k} > 0$ and $\partial^2\lambda/\partial k^2 = -e^{-k} < 0$.

It is assumed that human capital deteriorates during unemployment according to a function $h(q)$ with $\partial h(q)/\partial q < 0$ where q is the duration of unemployment. More specifically, the following linear function for the development of human capital during unemployment is chosen for sake of simplicity:

$$h(q) = \max\,[h_0(1 - rq), \bar{h}], \tag{3}$$

where r is a depreciation parameter, h_0 is the human capital of the employed workers and $\bar{h} < h_0$ is the non-perishable part of human capital which remains after a critical duration of unemployment $\bar{q}$ has been exceeded. Let us define unemployment up to duration $\bar{q}$ as 'short-term unemployment' and unemployment with duration $q > \bar{q}$ as 'long-term unemployment'. In the following, we first concentrate on short-term unemployment.

Short-Term Unemployment

Let $F[h(q)]$ be the distribution function of the productivity requirement of the vacancies with $F[h(0)] = 1$. If unemployment duration affects human capital then the event that an unemployed person is drawn from the unemployment register by a searching firm is no longer a guarantee that he or she gets the job. The probability that the employer refuses a contract because of inferior qualification of the applicant depends positively on the duration of unemployment and is

$$1 - F[h(q)]. \tag{4}$$

The probability for an unemployed person to be drawn x times from the unemployment pool is given by the Binomial distribution

$$p(x;k) = \binom{V}{x}\left(\frac{1}{U}\right)^x\left(1 - \frac{1}{U}\right)^{V-x} \tag{5}$$

with mean $V/U = k$. Since k is a relatively small number and there are V 'drawings' (where V is a large number), the Binomial distribution is suitably approximated by the Poisson-distribution:

$$p(x;k) \approx \frac{k^x}{x!} e^{-k} \tag{6}$$

For an unemployed person with x contacts the probability of being not accepted by the job-offering firms is $p(x; k)$ $[1 - F(\cdot)]^x$. Hence the hazard rate, i.e. the probability that an unemployed person with duration q leaves the unemployment register is

$$\lambda(q) = 1 - \sum_{x=0}^{V} p(x;k)\,\{1 - F[h(q)]\}^x, \tag{7}$$

where $p(x; k)$ is the probability function of the Poisson distribution for a given vacancy-unemployment ratio k. As can be verified easily, the hazard rate λ is a non-increasing function in q and r. Since $F(q) = 1$ for all q if there is no depreciation of human capital ($r = 0$), eq. (7) covers eq. (2) as a special case. The second term on the right side of eq. (7) is a Maclaurin series, so the following approximation can be used for the hazard rate

$$\lambda(q) \approx 1 - e^{-k}\, e^{k(1-F[h(q)])} = 1 - e^{-kF[h(q)]}. \tag{8}$$

Now the unemployment distribution over time for a given labour market situation is analysed. In each period U_0 persons newly enter unemployment, while some of the unemployed leave the register with probability $\lambda = \lambda(q; k, r)$. The size of a cohort of unemployed persons with duration q is

$$U(q) = U_0\, e^{-\int_0^q \lambda(\tilde{q})\,\mathrm{d}\tilde{q}}. \tag{9}$$

Since the probability of leaving unemployment is non-negative and declining with q for $r > 0$, eq. (9) is a non-increasing function in q and convex to the origin. Of course, the probability of leaving the unemployment pool is higher in the absence of deterioration of human capital during unemployment for all $q > 0$.

Let the reservation productivity of the firms (in terms of human capital) be identically distributed within the interval $[0, h_0]$. If human capital deteriorates according to a linear function, the distribution function of qualification requirements of the labour-seeking firms can be expressed as

$$F[h(q)] = \max[h(q)/h_0, 0] = \max[1 - rq, 0]. \tag{10}$$

Without loss of generality, it is assumed in the following that the human capital of a person just becoming unemployed (h_0) equals unity. *Figure 1* illustrates the depreciation of human capital depending on unemployment duration q and the corresponding distribution function of productivity reservation. An unemployed person with duration q_1 gets a contract with probability $F[h(q_1)]$, if chosen from the unemployment pool.

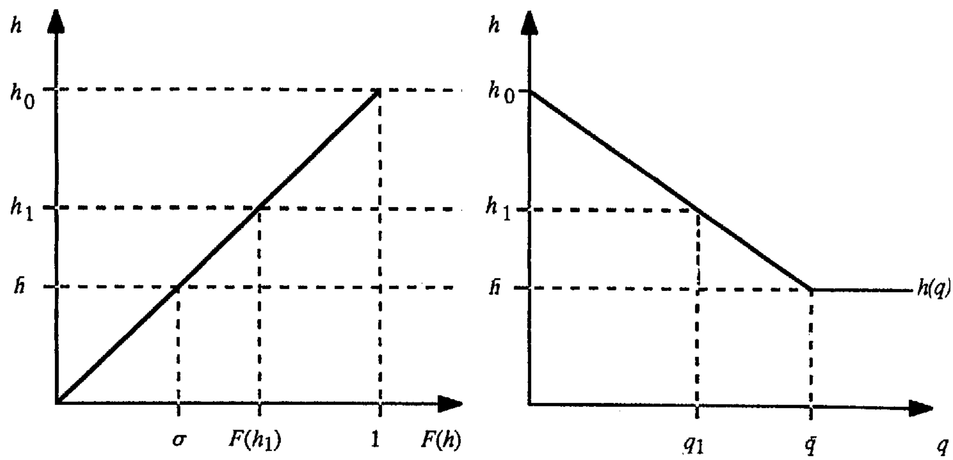

Fig. 1.
a) Distribution of the reservation productivity of firms (in terms of human capital)
b) Deterioration of human capital depending on the duration of unemployment.

These specifications lead to a distribution function for unemployment duration of the Gompertz-Makeham type.[3] This distribution function implies a hazard function of the general form $\lambda(q) = \alpha + \beta \exp(\gamma q)$. In our specific case the parameters are $\alpha = 1$, $\beta = -\exp(-k)$ and $\gamma = kr$. Given a positive depreciation parameter r, the cumulative hazard function can be written as follows:

$$\begin{aligned} L(q) &= \int_0^q \lambda(\tilde{q})d\tilde{q} \\ &= q - e^{-k}\int_0^q e^{kr\tilde{q}}\,d\tilde{q} \\ &= q - \frac{1}{kr}e^{-k}(e^{krq} - 1), \end{aligned} \qquad (11)$$

[3] See, for example, Blossfeld et al. (1989).

and the 'survivor function' is

$$S(q) = \exp[-L(q)] = \exp[-q - \frac{1}{kr} e^{-k}(1 - e^{krq})]. \tag{12}$$

Total short-term unemployment is determined by the integral over the survivor function

$$U^{st} = U_0 \int_0^{\bar{q}} S(q)\, \mathrm{d}q. \tag{13}$$

Since $L(q)$ is an exponential function in q, the integral in eq. (13) can not be solved analytically.

Long-Term Unemployment

After each period a fraction of the unemployed exceeds duration $\bar{q}$ and enters long-term unemployment. The size of this group is given by

$$U(\bar{q}) = U_0\, e^{-L(\bar{q})}. \tag{14}$$

Let the chance that a long-term unemployed will be accepted if drawn from the unemployment register be

$$\sigma \equiv F[h(\bar{q})] = \frac{\bar{h}}{h_0}. \tag{15}$$

The critical duration of unemployment which separates short-term from long-term unemployment can then be expressed as $\bar{q} = (1 - \sigma)/r$. Substituting this relation in eq. (12) yields

$$L(\bar{q}) = \bar{q}\left[1 - \frac{1}{(1-\sigma)k}(e^{-\sigma k} - e^{-k})\right]. \tag{16}$$

The probability of leaving long-term unemployment by getting a job, is a function of k and σ only:

$$\bar{\lambda} = 1 - e^{-k\sigma}. \tag{17}$$

Solving the expression for total long–term unemployment by partial integration leads to

$$U^{lt} = U(\bar{q})\int_{\bar{q}}^{\infty} e^{-(1-e^{k\sigma})(\tilde{q}-\bar{q})}\mathrm{d}\tilde{q}$$
$$= \frac{U(\bar{q})}{1-e^{-k\sigma}}, \tag{18}$$

where it has to be assumed that $\sigma > 0$.

Mean Duration of Unemployment and the Loss of Human Capital

If human capital deteriorates during periods of unemployment, hysteresis effects occur in response to shocks in the demand for labour because the term structure of unemployment is affected. The longer the mean duration of unemployment, the higher the loss in human capital and the less likely is that an unemployed person which is randomly drawn from the unemployment pool meets the reservation productivity of a labour-seeking firm.

If $g(q)$ is the density function for the distribution of unemployment, then the mean duration of unemployment can be expressed as

$$m_q = \int_0^{\infty} g(q)\, q\, \mathrm{d}q. \tag{19}$$

For the special case $r = 0$ the integral is easily solved:

$$m_q = \frac{1}{1-e^{-k}}. \tag{20}$$

Hence if human capital does not deteriorate during unemployment, mean duration of unemployment simply is a decreasing convex function in the vacancy-unemployment ratio k.

In the case $r > 0$, mean duration of unemployment is the weighted average duration of the short-term and long-term unemployed

$$m_q = G(\bar{q})\, m_q^{st} + [1 - G(\bar{q})]\, m_q^{lt}, \tag{21}$$

where $\mathrm{G}(\bullet) = \int g(q)\, \mathrm{d}q$ is the distribution function of unemployment, i.e. $\mathrm{G}(\bar{q})$ and $1 - G(\bar{q})$ are the shares of short-term resp. long-term unemployment in total unemployment. The mean duration of the long-term unemployed m_q^{lt} is $\bar{q} + 1/(1 - \mathrm{e}^{-k\sigma})$ and the mean duration of unemployment of the short-term unemployed m_q^{st} is

$\bar{q} - \int_0^{\bar{q}} G^{st}(q)\, dq$, where G^{st} is the distribution function of short-term unemployment. Furthermore, let us define $z \equiv \int_0^{\bar{q}} G(q)\, dq$. This expression is an indicator for the term structure of unemployment up to duration $\bar{q}$: the higher z, the less favourable is the term structure, i.e.\ the more the short-term unemployed are concentrated in groups with (relatively) high duration. Using these definitions and eq. (21) gives the formula

$$m_q = \bar{q} - z + [1 - G(\bar{q})] / \ddot{\lambda} , \tag{22}$$

since $G^{st}(q) = G(q)/G(\bar{q})$. It follows that mean durationis higher, (i) the less favourable is the term structure of the short-term unemployed, (ii) the higher is the ratio of long-term unemployment to total unemployment, and (iii) the lower is the hazard rate for the long-term unemployed.

The loss of human capital during unemployment can be calculated as the difference between the human capital of the employed and the average human capital of the unemployed. In general, the latter is

$$m_h = \int_0^{\infty} g(q) h(q)\, dq. \tag{23}$$

The integral can be solved for the short-term unemployed to yield

$$m_h^{st} = \bar{h} + r \int_0^{\bar{q}} G^{st}(q)\, dq, \tag{24}$$

while the average human capital of the long-term unemployed is $\bar{h}$. Hence eq. (23) can be written:

$$m_h = \bar{h} + rz, \tag{25}$$

where it should be noted that the steady state value of z depends negatively on r. Using eq. (25), the total loss in human capital can be calculated as $(h_0 - \bar{h} - rz)\, U$.

3 The Effect of Deterioration of Human Capital on the Beveridge Curve

In this section the steady-state relationship between unemployment and vacancies, as implied by the given model, will be analysed. To begin with, the case $r = 0$ is chosen for reference purposes. According to our definitions, no long-term unemployment occurs in the special case when unemployment does not affect human capital. Under this condition total unemployment simply is

$$U(k) = \frac{U_0}{1-e^{-k}}. \tag{26}$$

Eq. (26) implies a stable inverse relationship between vacancies V and unemployment U which is convex to the origin and can be taken as a theoretical foundation of the Beveridge curve [see, for example, Franz (1987)].

If deterioration of human capital during unemployment is introduced ($r > 0$), some of the unemployed loose all their 'perishable' skills. Total unemployment is the sum of short-term and long-term unemployment:

$$\begin{aligned} U(k, r, \sigma) &= U^{st} + U^{lt} \\ &= U_0[s^{st}(k, r, \sigma) + s^{lt}(k, r, \sigma)] \end{aligned}$$

with

$$s^{lt}(k, r, \sigma) \equiv \frac{e^{-L(\bar{q};k,\sigma)}}{1-e^{-k\sigma}}.$$

and

$$s^{lt}(k, r, \sigma) \equiv \frac{e^{l(\bar{q},k,\sigma)}}{1-e^{-k\sigma}}.$$

Eq. (27) also defines a steady-state relationship between vacancies and unemployment, but with different characteristics as compared to eq.(26). *Figure 2* shows the results of numerical simulations of eq. (27) for different parameter values r and σ. To transform the results into unemployment and vacancy *rates* an inflow to unemployment of 300000 persons per month and a labour force of 25 millions was assumed, which roughly represents the situation of the German labour market in 1987. In the first simulation the parameter σ was chosen as 0.3, in the second as 0.5 (whereas the former is rather realistic for German data as will be shown below). To obtain a Beveridge-type relationship, the labour market parameter k was varied in the range 0.15 to 2.0 for given r and σ.

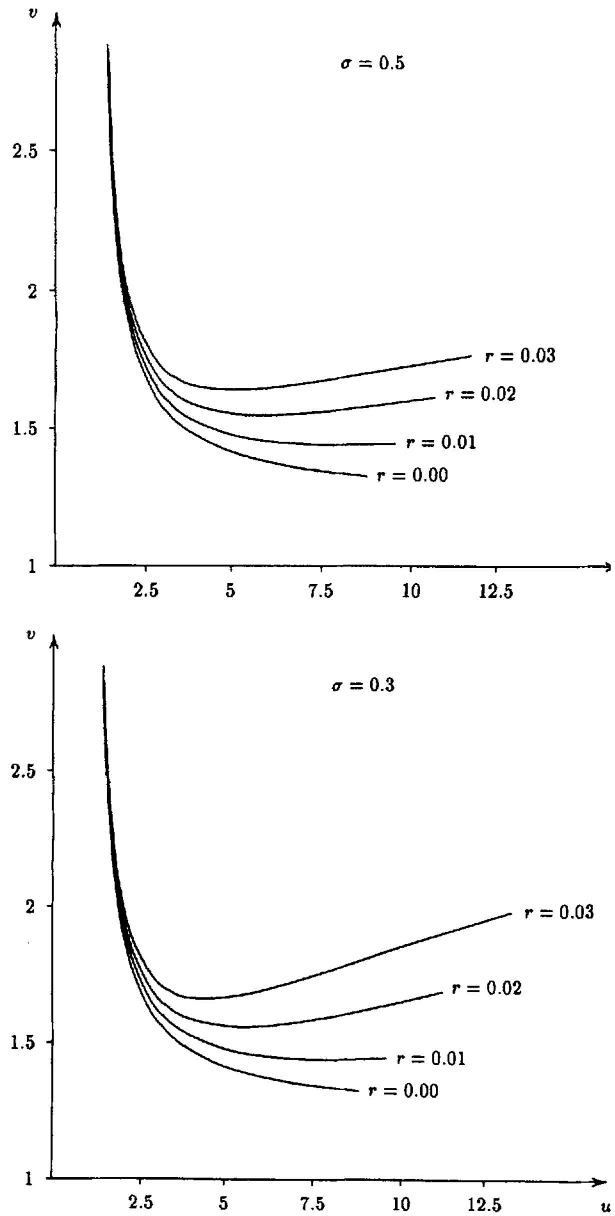

Fig. 2. The effect of deterioration of human capital during spells of unemployment on the Beveridge-Curve

For $r = 0$ the simulation yields the traditional Beveridge curve which neglects the effect of deterioration of human capital during unemployment. It is evident from this figure, that the Beveridge curves for $r > 0$ converge to the standard case in situations of strong excess demand on the labour market. Marked deviations, however, occur in a regime of predominant excess supply on the labour market. Hence, as might be clear from intuition, the effect of deterioration of human capital appears to be primarily a phenomenon of 'bad times'.

As can be seen from *figure 2*, the Beveridge curve will be a declining function if r does not exceed 0.02 and unemployment u is below 5%. In slack labour markets the curve for $r = 0.01$ becomes rather flat, indicating that a wide range of unemployment rates is compatible with almost the same vacancy rate in a steady state situation. For larger values of the deterioration parameter, the simulated steady-state Beveridge curve even has a *positive* slope in the high-unemployment region. The comparison between the lower and upper part of *figure 2* shows that this effect is less striking if the non-perishable part of human capital is larger (as should be expected). But also with σ set to 0.5 the steady-state Beveridge curve is upward sloping in the high unemployment region when r is 0.02 or higher.

These results have some important implications. If the Beveridge curve is almost horizontal or positively sloping within a certain range, combinations of u and v are no longer unique. According to the simulations we may, for example, obtain almost the same vacancy rate in a situation of low (say 4%) and high (say 8%) unemployment rate if the deterioration parameter r is 0.02 and $\sigma = 0.3$. Thus, significant deterioration of human capital during unemployment results in a situation of multiple equilibria. Moreover, if deterioration of human capital takes place very quickly, then in slack labour markets an even higher number of vacancies might be required to prevent unemployment from further rising than in high employment periods.

For an explanation of this result a comparison with the standard matching model is helpful: If spells of unemployment do not affect human capital ($r = 0$), the number of unfilled vacancies falls monotonically when unemployment rises. The reason is that with more persons being unemployed the chance diminishes that an applicant drawn by a specific labour-seeking firm is not available because he has been sucessful elsewhere. As a consequence, the number of vacancies required to keep the unemployment rate constant, falls with a growing excess supply of labour. In the case of a marked deterioration of human capital during unemployment, however, the positive effect of growing unemployment on the matching probability can be over-compensated by a negative effect. This negative effect is caused by the fact that the mean duration of unemployment is higher and human capital of the unemployed in the average is lower when labour markets are slack. Thus, an increasing portion of the unemployed does not meet the reservation productivity of the firms and the matching probability falls. Consequently, the steady-state condition only holds, if the number of vacancies rises. The deterioration of the u-v-

trade-off expresses the costs of an unfavourable term structure in the distribution of unemployment when labour markets are characterised by a high excess supply.

Table 1. Inflows and outflows from unemployment and the unemployment rate 1980–1987

year	unemployment level	rate	inflows	outflows
1980	888900	3.8	3084068	2832549
1981	1271574	5.5	3531038	2945478
1982	1833244	7.5	3706655	3187165
1983	2258235	9.1	3704185	3578551
1984	2265559	9.1	3672791	3696594
1985	2304014	9.3	3750240	3728294
1986	2228004	9.0	3637266	3766214
1987	2228788	8.9	3726460	3636411

Notes:– Source: Bundesanstalt für Arbeit, ANBA, 5, 1988

4 A Look at the Data

In order to check whether a flat or even rising steady-state Beveridge curve might be relevant in reality, we concentrate on recent German labour market data. *Table 1* gives some overall indicators of the labour market situation in the eighties. Inflows into unemployment were rising considerably during the OPEC II recession, followed by a rise in outflows from unemployment with a marked lag. Since 1983 inflows and outflows were roughly constant at a level of about 3.7 millions per year, and the overall unemployment rate remained almost constant at a level of about 9%. It is evident that in the latter time period the labour market situation was close to a steady state. If some lags of adjustment are allowed for[4], these data can be used to estimate a steady-state distribution of unemployment.

From the yearly special inquest of the Federal Employment Bureau (Bundesanstalt für Arbeit) in May/June data for completed spells of overall unemployment are available which are divided into those which are completed before 1, 3, 6, 12 and 24 months. From the same source data for extreme long-term unemployment (2 and more years) exist.

In order to apply the theoretical model to the data, the critical duration $\bar{q}$, after which a typical unemployed person has totally lost the perishable part of its human

[4] The observation period was 1984-1987 for this reason.

capital, must be specified. The official definition takes unemployment up to 12 months as 'short-term employment'. To employ this definition in our framework would imply the deterioration process of human capital being completed after one year of unemployment. Inspection of the data, however, suggests that this is not the case. Instead, since hazard rates are less different after unemployment duration of 2 years and longer, the critical duration $\bar{q}$ was chosen as 24 months.[5]

Table 2. Survivor function for unemployment (1984–1987)

year	Survival rates after month				
	1	3	6	12	24
	including discouraged workers				
1984	0.882	0.678	0.432	0.181	0.046
1985	0.865	0.636	0.368	0.158	0.039
1986	0.839	0.599	0.349	0.139	0.044
1987	0.832	0.591	0.332	0.137	0.047
	excluding discouraged workers				
1984	0.859	0.628	0.364	0.128	0.030
1985	0.848	0.597	0.316	0.121	0.027
1986	0.817	0.553	0.291	0.100	0.030
1987	0.803	0.534	0.264	0.089	0.027

Notes: – calculations by the author; source for original data: Bundesanstalt für Arbeit, ANBA, 5, 1988, p. 774.

The unemployment data with duration up to 24 months were used to calculate survivor functions under the steady-state assumption 'inflows = outflows' (*see table 2*). Since the data allow for discrimination between outflows into employment and in non-employment, where the latter essentially captures the discouraged worker effect, *table 2* gives two versions, with and without taking account of the discouraged worker effect.

[5] According to our calculations, hazard rates after one year of unemployment are nearly as twice as high as those after two years of unemployment. For a duration of more than 2 or 3 years, respectively, hazard rates between 0.07 and 0.05 are calculated. Hence, the assumption of constant hazard rates for long-term unemployment with a duration of more than 24 months seems far less critical with respect to the data than applying the same assumption to the official definition. Of course, this deviation from the standard definition implies that the notion 'short-term unemployment' in the theoretical model should not be taken too literally.

Table 3. Non-linear least squares estimation of the survivor function (1984–1987)

coefficient	regression (1)		regression (2)	
	coeff.	s.e.	coeff.	s.e.
$r \times 10^2$	2.562**	0.205	2.937	0.179
k	0.204**	0.011	0.254**	0.013
statistics				
R^2	0.999		0.999	
s.e.	0.078		0.091	

Notes: – ** indicates significance at the 1\% level
– regression (1) : including discouraged worker effect
– regression (2) : excluding discouraged worker effect

Let $s(q)$ be the log of the survivor function $S(q)$. Taking differences between the data for q and $q + n$ and re-arranging gives

$$s(q+n) - s(q) + n = \frac{1}{kr} e^{-k(1-rq)}(e^{krn} - 1), \tag{28}$$

which can be estimated by non-linear least squares techniques.[6] The results are shown in *table 3*. In the first regression the discouraged-worker effect was included in the data, while in the second only those outflows from unemployment were considered which led to new employment contracts. In both regressions r-squared is close to one. The parameters have the expected sign and are significant at the one percent level. The estimated k-coefficient is 0.20 in the first regression and somewhat higher (0.25) in the second. The deterioration parameter r is estimated as being higher (0.029) when the data are corrected for the discouraged worker effect against a value of 0.026 for the uncorrected data. This result reflects the fact that the discouraged worker effect increases markedly with longer duration of unemployment.

The magnitude and the high significance of the deterioration parameter r indicate that hazard rates decline considerably during unemployment. For a person who has just become unemployed the probability of getting a job within the next month is approximately 0.22, after one year of unemployment this probability falls to 0.15

[6] Since 'vacancies' in the sense of our theoretical model are not identical with the statistical concept of this variable, the parameter k as the ratio of vacancies to unemployment cannot be taken directly from labour market data but has to be estimated.

and after two years of unemployment it is about 0.07 only.[7] Given the hazard rates of (extreme) long-term unemployment, estimated values of k of 0.20 to 0.25 yield estimates of the parameter σ of 1/4 to 1/3. As has been shown in the previous section by numerical simulations, the parameter constellation obtained empirically, would imply a (moderately) upward sloping steady-state Beveridge curve in the relevant region.

Conclusion

Deterioration of human capital during periods of unemployment is one channel through which the hysteresis effect might come into effect. Sorting processes as well as duration-caused human capital depreciation may be responsible for this phenomenon. The theoretical model adopted here assumes a linear 'deterioration function' for a representative unemployed person and analyses the consequences for the matching process in a probabilistic model. It can be shown that the steady-state Beveridge curve, which allows for hazard rates of the unemployed to decline with longer duration of unemployment, bends away from the standard u-v-curve in situations of excess supply on the labour markets. This effect implies that the same vacancy rate might be compatible with different unemployment rates, so that a situation of multiple equilibria arises. The larger is the deterioration parameter r and the lower the non-perishable part of human capital, the more likely is the occurrence of multiple equilibria. It can be shown that under specific assumptions about the distribution of reservation productivity of firms that the steady-state distribution of unemployment with respect to unemployment duration can be described by a Gompertz-Makeham distribution. Since the aggregate German labour market came close to a steady state between 1984 to 1987, existing data of completed spells of unemployment for this time period can be used to estimate the parameters of the steady state distribution empirically. It turns out that the deterioration parameter is highly significant and in a order of magnitude which at least does not exclude the possibility of multiple equilibria.

If the vacancy rate is related to wage inflation, we may conclude that a low-inflation economy is possible as well as in a state of low unemployment as in a state of high unemployment. Analysing these effects in more detail would require the integration of the labour market approach adopted here in an broader macroeconomic

[7] This numbers somewhat underestimate the deterioration effect since with longer duration a growing part of the unemployed profits by public job creation ('Arbeitsbeschaffungsmassnahmen') or wage subsidies ('Eingliederungsbeihilfen'). Correcting for this effect, however, only led to minor modifications of the reported results.

model which is beyond the scope of the present paper. The possibility, however, that the economy has settled on a high unemployment equilibrium while a low unemployment equilibrium with the same inflation characteristics exists, has such far-reaching policy implications that it should by itself attract further research.

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