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Stefan Eriksson

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by

Stefan Eriksson✉

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Abstract:

This paper investigates the consequences of skill loss as a result of unemployment in an efficiency wage model with turnover costs and on-the-job search. Firms are unable to differentiate wages and therefore prefer to hire employed searchers or unemployed workers who have not lost human capital. It is shown that if some fundamental factor in the economy changes, this will result in a lengthy adjustment process with substantial long run unemployment effects. Moreover, the model is capable of generating persistence but the amount depends on the duration of the shock itself.

Keywords: Efficiency wage, Turnover, On-the-job search, Skill loss, Persistence, Short- and long-term unemployment.

JEL classification: E24, J64.

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✉ Department of Economics, Uppsala University, Box 513, SE-751 20 Uppsala, Sweden, telephone +46 18 4711132, e-mail Stefan.Eriksson@nek.uu.se.

Most European countries suffer from a chronically high unemployment rate. In major continental economies, such as Germany and France, around ten per cent of the labor force is unemployed. Moreover, almost half are classified as long-term unemployed; i.e. they have been unemployed for twelve months or more. Another fact is that shocks seem to have effects on employment long after the shocks themselves have disappeared. For some reason it seems to take considerable time for European economies to return to their equilibrium employment levels following a shock. This makes it important to try to understand how shocks, both temporary and permanent, affect the employment level.

One potential explanation of both the high level of unemployment and its persistent behavior following a shock is that the duration structure of unemployment somehow plays a role. Many authors have argued that long term unemployed workers do not compete well with other searchers for the available jobs because they have lost the abilities that employers find attractive etc. It is then argued that this duration dependence, through some mechanism, affects the wage setting in the economy, and thus puts upward pressure on wages.[1] One important paper that tries to formalize these ideas is Blanchard and Diamond (1994), who examine the effect of the composition of unemployment on wage determination in a matching model. They assume that a firm that receives multiple job applications always picks the applicant with the shortest unemployment spell; a strategy they call ranking. The wage is determined by Nash bargaining with the expected utility of a recently laid off worker as the threat point. Their main conclusion is that ranking affects the dynamics but has only minor permanent effects.

In this paper the consequences of skill loss as a result of unemployment is studied further by analyzing a new mechanism through which the duration structure of unemployment affects the wage setting. This is done by adapting the efficiency wage model with turnover costs and on-the-job search developed in Eriksson and Gottfries (2000), to a situation with two different types of unemployed workers; one group that is identical to employed workers and one group that is less attractive to hire.[2]

[1] Machin and Manning (1999) discuss these issues in some detail and also survey the literature.
[2] Eriksson and Gottfries (2000) focus on a situation where employers discriminate against all unemployed workers, and thus do not consider the duration structure of unemployment.

There are a number of reasons why a person who is unemployed for some time might lose some of his human capital. Inability to keep up with technological advances, loss of social skills and loss of motivation can make it less attractive for employers to hire unemployed workers. These factors should be particularly relevant for those who have been unemployed for a long time. At the same time, it is hardly likely that all workers suffer a loss of human capital after a specific duration of unemployment (e.g. twelve months) but rather that the timing differs between individual workers. Some workers lose skills rapidly while others maintain them for a long period of time. To capture these facts the model contains two stocks of unemployed workers called short-term unemployed (STU) and long-term unemployed (LTU), where workers in the second group have suffered a loss of human capital. Every STU worker faces a constant risk of becoming LTU every period.

If wages were perfectly flexible, firms should be indifferent among all job applicants since the wage can be adjusted to reflect differences in productivity/training costs. In real world labor markets this is hardly the case, because factors such as fairness considerations, union influence, unemployment insurance and minimum wages tend to compress wages relative to productivity differentials. In such a situation employers have incentives to screen job applicants for differences in productivity/training costs and then hire those with the best score. Hence, unemployed workers that have lost some of their human capital will not get hired if the employer receives enough applications from other more productive searchers. Thus, there might be complete discrimination of those in LTU. At the same time there are two factors that might prevent this. First, not all jobs are the same. Differences in human capital are important for some jobs while they are much less important in other types of jobs. Second, a lot of other factors than perceived productivity/training cost differences seem to affect the hiring process. To capture these facts in the model it is assumed that, for a fraction of the jobs, firms prefer to hire employed or STU applicants while for the rest of the jobs they are indifferent among all applicants.

In this paper, a theoretical model with these features is set up. Firms set their wages recognizing that labor turnover is costly since they encounter a hiring/training cost for every newly hired worker. Employed workers choose whether or not to search based on both the wages and their job satisfaction. Those who lose their jobs become

STU and face a risk of becoming LTU every period. Searchers send in job applications to a randomly chosen firm and firms then choose whom to hire from the pile of applications. As mentioned above, firms discriminate against the LTU for a fraction of the available jobs. The model is then solved for a general equilibrium solution. Due to the complexity of the model numerical solution methods are used. The model is calibrated with data for the German economy, and it is investigated what happens, both in and out of steady state, when different parameters are changed.

The steady state analysis shows that more ranking, a higher risk to become LTU or more wage pressure all raise equilibrium unemployment, and that the effects are concentrated to the stock of LTU workers. It is also shown that quite modest permanent changes in the key parameters in the model will result in very lengthy adjustment processes, involving substantial long run effects on the unemployment level. For example, a permanent increase in the probability to become LTU - e.g. due to more rapid technological advances - results in a situation where the unemployment rate increases for years until reaching its new steady state value. If such slow adjustment processes are a feature of real economies it is not surprising that economists have difficulties finding the structural causes of the rise in European unemployment.

The dynamic analysis shows that temporary shocks have persistent effects, but the degree of persistence is quite moderate after a temporary shock to employment. A prolonged shock where many workers fall into LTU generates more persistence. Still it is difficult to generate the extreme amount of persistence found in time series regressions for employment. However, it should be remembered that the model abstracts from a lot of other factors that probably also add to persistence.

The model presented here differs in a number of ways from the analysis in Blanchard and Diamond (1994). Most importantly both the wage setting assumptions and the mechanism through which the duration structure of unemployment affects the wage setting differ substantially. First, the "quasi labor supply curve" implied by Nash bargaining with unemployment as the threat point is replaced by an efficiency wage constraint. Second, the duration structure affects the probability that an employed searcher gets the job he applies for, inducing the firm to set a higher wage to keep costly turnover down. In Blanchard and Diamond, the duration structure of unemployment affects the outside option in the wage negotiation. It is these two facts that explain the large permanent effects found in my paper. In Blanchard and Diamond the threat point of the worker is affected by the fact that he runs a risk of becoming long term unemployed himself. Unless the discount rate of the worker is very high this will tend to keep the wage from rising in the long run. In my paper it is optimal for the firm to raise its wage at its own initiative following a rise in the probability to get a job for on-the-job searchers and this has nothing to do with the utility workers get if they become unemployed. Another difference is that while Blanchard and Diamond assume that the person with the shortest spell is always preferred, workers in this model lose human capital stochastically at different points in time, thus adding a bit of realism. A second related paper is Pissarides (1992) who formulates a matching model with the so called "thin market externality"; i.e. that the supply of jobs decreases when the duration of unemployment increases since those who have been unemployed for a long time have less human capital. In that model, an employer always hires the first unemployed worker he comes in contact with. Thus, Pissarides abstracts from the behavior of the employer in the hiring process, the focus in this paper.[3]

The rest of the paper is organized as follows. Section I briefly discusses empirical evidence on the employability of LTU workers. In Section II the theoretical model is formulated, the general equilibrium is derived and some analytical results are shown. In section III the model is calibrated with German labor market data and the effects of parameter changes and shocks are analyzed both in steady state and dynamically. Section IV concludes the discussion.

I Empirical Evidence on the Employability of LTU Workers

Two empirical questions are particularly relevant for the present analysis. First, does the probability to find regular employment decline with the duration of unemployment? Second, do employers discriminate against LTU workers?

The first question is analyzed in the substantial literature on duration dependence. It is fairly clear from raw data that the exit rate from unemployment declines with the duration of unemployment for most European economies. However,

[3] Other related papers are Acemoglu (1995) and Lockwood (1991) that both focus on a situation where employers cannot perfectly observe the productivity of unemployed workers and therefore use statistical discrimination against them. Ljungqvist and Sargent (1998) try to explain the high and persistent unemployment rates from the supply side by arguing that generous welfare benefits encourages workers, who have lost human capital, to demand higher wages than employers are willing to pay.

the more interesting question is if there exists so called true duration dependence; i.e. whether the probability to leave unemployment for a particular worker declines with the duration of his unemployment. Essentially, this boils down to trying to eliminate observed as well as unobserved heterogeneity. Machin and Manning (1999) review this issue in some depth. They point out that in order to obtain identification it is normally necessary to make assumptions about the specific functional forms of the baseline hazard function and the distribution of unobserved heterogeneity.[4] Moreover, they conclude "it does not seem possible to identify separately the effect of heterogeneity from that of duration dependence without making some very strong assumptions about functional form which have no foundation in any economic theory"[5]. This, at the very least, implies that one should be very careful when interpreting results on duration dependence.

Turning now to the studies that have been performed the results are mixed. A particularly large number of studies have looked at data for the UK and Sweden. Studies of UK data normally find strong evidence of negative duration dependence while studies using Swedish data find only weak or even positive duration dependence. Studies of data for other European countries are more rare but often do not find strong duration dependence. Three factors might complicate the interpretation of these results. The first is exits to out-of-the labor force. A number of studies of duration dependence do not distinguish between exits to different states whereas others do.[6] Second, Pissarides (1992) emphasizes that since most studies are cross sections they use samples that do not contain very long durations. This can result in a situation where too much of the duration dependence is classified as being due to heterogeneity.[7] Third, the widespread use of active labor market policy can result in breaks in unemployment spells and reclassification of workers as newly unemployed.

The conclusion from the empirical studies of duration dependence seems to be that it still is uncertain whether this is an important problem or not. The research so far shows that it is a problem in some countries, such as the UK, while it does not seem to

[4] For example, a proportional hazard function and a gamma distribution for unobserved heterogeneity.
[5] Machin and Manning (1999) page 3111.
[6] Intuitively, it is natural to think that exits to out-of-the labor force exhibit positive duration dependence; e.g. discouraged worker effects.
[7] One example of a study that takes account of this is Jackman and Layard (1991) who, using time series data, finds strong duration dependence effects for the UK.

be a problem in other countries like Sweden, though the extensive use of active labor market policy may explain the latter finding.

The idea that employers do view LTU as a negative factor when making hiring decisions has received quite strong support.[8] Bewley (1999) interviewed a large number of employers in the US about, among other things, their hiring procedures. He finds that a quite substantial fraction view unemployment as a negative factor. Agell and Lundborg (1999) find that around one forth of the Swedish employers in their sample view LTU as a strong negative signal.[9] Atkinson, Giles and Meager (1996) find similar evidence for the UK. They emphasize that LTU, at least, makes employers suspicious that the worker has lost abilities like social skills and work motivation etc.[10] Klingvall (1998) reports that around half of the Swedish employers in his survey state that the duration of unemployment is important when evaluating the suitability of an applicant. The stated reasons are loss of skills as well as loss of social abilities.[11] Layard, Nickell and Jackman (1991) cite several studies that indicate that unemployment causes demotivation and demoralization. The conclusion from this survey and interview based literature is that employers really seem to view LTU as a negative worker characteristic for a substantial number of jobs and that one important reason for this is the belief that workers lose human capital while being unemployed.

Does unemployment result in the loss of skills? Though the literature on duration dependence does not give any clear answers, the survey based literature supports this idea. Thus, it seems quite likely that unemployment results in skill loss and a declining probability to find a job as the duration of unemployment increases. This makes it important to investigate the consequences of such behavior theoretically.

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[8] It should be noted that, since employers are unlikely to admit that they avoid hiring LTU workers, the studies mentioned probably only gives a lower bound on the actual extent of this type of discrimination.

[9] Other studies using Swedish data are Klingvall (1998), who reports that 25 per cent of firms view workers who have been unemployed long unfavorably, and Behrentz and Delander (1998), who report that 40 per cent of firms would not choose the unemployed worker when having two otherwise similar applicants to choose from.

[10] An interesting finding in this study is that most respondents did not support the idea that those becoming unemployed are less productive than other workers but rather that it is unemployment *in itself* that makes LTU workers less attractive; i.e. this study indicates that state dependence is more important than heterogeneity.

[11] Not surprisingly the data indicate that the fraction of employers that view the duration of unemployment as an important factor is an increasing function of duration. The function is not smooth but rather exhibits jumps at 3-6, 9-12 and 21-24 months.

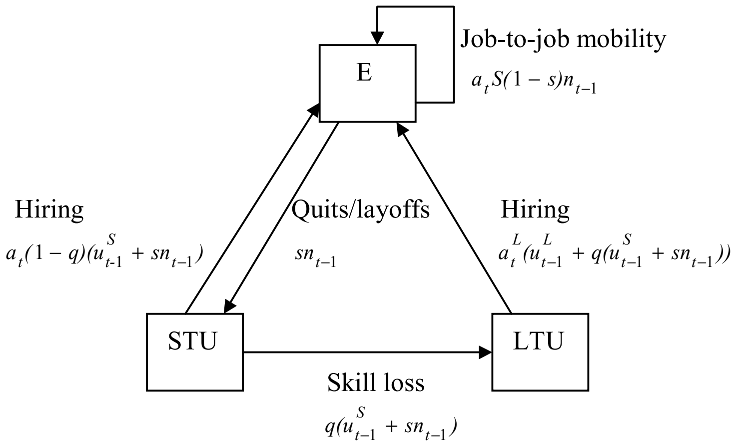
II The Model

Events take place in discrete time and we may think of a period as one month long. There are a large number of workers who can be in either of three different states; employed, short-term unemployed (STU) or long-term unemployed (LTU). It should be noted that the terms short- and long-term are not equivalent with the definitions normally found in labor market statistics. In this model, a person who has become unemployed faces a risk of becoming LTU every period rather than automatically falling into LTU after six or twelve months. At the same time the terms STU and LTU are appropriate since, on average, a person belonging to the LTU group has been unemployed a longer time and is expected to remain unemployed for a longer period of time.[12] The total labor force is assumed to be constant and is normalized to one. There are a large number of identical firms in the economy, although the fixed number of firms is much smaller that the number of workers.[13]

The sequence of events in the model is the following. At the beginning of every period an exogenous fraction, s, of the employed workers lose their jobs and fall into STU. This fraction includes both workers quitting into unemployment and workers being laid off for some exogenous reason. Firms set their wages recognizing that wages affect turnover. Turnover is costly since firms have to pay a hiring/training cost for every newly hired worker. Those remaining employed choose whether or not to search on the job considering both the wage level offered by their present employer and their job satisfaction. An exogenous fraction, q, of the workers in STU, including those who just became unemployed, then fall into LTU. On-the-job searchers and all unemployed workers then submit one application to a randomly chosen firm. Finally, firms choose whom to hire amongst the pile of applications. For a fraction, r, of the jobs employers prefer to hire a worker who has a job or is STU while for the rest of the vacant jobs employers are indifferent among all applicants. Figure 1 illustrates the stocks and flows of the model.

[12] An alternative is to call the LTU workers "stigmatized".
[13] The model could easily be extended to a situation with an endogenous number of firms for example by imposing some kind of fixed cost.

Figure 1 An illustration of the stocks and flows in the model.[14]



There are three basic micro-economic decisions that must be made every period: (i) the wage setting decisions made by the firms (ii) the decision whether or not to search made by every worker who is employed at the start of the period, and (iii) the hiring decisions made by the firms.[15] The following sections discuss these decisions starting with the last, and describe the general equilibrium outcome of the economy.

Job Applications and Hiring

On-the-job searchers and both types of unemployed workers search with the same intensity. Every worker looking for a new job submits one application per period. Furthermore, the applications are sent to a randomly chosen firm.[16]

Since there are many more workers than firms in this economy, every firm receives a large number of applications. The crucial assumption is that a firm always receives a sufficient number of applicants, so that every vacancy can be filled within the period from the pile of applications. Therefore, the firm has to make a decision of whom to hire. The following assumptions are made: (i) firms can observe whether the applicant is employed, STU or LTU, (ii) for a fraction of the jobs, employed and STU

[14] The notation will be introduced in the sections below.

[15] The first two of these decisions are simplified versions of those analyzed in Eriksson and Gottfries (2000).

[16] This is of course a simplification of real world behavior but, at the same time, it receives some support in empirical work. Layard, Nickell and Jackman (1991), point out that the time spent on search is fairly limited and does not seem to diminish with the duration of unemployment in the UK. Blau and Robins (1990) show that, in a US sample, the search intensity differs little between employed and unemployed searchers. Layard, Nickell and Jackman (1991), report estimates for the UK of between one and three applications being submitted per month.

applicants have identical training costs while LTU workers have higher training costs[17], (iii) all applicants are equal for the rest of the jobs, and (iv) the division of jobs between these two types is fixed. In such a situation one would expect the employer to only consider hiring employed or STU workers for a fraction, r, of the jobs and choose a random applicant for the rest of the jobs. In this paper, such a hiring strategy is called ranking.

On-the-job Search

Every worker who remains employed has to decide whether to start on-the-job search or not. It is assumed that both the wage levels and non-pecuniary factors matter for the decision whether or not to quit.[18] Let w_t^i and w_t denote the wage in company i and the average wage respectively. Each period every employed worker draws a number ν_t that determines his current job dissatisfaction from a random process with cdf G(ν) which is unimodal and has a mean smaller than unity.[19] The utility of a worker is the discounted sum of expected wages divided by the expected job dissatisfactions. Since the worker is back in the same position the next period regardless of whether he changes jobs or not, only the current period payoff affects his decision. The worker, therefore, compares the utility from continuing at his present job, given by w_t^i / ν_t^i, with the expected utility from finding a new job $\lambda E[w_t / \nu]$, where $\lambda < 1$ represents the cost of switching jobs.[20] This means that there exists a cut-off value for ν_t^i for which the worker is indifferent between quitting and remaining in his present job.[21] It is assumed that $\lambda E[1/\nu] < 1$; i.e. given the same wage most workers prefer to stay in their present jobs. The fraction of workers that searches on-the-job is given by:

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[17] That is, it is assumed that after the training all workers are equally productive in these jobs. Also note that LTU workers never are employed in these jobs and no firm ends up paying the higher training cost. Therefore, this high training cost does not appear in the profit maximization problem.

[18] Akerlof, Rose and Yellen (1988) emphasize that non-pecuniary factors are as important as the wage levels for quit decisions

[19] The assumption that the worker makes an independent new draw every period is obviously a simplification of real world behavior. It is motivated purely by the fact that the model, otherwise, would be overly complicated to solve since we would need to keep track of a distribution of workers with different levels of job satisfaction.

[20] Note that when making this decision, the worker knows the average wage level, w_t, but does not know the non-pecuniary factor associated with a new job.

[21] Note that $\nu_t^i = w_t^i / (w_t \lambda E(1/\nu))$ for the cut-off value of ν_t^i.

$$S(w_t^i / w_t) = 1 - G(w_t^i /(w_t \lambda E(1/v))) , \qquad (1)$$

where S is decreasing with S''(1)>0.

Wage Setting

Firms are assumed to face a hiring/training cost for every worker they hire implying that labor turnover is costly.[22] The hiring/training cost is given by a constant c times the average wage level w_t[23], the production function is given by $\theta_t F(n_t^i)$ where θ_t represents a shock factor, voluntary quits are sufficiently large to accommodate all employment adjustment and firms optimize as if the world was known with certainty.[24] Let n_t^i denote the employment level of firm i period t, a_t the probability to find a job for an employed/STU worker in period t and β the discount factor. The maximization problem solved by the firm is then

$$\max_{w_{t+j}^i, n_{t+j}^i} \sum_{\mathrm{j}=0}^{\infty} \beta^{\mathrm{j}} \left(\theta_{t+j} F(n_{\mathrm{t+j}}^{\mathrm{i}}) - w_{t+j}^i n_{t+j}^i - c w_{t+j} (n_{t+j}^i - (1 - s - (1-s) S(w_{t+j}^i / w_{t+j}) a_{t+j}) n_{t+j-1}^i) \right) . \qquad (2)$$

With first order conditions for period t given by

$$- n_t^i - cS'(w_t^i / w_t)(1-s) a_t n_{t-1}^i = 0 , \qquad (3)$$

$$\theta_t F'(n_t^i) - w_t^i - c w_t + \beta c w_{t+1} (1-s) S(w_{t+1}^i / w_{t+1}) a_{t+1} = 0 . \qquad (4)$$

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[22] In practice, the prevention of excessive turnover seems to be important for real world firms and hiring/training costs appear to be substantial (see Blinder and Choi (1990) and Campbell and Kamlani (1997)).

[23] The average wage is used here to simplify the analysis.

[24] It is possible to explicitly incorporate uncertainty in the model and obtain the same results. To keep the model simple this is neglected in this paper. For details of how to model the wage setting with uncertainty see Eriksson and Gottfries (2000). Here the timing of events are the following: the wage is set, the shocks are observed and then the hiring decisions are made.

The intuition behind the wage setting mechanism is that the firm finds it optimal to raise the wage until the marginal benefit of the reduction in turnover costs is equal to the marginal cost of increasing the wage.

Note that it is assumed that the same wage is set for all workers. This means that the firm cannot differentiate wages according to perceived productivity/training cost differences among workers. There is some rigidity in the wage structure that prevents such wage differentials. Such an assumption can be justified by fairness considerations, union influence or by arguing that for some other reason there exists a "company wage policy" that prevents wage dispersion.[25]

General Equilibrium

Consider a symmetric general equilibrium where all firms set the same wage ($w_t^i = w_t$). This is the natural situation to analyze since all firms are assumed to be identical and, therefore, face the same wage setting problem. Let n_t, u_t^S and u_t^L denote the aggregate levels of employment, STU and LTU respectively. This gives us an equation for employment (from the first order conditions):

$$n_t = \Omega(1-s)a_t n_{t-1}, \tag{5}$$

where Ω=-cS'(1), Ω being a measure of "wage pressure" due to the efficiency wage mechanism.[26]

Now a_t, the probability that an employed or STU worker gets the job he applies for, has to be determined. This probability is defined as:

$$a_t = r\frac{n_t-(1-s)n_{t-1}+a_tS(1-s)n_{t-1}}{(1-s)Sn_{t-1}+(1-q)(sn_{t-1}+u_{t-1}^S)} + (1-r)\frac{n_t-(1-s)n_{t-1}+a_tS(1-s)n_{t-1}}{1-(1-s)n_{t-1}+(1-s)Sn_{t-1}}. \tag{6}$$

[25] See for example Akerlof and Yellen (1990) or Manning (1994) for a discussion about why a firm might not want to differentiate wages

[26] Intuitively, this factor might also include other factors that raise the wage like union influence. See for example Gottfries and Westermark (1998) for a discussion of how to model this.

It consists of two parts; the probability to get a job for which ranking is used plus the probability to get a job for which ranking is not used. Note that the number of vacant jobs consist of new jobs and existing jobs left unfilled after both exogenous and endogenous quits. The first term consists of the fraction of jobs for which firms rank divided by the number of employed workers searching on-the-job, plus all STU workers. The second term comprises the fraction of jobs the firm does not use ranking for divided by all applicants.[27] Equation (6) can be solved for a_t to obtain

$$a_t = \frac{(n_t - (1-s)n_{t-1})(r(1-(1-s)n_{t-1}) + S(1-s)n_{t-1} + (1-r)(1-q)(sn_{t-1} + u^S_{t-1}))}{(1-(1-s)n_{t-1})((1-r)(1-s)Sn_{t-1} + (1-q)(sn_{t-1} + u^S_{t-1})) + rS(1-s)n_{t-1}(1-q)(sn_{t-1} + u^S_{t-1})}. \tag{7}$$

Let us now turn to the state variables in the model. The two unemployment stocks evolve according to the following equations:

$$u^S_t = u^S_{t-1} + sn_{t-1} - a_t(1-q)(u^S_{t-1} + sn_{t-1}) - q(u^S_{t-1} + sn_{t-1}), \tag{8}$$

$$u^L_t = u^L_{t-1} + q(u^S_{t-1} + sn_{t-1}) - a^L_t(u^S_{t-1} + q(sn_{t-1} + u^S_{t-1})). \tag{9}$$

Equation (8) says that the current stock of STU workers consists of four components; the stock the previous period plus those becoming unemployed minus those finding a job minus those who fall into LTU. Similarly, equation (9) says that the current stock of LTU workers consist of the stock the previous period plus those who become LTU in the period minus those who find a job. Note that a_t denotes the chance to get a job for a worker in the pool of STU and a^L_t denotes the corresponding chance for a LTU worker. Using equations (8) and (9) in (5) gives us the following expressions:

[27] Note that if q equals one we are back in the situation analyzed in Eriksson and Gottfries (2000); i.e. an employer that has a bias against all unemployed workers.

$$u_t^S = 1 - u_{t-1}^L - q(u_{t-1}^S + s(1 - u_{t-1}^S - u_{t-1}^L)) + a_t^L(u_{t-1}^L + q(s(1 - u_{t-1}^S - u_{t-1}^L) + u_{t-1}^S)) +$$

$$+ \Omega(1-s)a_t(1 - u_{t-1}^S - u_{t-1}^L), \qquad (10)$$

$$u_t^L = 1 - u_{t-1}^S - s(1 - u_{t-1}^S - u_{t-1}^L) + a_t(1-q)(u_{t-1}^S + s(1 - u_{t-1}^S - u_{t-1}^L)) + q(u_{t-1}^S + s(1 - u_{t-1}^S - u_{t-1}^L)) +$$

$$+ \Omega(1-s)a_t(1 - u_{t-1}^S - u_{t-1}^L). \qquad (11)$$

Substituting the expressions for a_t and a_t^L into equations (10) and (11), we get an equation system which in principle can be solved for u_t^S and u_t^L. Analytically though this would be very complex since both a_t and a_t^L are nonlinear functions of u_t^S and u_t^L. Further analysis of this system is therefore deferred to the numerical section below.

Initial Effects of Changes in Parameters

However, some further understanding of the model can be gained by combining equations (5) and (7) to a dynamic employment equation:

$$n_t = h(n_{t-1}, u_{t-1}^S). \qquad (12)$$

This equation is written out explicitly in Appendix 1 and gives the desired aggregate employment in the current period as a function of employment and STU the previous period. Consider for a moment the intuition behind equation (12). Employment dynamics arise because the optimal wage depends positively on the probability to get a job for an *employed* searcher. Therefore, it is obvious that the employment level of the previous period matters. The division of unemployment between STU and LTU also matters because if a larger fraction of the unemployed workers are in the LTU pool this results in a higher probability to get a job for on-the-job searchers. This induces firms to raise the wage even more to keep their employees and, in equilibrium, the employment level falls.[28]

[28] Note that an individual firm perceives this probability as exogenous. The only way for a firm to reduce turnover is by raising the wage to discourage search among its employees. Since all firms are identical all firms have the same incentive, all wages rise, and employment falls.

Expression (12) cannot be solved for steady state employment since it contains two state variables but it is possible to ask, for a given number of employed/unemployed workers in the previous period, what are the effects of changes in the parameters on employment. Clearly, this gives us only the initial effects but it does provide some useful intuition.

First, one might be interested in the effect of ranking on the current employment level. In Appendix 1 it is shown that

$$\frac{\partial n_t}{\partial r} < 0. \tag{13}$$

In other words, if a larger fraction of the vacant jobs is reserved for employed and STU applicants we get a lower aggregate employment level. If more jobs are reserved for the privileged group this will tend to increase the chance for employed workers to get a job. To prevent costly turnover firms will then raise their wages, leading to lower employment.

Second, consider the effects from faster skill loss among the unemployed, which in this model is captured by an increase in q. In Appendix 1, it is shown that

$$\frac{\partial n_t}{\partial q} < 0 \quad \text{if } r > 0. \tag{14}$$

In other words, if the probability that an unemployed worker falls from STU to LTU increases this will tend to decrease aggregate employment. This result holds only if some firms rank job applicants since the division of workers between STU and LTU would otherwise be irrelevant. The intuition is that if q increases this implies a reduction in the pool of privileged job seekers. This increases the probability to find a job for employed workers, resulting in higher wages and, in equilibrium, lower employment.

III Numerical Analysis

In order to gain some further understanding of the model, it is useful to set numerical values for the different parameters. This makes it possible to solve the model for steady state values of employment, STU and LTU and look at how these variables are affected by parameter changes. In addition, it allows us to study the dynamic adjustment process following both permanent and temporary shocks. Choosing reasonable values for the parameters, we can get a sense of how large the effects are and how long the adjustment takes.

Calibration

In steady state the model contains the following five parameters: (i) the fraction that leaves employment for unemployment every period, s, (ii) the fraction searching on the job, S, (iii) the amount of wage pressure, Ω, (iv) the fraction of jobs for which firms use ranking, r, and (v) the risk that a STU worker faces of becoming LTU, q. Although, estimates of several of these key parameters do not exist, it turns out that it is possible to use other facts about the labor market to deduce the values the parameters have to take for the steady state solution to be consistent with these facts. To implement this strategy it must be decided which facts the model should be fitted against. What is needed is at least as many facts as unknown parameters, and preferably some more to check the model against. Table 1 presents values for the German economy (all steady state values).[29] Essentially, these facts are of two types; data about labor market stocks and flows and data about the probability to find a job for an unemployed worker at different durations of unemployment. The details of the data are presented in Appendix 2.

[29] In view of the purpose of this paper it is natural to choose a typical European continental economy.

Table 1 Data for the German economy.

Fraction of employed workers entering unemployment	s	**0.005**
Fraction of employed job-to-job switchers	$x^{E\to E}$	**0.005**
Employment	n	**0.934**
Probability to remain unemployed after one month	$y^{1\text{ month}}$	**0.90**
Probability to remain unemployed after three months	$y^{3\text{ months}}$	0.70
Probability to remain unemployed after six months	$y^{6\text{ months}}$	0.54
Probability to remain unemployed after nine months	$y^{9\text{ months}}$	0.44
Probability to remain unemployed after twelve months	$y^{12\text{ months}}$	**0.36**
Fraction of all unemployed with duration <12 months	$u^{<12\, months}/u$	0.51
The outflow rate from unemployment	$x^{U\to E}$	0.076
Fraction searching on the job (estimate for the UK)	S	≈ 0.05

To be able to calibrate the model we need an explicit definition of a steady state. It is natural to define it as a situation where all stocks remain constant. In the context of this model this means that the numbers of employed, STU and LTU are kept constant. Note that it is sufficient to write conditions that ensure that two of the stocks are kept unchanged to know that all three stocks remain constant. Therefore, these conditions can be written in the form most beneficial to solving the model. First, to ensure that employment is kept constant it is assumed that equation (5) satisfies:

$$n_t = n_{t-1} = n \,. \tag{15}$$

Furthermore, to keep the two stocks of unemployed workers constant it is sufficient that the flows in and out of STU remain equal. This requirement can be written as:

$$sn = q(u^S + sn) + a(1-q)(u^S + sn) \,. \tag{16}$$

We also need a number of equations linking the facts in Table 1 to the theoretical model. First, the fraction of employed workers switching jobs, $x^{E\to E}$, is given by:

$$x^{E\to E} = Sa \,. \tag{17}$$

Second, the number of workers that at any given time have been unemployed for less than one year is given by:

$$u^{<12\,months} = sn\sum_{i=1}^{12}(1-q)^i(1-a)^i + snq\sum_{k=0}^{11}\left\{\sum_{i=0}^{k}(1-q)^i(1-a)^i(1-a^L)^{(k+1)-i}\right\}. \tag{18}$$

Third, the probability to remain unemployed after z months of unemployment, y^z, is given by:

$$y^z = (1-q)^z(1-a)^z + q\sum_{k=0}^{z-1}(1-q)^k(1-a)^k(1-a^L)^{z-k} \quad . \tag{19}$$

Fourth, an expression for the outflow rate from unemployment, $x^{U\to E}$, can be derived. Since the outflow from unemployment must be equal to the inflow into unemployment this is given by:

$$x^{U\to E} = \frac{sn}{u}. \tag{20}$$

The next step is to perform the actual calibration. The facts reported with bold face numbers in Table 1 are used to calculate the values of the parameters identified above. The facts in the rest of the rows are then used as a check of the model. The details of the calibration method are presented in Appendix 3. This exercise yields the values summarized in Table 2.

Table 2 Calculated parameter values for the German economy.

Parameter:		
Fraction of employed workers falling into STU	s	0.005
Fraction of employed workers searching on the job	S	0.048
Wage pressure	Ω	9.706
Fraction of jobs for which ranking is used	r	0.497
Risk a STU worker faces of becoming LTU	q	0.056
Implied variable value:		
STU	u^S	0.026
LTU	u^L	0.040
Probability to find a job for an employed/STU worker	a	0.104
Probability to find a job for a LTU worker	a^L	0.041
Risk of remaining unemployed after three months	$y^{3\text{ months}}$	0.74
Risk of remaining unemployed after six months	$y^{6\text{ months}}$	0.56
Risk of remaining unemployed after nine months	$y^{9\text{ months}}$	0.44
Fraction of all unemployed with duration <12 months	$u^{<12\,months} / u$	0.49
Outflow from unemployment	$x^{U \rightarrow E}$	0.07

Looking at the parameter values in Table 2 it should be noted that none of them seem unreasonable. Since there do not exist empirical estimates for several of them it is difficult to judge the accurateness of these values but the reader should note that the exact numbers are not important for the analysis. Generally, what are interesting are the signs and rough magnitudes of the effects. It should be noted that the calibration implies that employed and STU workers have around a two and a half times higher probability to find a job than those being LTU.

Steady-state Analysis

Using the parameter values in Table 2 it is possible to investigate the steady state effects of parameter changes. Table 3 shows the effects of changing one parameter at a time by 20 per cent of its initial value.

Table 3 Steady state effects of 20 per cent parameter changes.

	Base value	New value	STU	LTU	U
Base case			2.57	4.03	6.60
r increases	r=0.50	r=0.60	2.52	5.82	8.34
q increases	q=0.056	q=0.068	2.37	4.74	7.11
Ω increases	Ω=9.71	Ω=11.65	2.86	5.81	8.67
s increases	s=0.005	s=0.006	3.03	4.93	7.96
S increases	S=0.048	S=0.058	2.57	3.91	6.48
Ω/r increase	Ω=9.71/r=0.50	Ω=11.65/r=0.60	2.76	9.00	11.76
Ω/q increase	Ω=9.71/q=0.056	Ω=11.65/q=0.068	2.60	6.92	9.51
r/q increase	r=0.5/q=0.056	r=0.60/q=0.068	2.31	7.05	9.36

Now consider these results in detail. First, if the degree of ranking in the economy increases we see that this results in substantial increases in LTU and total unemployment while STU remains essentially unchanged. The result that total unemployment increases is expected from the previous discussion. More ranking implies higher LTU for two reasons. First, for a given number of jobs more ranking implies higher LTU since these workers face a decreased chance to find a job; fewer of the vacancies are open to them. Second, more ranking has a negative effect on the total number of jobs in the economy and this also implies higher LTU. Moreover, these two factors have opposite effects on the stock of STU and roughly seem to cancel each other out.

Second, if the probability to become LTU for an unemployed worker increases we see that STU decreases while LTU and total unemployment increases. As was discussed in the previous section, higher q leads to an increased chance to get a job for on-the-job searchers, upwards pressure on wages and lower aggregate employment. Turning to the STU it should be noted that there are two opposing effects at work here. First, higher q means an increased outflow from STU, which tends to decrease this stock. Second, higher q means fewer jobs in the economy something that implies higher STU. Using the calculated values it seems that the first effect dominates; higher q tends to reduce STU. LTU on the other hand increases due to both of the mentioned effects.

Third, if the degree of wage pressure increases all unemployment stocks increase. It should be noted that the numerical analysis indicates a difference between the effects of wage pressure and the degree of ranking in the economy. More ranking implies that the whole increase in unemployment is concentrated to LTU. More wage pressure, on the other hand, results in increases in both STU and LTU even though the effect on LTU is stronger.

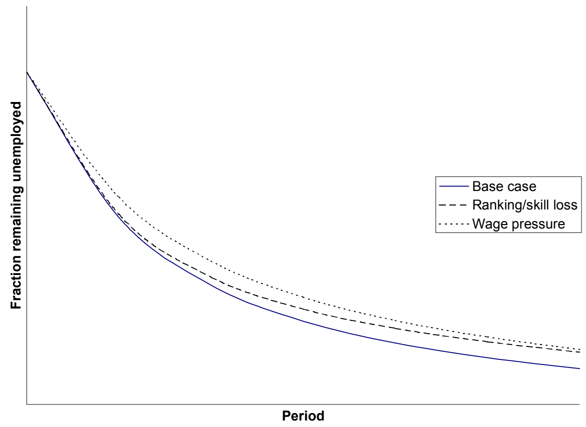
Fourth, an increase in the flow from employment to unemployment implies an increase in all unemployment stocks. The reason is that a higher s implies more job vacancies, increased opportunities for on-the-job searchers, upward pressure on wages and lower employment. It is natural that both stocks of unemployed workers increase since nothing really changes in the relation between STU and LTU.

Fifth, an increase in the number of on-the-job searchers implies less LTU and total unemployment and essentially no change in STU. More on-the-job searchers imply an increase in the number of searchers something that induces firms to reduce wages and employ more workers. Again this does not really affect the relative position of those who are STU or LTU.

Finally, it is interesting to look a little bit at how Ω, r and q interact. The last three rows in Table 3 show that the effects of parameter changes are reinforced when we increase another parameter. This can be seen by noting that the unemployment rate increases by more than the sum of the individual effects. In other words, if skill loss and ranking are widespread in an economy this reinforces the negative employment effects of increased wage pressure etc. too.

Before leaving the steady state discussion it is worthwhile to briefly look at differences in the effects of the various factors that might generate both persistence and long run effects; wage pressure, ranking and skill loss. Intuitively, the different effects of these three factors can be understood by thinking in terms of survivor functions where surviving means remaining unemployed after different durations of unemployment. This is illustrated in Figure 2.

Figure 2 An illustration of the different effects of r,q, and Ω*.*



In Figure 2 the solid curve shows the survivor function with the calibrated parameter values. The other two curves show what happens when either ranking or wage pressure are changed keeping all other parameters constant. Here, the differences between changing the amount of ranking and changing the amount of wage pressure are apparent. More wage pressure shifts the whole curve upwards implying that the probability to get a job declines at all durations. More ranking on the other hand mostly harms those with long durations of unemployment.[30]

Dynamic Adjustment to Permanent Shocks

A natural starting point for a dynamic analysis is to analyze what the adjustment path looks like after a permanent change in one or more of the parameters. Since the inflow rate into unemployment seems to have remained virtually unchanged this means that we have three factors that potentially could have caused rising unemployment; skill loss, ranking and wage pressure.[31] The first two may result from more rapid technological advances or changes in the organization of firms that increase the skill requirements of individual workers. The latter one may change as the result of increased training costs, more focus on keeping down turnover or increased union strength.[32]

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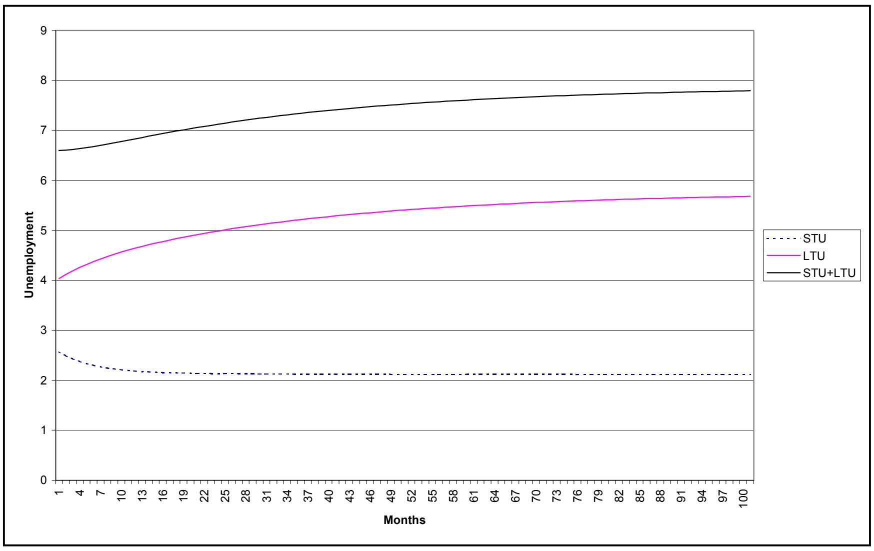
[30] This also helps us understand the numbers falling out of the calibration. The model is essentially calibrated using such a curve as an input and the curve used implies that the probability to leave unemployment declines with duration. Since Ω cannot generate such an outcome $r>0$ and $q>0$ are needed.

[31] Evidence that s has remained essentially unchanged can be found in Layard, Nickell and Jackman (1991). It is of course also possible that the extent of on-the-job search also has increased.

[32] Remember that the effects of increased union strength intuitively are identical to an increase in Ω.

Let us start by investigating the effects of a permanent increase in the risk to become LTU for a STU worker (q). This is illustrated in Figure 3.

Figure 3 The effects of a 50 per cent increase in q.



Recall the discussion above where it was shown that an increase in q leads to lower STU and higher LTU with the net effect on unemployment positive. In Figure 3 it is clear that these effects are present but we also see that the timing of the effects differ markedly.[33] The decrease in STU seems to occur during the first few periods while the increase in LTU is drawn out over a very long period of time. The implication for an economy, that for some reason experiences an increase in the risk to become LTU, is a steady increase in unemployment for years to come. These effects eventually die out, but the analysis indicates that it takes a very long time. The effect might be even more severe if the economy suffers several increases in the LTU risk due to technological advances that increase the mismatch in the labor market.

Turning now to the effects of an increase in the degree of ranking one might expect the outcome to be similar; a substantial increase in LTU and smaller effects on STU. Figure 4 shows the adjustment after an increase of r from 50 to 75 per cent.

[33] It is interesting to look at the effects of an increase in q on the number of workers that have been unemployed for less than one year. Using equation (18) gives us $u^{<12\,months}$ =0.033; i.e. a slight increase. Remember that those workers, in the model, can be both STU and LTU even though most are STU. An increase in q has three effects; the advantage to be STU increases, more workers fall into LTU and fewer jobs are available.

Figure 4 The effects of a 50 per cent increase in r.

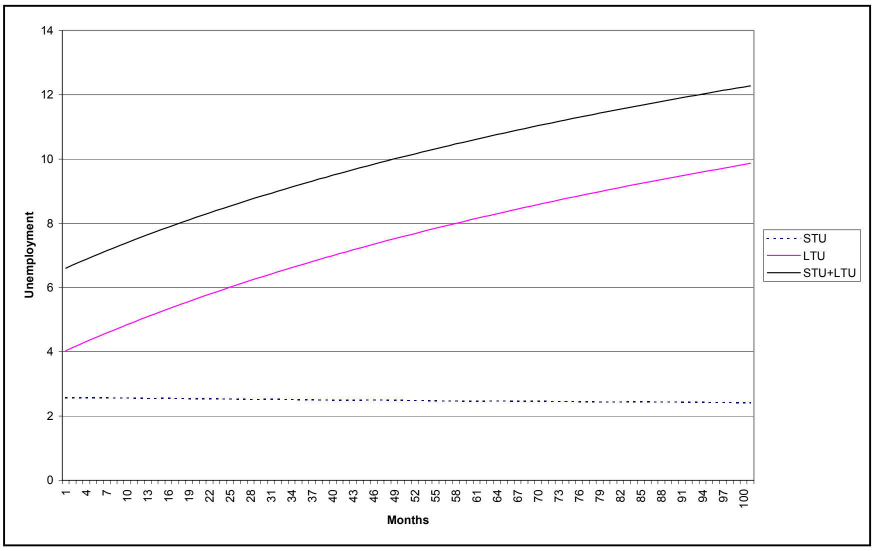
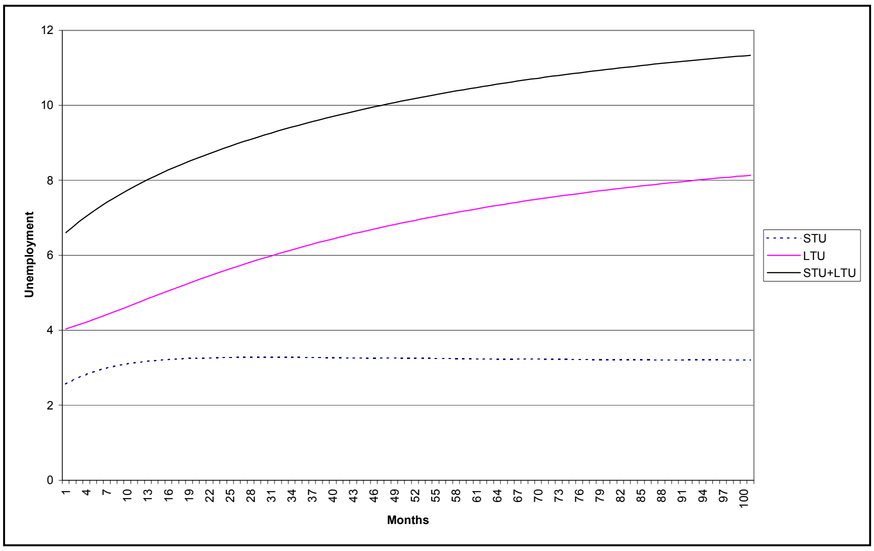


Figure 4 shows that the effects from more ranking really are similar to those in Figure 3. The intuition behind this result is that r and q in some sense are substitutes; more discrimination against the LTU with the same inflow or a bigger inflow and the same amount of discrimination are somewhat similar in their effects. However, two differences are worth noting.[34] First, if r increases this results in a nearly unchanged STU whereas an increase in q leads to a decrease in STU. Second, the effect on LTU appears to be much stronger from ranking.

Finally, let us turn to the consequences of an increase in the degree of wage pressure. Figure 5 shows what happens after such a change.

[34] Another difference is the consequences for the number of workers that have been unemployed for less than one year. Here, we get $u^{<12\,months}$ =0.030; i.e. a slight decrease. Remember that this stock contains both STU and LTU workers. More ranking has three effects; the advantage to be STU increases, the disadvantage to be LTU increases and there are fewer jobs in the economy.

Figure 5 The effects of a 50 per cent increase in Ω.



Recall the steady state analysis where it was shown that more wage pressure results in an increase in both stocks of unemployed workers. That result is confirmed in Figure 5.[35] However, note that the STU increase occurs during the first year whereas the LTU increase is much more substantial and drawn out.

To summarize these experiments it is obvious that the mechanisms analyzed in this paper can have strong effects on the unemployment level. Quite moderate changes in the parameters can lead to a prolonged period of adjustment to a new equilibrium that entails a substantial change in the unemployment level. It should also be noted that it is quite possible that real world labor markets have suffered permanent shocks that are a combination of the three types analyzed in this section.

An interesting question is whether these experiments can help us to understand the rise in European unemployment.[36] During the last decades both short- and long-term unemployment have increased even though the increase has been particularly big in long-term unemployment. This means that the relative incidence of long-term unemployment has increased substantially over time.[37] From Figures 3 and 4 it is clear

[35] The consequences for the number of workers who have been unemployed for less than one year is now a substantial increase; $u^{<12\,months}$ =0.037. More wage pressure results in fewer jobs in the economy. Over time though the effects becomes concentrated to the stock of workers who have been unemployed for one year or more.

[36] It should be noted that STU and LTU in the model are not identical to short and long term unemployment in the data (see the discussion in Section II).

[37] For example, in Germany the incidence of long-term unemployment increased from around 30 per cent 1979 to almost 50 per cent in the mid 80's (OECD 1993).

that ranking and skill loss alone cannot explain what has happened since both short and long term unemployment have increased. From Figure 5 we see that wage pressure affects both STU and LTU. However, it is impossible to distinguish between different combinations of factors in a purely theoretical analysis. What is needed to fully analyze this important question is data about the evolution over time of the probability to find a job at different durations and such data are not readily available. Further empirical research is clearly needed to distinguish between hypotheses.

Temporary Shocks

We may also analyze what the dynamic adjustment path looks like after a temporary shock. Let us start by stating the difference equations that determine the stocks of STU and LTU respectively. Linearizing these equations and evaluating them in steady state yields the following two expressions:

$$u_t^S = 0.841 u_{t-1}^S - 0.00434 u_{t-1}^L , \quad (21)$$

$$u_t^L = 0.0494 u_{t-1}^S + 0.963 u_{t-1}^L . \quad (22)$$

Consider first an increase in STU with one per cent. According to these equations this implies an increase in STU the next period by 0.84 per cent as well as an increase in LTU the next period by 0.05 per cent. The intuition is that firms are reluctant to cut wages since this would lead to costly turnover. Hence, the employment level returns only slowly to equilibrium following a shock. If LTU is one percent higher this implies an increase of LTU the next period by more than 0.96 per cent but has a small effect on STU the next period. The explanation is the slow employment adjustment effect combined with the limited number of jobs open to LTU workers.

Now let us look more closely at the adjustment back to equilibrium following a shock to unemployment. As a first experiment let us study the effects of a temporary increase in the flow from employment to unemployment, s.[38] This experiment can be

[38] This situation is analyzed with the assumption that all agents assume the change in s to be permanent. Otherwise the structure of the optimization problem would have to be changed to accommodate several different values of s.

motivated by the fact that a recession seems to be a fairly short period of high job destruction and the model equivalent of this is an increase in s. To be concrete let us assume that s doubles for six periods and then returns to the original level. Figure 6 shows how the two stocks of unemployed workers are affected by such a shock.

Figure 6 Adjustment back to equilibrium after a 6 months shock to STU.

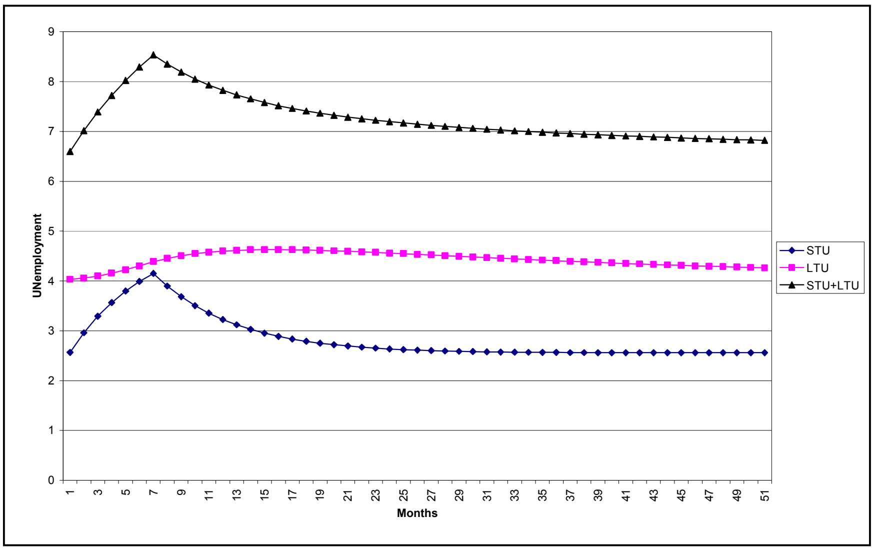
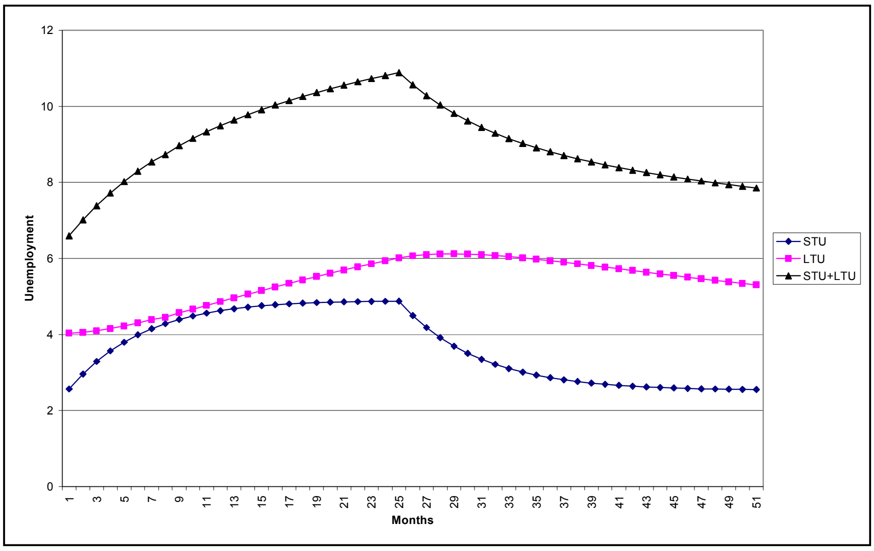


Figure 6 reveals several interesting facts. First, STU increases during the period with a big inflow but then returns fairly quickly to its steady state value. This is hardly surprising since employers perceive these workers to be equivalent to their present employees in all jobs. Meanwhile, LTU initially increases slowly but instead continues to increase several periods after the shock and then only very slowly adjusts back to its steady state value. This is the result of two forces; a bigger stock of STU workers implies a larger inflow into LTU for a number of periods and, in addition, employers to a large extent refuse to hire LTU workers, since they are perceived as more costly to hire than other applicants. Total unemployment falls during the whole period after the shock but due to the lengthy adjustment path of LTU it takes some time for total unemployment to return to its pre-shock value; i.e. unemployment shows persistence (after 12 months around 40 per cent of the shock remains).

One might expect more persistent effects from a shock that lasts longer since, in such a situation, more workers would fall into LTU. Figure 7 shows what happens if the economy suffers a shock lasting two years.

Figure 7 Adjustment back to equilibrium after a 24 months shock to STU.



Since the shock lasts longer a larger number of workers fall into LTU and this results in a more drawn out adjustment back to equilibrium than in the previous experiment (after 12 months around 50 per cent of the shock remains). Similar results are obtained if we let the shock last for six months, as in Figure 6, but also let the risk to become LTU be twice as large. This would correspond to a shock that involves more job destruction as well as an increased mismatch in the labor market. Such a shock results in dynamics mainly involving LTU and, as expected, the outcome is a more drawn out adjustment process.

The conclusion from this section is that the model implies persistence but that the degree of persistence depends on the nature of the shock. A shock that involves a bigger inflow into unemployment for only a short period results in some persistence. A more prolonged shock to this inflow or a short shock that affects both the inflow and the probability to become LTU results in more persistence. Essentially, the key to getting a substantial amount of persistence is that the shock implies a substantial increase in LTU and not just STU. Depending on the duration and type of the shock the model generates yearly persistence rates of 40-60 percent. It should be noted though that the model cannot generate the near unit root persistence found in empirical studies of total unemployment time series.[39] At the same time it should be remembered

[39] Empirical estimates of the serial correlation of unemployment series for Germany often find persistence around 90 per cent (see for example Blanchard and Summers (1986)).

that the model abstracts from several factors that probably also add to persistence such as wage contracts spanning several periods and overlapping wage contracts.

IV Conclusions

This paper investigates the consequences of skill loss as a result of unemployment. Unemployed workers risk losing some of their human capital every period and firms, who are unable to differentiate wages according to productivity/training cost differences, partly avoid hiring workers who have lost human capital. Firms set a wage above the market-clearing wage to prevent costly turnover. The paper then analyzes how such an economy responds to both temporary and permanent shocks.

It is shown that both an increased risk of losing human capital, an increased degree of ranking or more wage pressure result in higher steady state unemployment with the effects being concentrated to the stock of LTU workers. Moreover, the negative employment effects of both skill loss and wage pressure increase when combined with ranking. It is also shown that permanent changes in these key factors generate lengthy adjustment phases involving substantial effects on the employment level. The numerical analysis indicates that it takes several years for the economy to reach the new steady state level even when the parameter change is quite moderate.

It is also shown that temporary shocks have persistent effects on employment. The amount of persistence depends on the type and duration of the shock but the model is not capable of producing the near unit root serial correlation found in empirical studies. It should be remembered, though, that we are abstracting from several factors that might add persistence such as wage contracts that span several periods and overlapping contracts. Another way to get more persistence is to allow for discrimination against all unemployed workers as in Eriksson and Gottfries (2000).

What conclusions can be drawn from this study about the high and persistent European unemployment rates? The main contribution of this paper is the demonstration that if turnover considerations, skill loss as a result of unemployment, and inability to differentiate wages are important features of real world economies this will affect how the economies respond to both permanent and temporary shocks, resulting in lengthy adjustment phases involving substantial effects on the unemployment rates.

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Appendix 1: Derivation of Selected Expressions

Combining equations (5) and (7) the employment equation in (12) can be written as:

$$n_t = \frac{-\Omega(1-s)^2 n_{t-1}^2 (r(1-(1-s)n_{t-1}) + S(1-s)n_{t-1} + (1-r)(1-q)(sn_{t-1} + u_{t-1}^S))}{(1-(1-s)n_{t-1})((1-r)(1-s)Sn_{t-1} + (1-q)(sn_{t-1} + u_{t-1}^S)) + rS(1-s)n_{t-1}(1-q)(sn_{t-1} + u_{t-1}^S)}$$

$$\overline{-\Omega(1-s)n_{t-1}r(1-(1-s)n_{t-1}) - \Omega(1-s)^2 n_{t-1}^2 S - \Omega(1-s)n_{t-1}(1-r)(1-q)(sn_{t-1} + u_{t-1}^S)}$$

(A1)

Differentiation of equation (A1) with respect to r and q respectively yields the following expressions (let N denote the numerator and D the denominator in (A1)):

$$\frac{\partial n_t}{\partial r} = \frac{1}{D^2}[[-\Omega(1-s)^2 n_{t-1}^2 [1-(1-s)n_{t-1} - (1-q)(sn_{t-1} + u_{t-1}^S)]]\ [\mathrm{D}] - [-(1-s)Sn_{t-1}(1-(1-s)n_{t-1}) +$$

$$(1-s)Sn_{t-1}(1-q)(sn_{t-1} + u_{t-1}^S) - \Omega(1-s)n_{t-1}(1-(1-s)n_{t-1}) + \Omega(1-s)n_{t-1}(1-q)(sn_{t-1} + u_{t-1}^S)]\ [N]]$$

$$= \frac{1}{D^2}[[1-(1-s)n_{t-1} - (1-q)(sn_{t-1} + u_{t-1}^S)][(-\Omega(1-s)^2 n_{t-1}^2)(D) + ((1-s)Sn_{t-1} + \Omega(1-s)n_{t-1})(N)]]$$

$$= \frac{1}{D^2}[u_{t-1}^L + q(sn_{t-1} + u_{t-1}^S)][-\Omega(1-s)^3 n_{t-1}^3 S(1-r)(1-(1-s)n_{t-1}) - \Omega(1-s)^2 n_{t-1}^2 (1-q)(sn_{t-1} + u_{t-1}^S)$$

$$(1-(1-s)n) - \Omega(1-s)^3 n_{t-1}^3 Sr(1-q)(sn_{t-1} + u_{t-1}^S) + \Omega^2(1-s)^3 n_{t-1}^3 r(1-(1-s)n_{t-1}) + \Omega^2(1-s)^4 n_{t-1}^4 S +$$

$$\Omega^2(1-s)^3 n_{t-1}^3 (1-r)(1-q)(sn_{t-1} + u_{t-1}^S) - \Omega(1-s)^3 n_{t-1}^3 Sr(1-(1-s)n_{t-1}) - \Omega(1-s)^4 n_{t-1}^4 S^2 -$$

$$\Omega(1-s)^3 n_{t-1}^3 S(1-r)(1-q)(sn_{t-1} + u_{t-1}^S) - \Omega^2(1-s)^3 n_{t-1}^3 r(1-(1-s)n_{t-1}) - \Omega^2(1-s)^4 n_{t-1}^4 S -$$

$$\Omega^2(1-s)^3 n_{t-1}^3 (1-r)(1-q)(sn_{t-1} + u_{t-1}^S)] =$$

$$= \frac{1}{D^2}[u_{t-1}^L + q(sn_{t-1} + u_{t-1}^S)][-\Omega(1-s)^3 n_{t-1}^3 S)(1-(1-s)n_{t-1}) - \Omega(1-s)^2 n_{t-1}^2 (1-q)(sn_{t-1} + u_{t-1}^S)$$

$$(1-(1-s)n_{t-1}) - \Omega(1-s)^4 n_{t-1}^4 S^2 - \Omega(1-s)^3 n_{t-1}^3 S(1-q)(sn_{t-1} + u_{t-1}^S)] < 0$$

(A2)

$$\frac{\partial n_t}{\partial q} = \frac{1}{D^2}[\Omega(1-s)^2 n_{t-1}^2 (1-r)(sn_{t-1} + u_{t-1}^S)][D] - [-(1-(1-s)n_{t-1})(sn_{t-1} + u_{t-1}^S) -$$

$$rS(1-s)n_{t-1}(sn_{t-1} + u_{t-1}^S) + \Omega(1-s)n_{t-1}(1-r)(sn_{t-1} + u_{t-1}^S)][N]$$

$$= \frac{1}{D^2}[sn_{t-1} + u_{t-1}^S][\Omega(1-s)^3 n_{t-1}^3 S(1-r)^2 (1-(1-s)n_{t-1}) + \Omega(1-s)^2 n_{t-1}^2 (1-r)(1-q)(sn_{t-1} + u_{t-1}^S)$$

$$(1-(1-s)n_{t-1}) + \Omega(1-s)^3 n_{t-1}^3 r(1-r)S(1-q)(sn_{t-1} + u_{t-1}^S) - \Omega^2(1-s)^3 n_{t-1}^3 r(1-r)(1-(1-s)n_{t-1}) -$$

$$\Omega^2(1-s)^4 n_{t-1}^4 (1-r)S - \Omega^2(1-s)^3 n_{t-1}^3 (1-r)^2 (1-q)(sn_{t-1} + u_{t-1}^S) - \Omega(1-s)^2 n_{t-1}^2 r(1-(1-s)n_{t-1})^2 -$$

$$\Omega(1-s)^3 n_{t-1}^3 S(1-(1-s)n_{t-1}) - \Omega(1-s)^2 n_{t-1}^2 (1-r)(1-q)(sn_{t-1} + u_{t-1}^S)(1-(1-s)n_{t-1}) -$$

$$\Omega(1-s)^3 n_{t-1}^3 r^2 S(1-(1-s)n_{t-1}) - \Omega(1-s)^4 n_{t-1}^4 rS^2 - \Omega(1-s)^3 n_{t-1}^3 r(1-r)S(1-q)(sn_{t-1} + u_{t-1}^S) +$$

$$\Omega^2(1-s)^3 n_{t-1}^3 r(1-r)(1-(1-s)n_{t-1}) + \Omega^2(1-s)^4 n_{t-1}^4 (1-r)S +$$

$$\Omega^2(1-s)^3 n_{t-1}^3 (1-r)^2 (1-q)(sn_{t-1} + u_{t-1}^S)]$$

$$= \frac{1}{D^2}[sn_{t-1} + u_{t-1}^S)][-\Omega(1-s)^3 n_{t-1}^3 S2r(1-(1-s)n_{t-1}) - \Omega(1-s)^2 n_{t-1}^2 r(1-(1-s)n_{t-1})^2 -$$

$$\Omega(1-s)^4 n_{t-1}^4 rS^2] < 0 \quad \text{if r} > 0$$

(A3)

Appendix 2: Data

Here, the data used in the calibration is presented briefly. First, we need to consider some conceptual questions and then go through the data in detail.

In a real world labor market there exists at least three distinct states; employed, one or more groups of unemployed and out-of-the labor force (OLF). In this paper the last group is left out to keep the model manageable and to focus attention on the central mechanisms. In a more complete model of actual labor markets OLF force dynamics should be included. The exclusion of this stock can partially be justified by arguing that these flows merely represent the exchange of workers; i.e. workers being retired and being replaced by workers directly from school, parents taking child leave etc. In addition, Blanchard and Diamond (1990) point out that the net flows to and from the labor force varies less than other flows over the business cycle. This adds a bit of complication to the calibration since labor market data includes this stock with flows to and from it. In this paper all flows from and to OLF are ignored.

As already mentioned German labor market data for the period of the mid-eighties are used. Here follows a description of the data used.

- Fraction of employed entering unemployment (s). Layard, Nickell and Jackman (1991), using OECD data, report a monthly inflow rate of 0.4 per cent of employment. This figure is obtained by taking the number of unemployed with duration of less than one month. This excludes roughly half of those whose completed spell is less than one month. To take account of this the fact the slightly higher value 0.5 per cent is used in the calibration.
- Fraction of employed job-to-job switchers ($x^{E \to E}$). Here two possible sources of data have been found. Burda and Wyplosz (1994) report that in 1987 0.3 per cent of those employed jump from job-to-job while Boeri (1999) report that the figure in 1992 is 0.7 per cent. Here we assume that half of those hired are employed and use the figure 0.5 per cent in the calibration.
- Employment (n). Layard, Nickell and Jackman (1991) report unemployment rates from OECD sources. The average unemployment rate for the period 1985-87 is 6.6 per cent.

- Unemployed less than one year ($u^{<12\,months}$). OECD (1993) report that 1986 around 49 per cent of those being unemployed had been so for twelve months or more.
- Probability to remain unemployed for after 1, 3, 6, 9 and 12 months (y^{z}). Hunt (1995) report data from the public use version of the household-based GSOEP. Using data for the time period 1983-88 she calculates Kaplan-Meier survival curves. From these figures it is clear that around 90 per cent remain unemployed one month after becoming unemployed. Furthermore, 70, 54, 44 and 36 per cent remain unemployed after three, six, nine and twelve months respectively. The latter figures are obtained by calculating escapes only to employment while keeping escapes to OLF recorded as censored. Since the model does not contain OLF dynamics it is that figure that is relevant here.
- The outflow rate from unemployment ($x^{U \to E}$). OECD (1993) reports estimates of 7.6 per cent monthly for the year 1989. It should be remembered though that this figure includes all flows from unemployment and therefore should be used with caution.
- Fraction searching-on the-job (S). Layard, Nickell and Jackman (1991), which report data for the UK from the Labour Force Study, say that around five per cent of those being employed do on-the-job search. Since this is the only estimate available it at least gives a rough guide as to what value that can be considered reasonable.

Appendix 3: Calibration

The objective of the calibration is to find a set of values for the unobservable magnitudes, $\{\Omega, S, r, q, a, u^S\}$, that satisfy the following equation system:

$$1 = \Omega(1-s)a\,, \tag{A4}$$

$$x^{E\to E} = Sa\,, \tag{A5}$$

$$a = \frac{sn(r(1-(1-s)n) + S(1-s)n + (1-r)(1-q)(sn+u^S))}{(1-(1-s)n)((1-r)(1-s)Sn + (1-q)(sn+u^S)) + rS(1-s)n(1-q)(sn+u^S)}\,, \tag{A6}$$

$$sn = q(sn+u^S) + a(1-q)(sn+u^S)\,, \tag{A7}$$

$$y^{1\text{ months}} = (1-q)(1-a) + q(1-\frac{(1-r)(sn+aS(1-s)n)}{1-(1-s)n+(1-s)Sn})\,, \tag{A8}$$

$$y^{12\text{ months}} = (1-q)^{12}(1-a)^{12} + q\sum_{k=0}^{11}(1-q)^k(1-a)^k(1-\frac{(1-r)(sn+aS(1-s)n)}{1-(1-s)n+(1-s)Sn})^{11-k}\,, \tag{A9}$$

with the observable magnitudes, $\{s, n, x^{\text{E}\to\text{E}}, y^{1\text{ month}}, y^{12\text{ months}}\}$, set equal to their steady state values given in Table 1.

Essentially, the equation system in (A4)-(A9) could be solved directly. However, due to the complexity of this system an iterative method is used. The algorithm used can be described by the following four steps.

- A value is set for the variable q.
- The system in (A4)-(A8) is solved for $\{\Omega, S, r, a, u^S\}$.
- The value of (A9) is calculated.
- A new value of q is chosen until convergence is achieved, i.e. (A9) is satisfied.