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Discussion Papers

Technical Series

No 47

Unemployment, duration dependence and hysteresis

by

Spencer Dale

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The object of this Technical Series of Discussion Papers is to give wider circulation to research work in the Bank's Economics Division, and to invite comment upon it; any comments should be sent to the author at the address given below.

The author would like to thank Ben Knight for many helpful comments and suggestions. All remaining errors are the resposibility of the author. The views expressed are those of the author and not necessarily those of the Bank of England.

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Abstract

Much of the theoretical literature on unemployment hysteresis has stressed the importance of 'turnover costs' in distinguishing between insiders and outsiders. In contrast, this paper argues that insider power may stem from the costs faced by the long-term unemployed - in terms of the increasing costs (and diminishing expected gains) associated with searching - implying that the insider-outsider distinction should be defined according to unemployment duration rather than employment or union status. By developing a microeconomic model of duration dependence, the paper succeeds in providing a formal model of 'duration-led' hysteresis.

UNEMPLOYMENT, DURATION DEPENDENCE AND HYSTERESIS

INTRODUCTION

Blanchard and Summers have highlighted, in a series of papers (Blanchard and Summers 1986,1987,1988), the inability of conventional macroeconomic theories, either Classical or Keynesian, to explain the persistence of high unemployment observed both in the UK and many other European economies in the 1980s. This inability has led to theories of "fragile equilibrium" (Blanchard and Summers 1988), which suggest that unemployment, rather than returning to a stable (or natural) equilibrium over time, is history dependent. A principal form such a fragile equilibrium may take is described by theories of hysteresis, the tendency of the equilibrium rate of unemployment to follow developments in the actual rate.

The hysteresis literature up to now, has tended to be dominated by models of union bargaining developed within a framework of insiders and outsiders. This paper postulates an alternative source of hysteresis, in which the existence of long-term unemployment, rather than the structure of the wage bargaining process, is the principal determinant of unemployment hysteresis. The next section of the paper outlines the potential importance of duration effects in explaining unemployment hysteresis, while in section 3 we develop a microeconomic model of duration dependence, which succeeds in providing a formal model of 'duration-led' hysteresis. The paper ends with some brief conclusions and thoughts for further research.

SECTION 2 THE IMPORTANCE OF DURATION EFFECTS

Much of the theoretical literature on hysteresis (eg Blanchard and Summers 1986,1987, Lindbeck and Snower 1986,1987) has stressed the importance of the distinction between insiders and outsiders. This distinction between insiders and outsiders is determined by the existence of certain costs. Without specifying the form of these costs, however, the insider-outsider framework becomes very general, encompassing virtually any model of hysteresis which acts through the wage bargaining process. It is not the insider-outsider framework which is of importance, but rather the criteria for distinguishing between the two groups.

The principal theoretical models of hysteresis this far (Blanchard and Summers 1986, 1987) have tended to be developed within models of union bargaining, in which it is the presence of significant turnover costs, making it costly for the firm to replace the present workforce with new workers, which distinguishes the insiders - consisting mainly of incumbent (union) workers - from the outsiders. In contrast, this paper argues that the existence of powerful duration effects, causing the long-term unemployed to become increasingly isolated from the 'central core' of the labour market, implies that the insider-outsider distinction should be defined according to unemployment duration rather than employment or union status.

The model presented in section 3 is underpinned by an array of psychological and case-study literature which describes the plethora of problems associated with long-term unemployment duration. A dominant theme of this literature is how these duration effects may culminate in causing the long-term unemployed to lose their motivation and cease actively searching for work (Colledge and Bartholomew 1980, Harrison 1976, OECD Employment Outlook 1983, 1987). The significance of these sort of effects for the equilibrium rate of unemployment and unemployment hysteresis are clear. If we define the central core of the labour market as containing the 'effective' supply of labour, which through its effect on wage negotiations determines the equilibrium rate of unemployment, it implies that duration effects, causing unemployed workers to become increasingly isolated from this central core, will cause the equilibrium rate of unemployment to be history dependent, determined by the past levels and duration composition of unemployment.

The analysis of duration effects is closely related to the literature on duration dependence, which suggests that the probability of unemployed workers leaving unemployment is inversely related to their unemployment duration. In the past, longtitudinal studies analysing individual data (eg Narendranathan et al 1985) have not tended to find strong evidence of duration dependence. However, more recent studies (Narendranathan and Stewart 1989) suggest that this was largely due to statistical and modelling problems, and that when a less restrictive approach is followed there is stronger evidence of duration

dependence. In addition, the existence of duration effects underlies the wealth of empirical literature finding significant roles for long-term unemployment in explaining both wage behaviour (Budd et al 1988b, Layard and Nickell 1985, 1987, Nickell 1987) and shifts in the unemployment-vacancy relationship (Budd et al 1987, 1988a, 1988b).

However, despite both the theoretical importance of duration effects and the empirical evidence confirming their significance, a formal framework in which to analyse these effects has not been developed. The model presented in section 3 is an attempt to harness and formalise the problems associated with long-term unemployment within a theoretical framework which can be used to analyse the nature and implications of these effects.

SECTION 3 A "DURATION-LED" MODEL OF HYSTERESIS

The framework developed draws heavily on an approach used by Starrett (1976) to analyse inequalities in the distribution of income. In the model it was shown how the low expectations disadvantaged groups had of improving themselves - by reducing their motivation to invest in the uncertain process of improving their well-being - could become self-confirming. The similarities between this problem and the search decision facing long-term unemployed workers are clear.

Our model analyses the search decision facing heterogeneous unemployed workers, in an environment in which there is imperfect information concerning the probability of success once search is undertaken, ie the re-employment probability. As the limiting case, the model within a perfect information scenario is shown to provide a formalisation of the decision taken by "discouraged workers" to stop searching - determined by the cost of search exceeding the expected gain.

The introduction of imperfect information generates a new class of discouraged workers who are 'fooled' into quitting their search activities. The framework develops a microeconomic model of duration dependence which predicts that, as unemployment duration increases, the likelihood of a low or zero search equilibrium progressively increases. In doing so, the framework succeeds in providing a formal model of 'duration-led' unemployment hysteresis.

The Model

The model is composed of cohorts of unemployed workers, with each cohort defined in terms of the workers' unemployment duration. The duration categories are normalised so that they correspond to a single time period of the model. That is, the residual of each unemployment cohort remaining unemployed at the end of a time period flows into the next duration category. For simplicity workers are assumed to live forever.

The workforce is assumed to be heterogeneous. In particular, the cost of undertaking search activities is assumed to differ across workers; these differences being summarised by a single, exogenously determined, quantitative variable α (where α follows a unimodal density function $g(\alpha)$ between the limits 0 and 1, and a worker can only observe his individual level of α).[1]

The Search Decision

If a worker is unemployed he receives (duration independent) unemployment benefit equal to b. If, however, a worker undertakes a successful search strategy and is re-employed, he receives the wage w. As such, the return associated with a successful search strategy is given by the discounted sum of the difference between wages and unemployment benefit (k)[2]

where:

$k = 1/r\ (w-b)$

r is the discount factor

---

1 The distribution $g(\alpha)$ is likely to vary across duration cohorts (see below). However, as the probability of being made unemployed does not depend on α, the distribution over the cohort of newly unemployed workers will be representative of the distribution across the entire (employed) workforce.

2 It is assumed, for simplicity, that once a worker is re-employed they never (or never expect to) lose their job. It is perfectly straightforward, however, to modify the model to allow for the possibility of a worker losing their job. Such an extension serves to illustrate how workers experiencing repeated spells of unemployment face similar problems to the long-term unemployed, and, furthermore, how repeated spells of unemployment may actually serve to precipitate long-term unemployment (OECD Employment Outlook 1983, 1987).

If an unemployed worker decides to search, there is a re-employment probability q, where $0< q <1$. The re-employment probability depends potentially on an array of factors including the duration cohort (δ) to which the unemployed worker belongs, and various economic and individual characteristics summarised by (Φ).[3]

$$q = q(\delta, \Phi)$$

Imperfect information is introduced into the model, by assuming that the actual re-employment probability $q(\delta, \Phi)$ is unknown to the workforce.

For ease of exposition we have abstracted from the potential dependence of both the competitive wage and the re-employment probability on the number of workers deciding to search. The model is generalised in Appendix 1 to incorporate these effects and reveals such generalisations do not alter the qualitative nature of the results presented here.

The unemployed worker, at various phases within each time-period, decides whether to search or not. Each time a worker decides to search it entails a fixed lump-sum cost c. It is not possible for the worker to vary this cost, for example by varying the nature or intensity of the search process. The cost of search for each individual depends on their value of α;

$$c=c(\alpha) \quad c_{\alpha} < 0 \ , \quad c_{\alpha\alpha} > 0 \quad [4]$$

This dependence of the cost of search on α can be motivated by a variety of considerations. Perhaps the most simple interpretation is to view α as reflecting differences across various personality traits, such as the efficiency of the worker in various search activities (such as collating information and being interviewed) and the costs to their psyche associated with the inevitable failure and rejections associated with some 'contacts'. Alternatively, in the absence of perfect capital markets, α may be reflective of the worker's access - which in turn may depend both on their position within the social class hierarchy and within their life-cycle - to the funds

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3 Some of the characteristics summarised in Φ (such as the level of unemployment and the quality of workers) are considered in more detail later.

4 Where a subscript denotes a partial derivative.

required to undertake the search process. A third interpretation is that α may reflect some aspect of the worker's ability which allows them to signal their productivity at a lower cost.[5] In addition, analogous to q, the cost of search may depend on a host of other considerations including the duration cohort (δ) to which the worker belongs and various individual characteristics of the worker, again summarised by Φ.

$$c = c(\alpha, \delta, \Phi)$$

The hysteresial results highlighted by the model are driven by the duration effects which cause the cost of search to rise (and the re-employment probability to fall) as workers flow into cohorts of increasing unemployment duration.

Perfect Information Case

Consider the search decision faced by the unemployed workers within a given duration cohort. We look first at the limiting case in which there is perfect information about q. From within the cohort, unemployed workers will be drawn into the search process up to the equilibrium point at which the expected gain from search is equal to its cost. This equilibrium condition determines a critical value of α, α^* such that:

$$q\,k = c(\alpha^*)$$

implying that it is only optimal for individual i to search if $\alpha_i > \alpha^*$. The perfect information case can be seen to represent an explicit characterisation of the decision taken by conventional discouraged workers. That is, for individuals where $\alpha_i < \alpha^*$, the expected gains from search do not compensate for the cost, and, as such, it is optimal for the worker to refrain from searching and so leave the central core of the labour market.[6]

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5 The independence of the wage in respect to α in this final case, can be justified by appealing to some form of efficiency wage argument stemming from the assumption that the worker's α (and hence productivity) is not observable to employers.

6 As the imperfect information case is developed, and the effects of unemployment duration are analysed, it is easily seen that these duration effects have identical qualitative effects within this 'full-information, discouraged workers' case.

Imperfect Information Case

Consider now the imperfect information case in which the re-employment probability is unknown. That is, although the unemployed individuals are able to observe the proportion of their cohort which is successfully re-employed, they can not discriminate between the re-employment probability and the proportion of the cohort which is searching, ie they face a type of 'signal extraction' problem. This arises because each worker's α is unobservable to other workers and because it is assumed that there is an incentive for those choosing not to search to conceal this fact. This latter assumption can be motivated by the receipt of unemployment benefit being conditional on the individual 'actively seeking work', or in terms of the social pressures and stigma inflicted on unemployed workers perceived as 'sponging' off the state.

In the initial phase (phase 0) of each time period, some proportion of the cohort will decide to search. Let this proportion be given by:

$$\int_{\alpha_0}^{1} g(\alpha)\, d\alpha \qquad (1)$$

where α_0 is some subjectively determined critical value of α. (The subscript on α refers to the phase number.) The size of this initial proportion (the value of α_0) is shown to be of crucial importance to the equilibrium solution of the model and is discussed later.

In later phases of the time period, the unemployed workers of each duration cohort need to make an estimate ($\hat{q}$) of their re-employment probability. This estimate will be based on the proportion of the cohort which is observed being successfully re-employed in the previous phase. The workers know, however, that only a proportion of the cohort is searching in any given phase, and hence will choose a probability function (f) such that the estimate is a positive function of the observed re-employment success rate but lies consistently above the observed rate:

$$\hat{q}_t = f\left[q \int_{\alpha_{t-1}}^{1} g(\alpha)\, d\alpha \right] \qquad (2)$$

The equilibriating process is now one of dynamically adjusting to a changing critical level of α given by the difference equation:[7]

$$f\left[q \int_{\alpha_{t-1}}^{1} g(\alpha)\, d\alpha \right] k = c(\alpha_t) \qquad (3)$$

or

$$p(\alpha_{t-1}) = c(\alpha_t) \qquad (4)$$

where

$$p(\alpha_{t-1}) = f\left[q \int_{\alpha_{t-1}}^{1} g(\alpha)\, d\alpha \right] k$$

That is, within each time period, the critical level of α (determining the proportion of workers which decide to search) will vary as agents learn about their true re-employment probability. The difference equation (4) describes the path of α, and its ultimate equilibrium value, for a given duration cohort in a particular time period.

Given $g(\alpha)$ is unimodal, under relatively weak assumptions about the probability function f, it can be shown that $p(\alpha)$ has a point of inflection, as indicated in Figure 1. (The formal proof is outlined in appendix 2.) The form of the potential solutions are dependent on whether $p(0) > c(0)$, the 'low cost' case, or $p(0) < c(0)$, the 'high cost' case. Figure 1 indicates the three possible solutions associated with the low cost case.

The qualitative results of the imperfect information solutions can be illustrated by reference to case (i). The equilibrium level of α, $\alpha^*(i)$, is an unstable equilibrium. Therefore, whether unemployed workers in equilibrium decide to search or not is history dependent, depending critically on the relationship between the proportion of the cohort which initially searches and the proportion implied by the unstable equilibrium. If the cohort's initial expectations are 'favourable', defined as $\alpha_0 < \alpha^*(i)$, it implies that in equilibrium the entire cohort will decide to search. If, however, $\alpha_0 > \alpha^*(i)$ the equilibrium optimising decision for the entire cohort will be to choose

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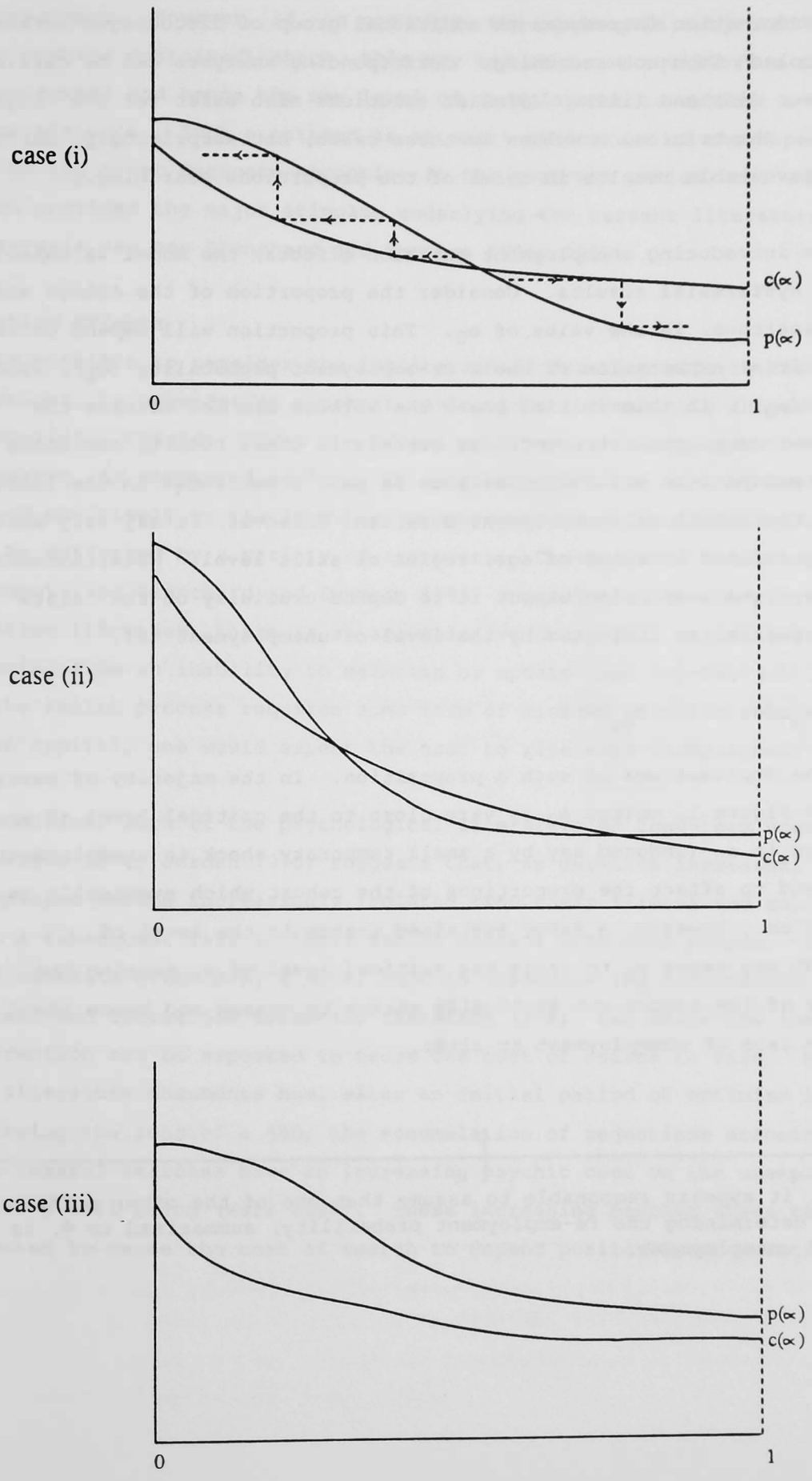
7 A "time period" is defined such that there is sufficient (search) phases for each cohort to reach its equilibrium.

Figure 1



not to search. This represents an outflow from the central core of the labour market and as such, an increase in the equilibrium rate of unemployment. The imperfect information introduces an additional group of discouraged workers who are 'fooled' into not searching. Corresponding analyses can be carried out for cases (ii) and (iii). (Similar solutions also exist for the 'high cost' case. The critical α values in these cases, not surprisingly, derive even less favourable results in terms of the proportions searching.)

Even before introducing unemployment duration effects, the model is capable of generating hysteresial results. Consider the proportion of the cohort which initially searches, ie the value of α_0. This proportion will depend on the cohort's initial expectation of their re-employment probability ($\hat{q}_0$), such that $\hat{q}_0.k=c(\alpha_0)$. In this initial phase the workers can not observe the re-employment rate of other unemployed workers in their cohort, and hence $\hat{q}_0$ will tend to depend on other factors such as past experiences in the labour market and the length of unemployment duration. Moreover, it may vary across sub-cohorts defined in terms of age, region or skill level. Notwithstanding these factors, we would also expect it to depend crucially on the 'state' of the labour market, as indicated by the level of unemployment (u).[8]

$$\alpha_0 = \alpha_0 (u, \ldots) \qquad \alpha_{0u} > 0$$

Consider the implications of such a proposition. In the majority of cases outlined in Figure 1, unless α_0 is very close to the critical level of α, a small change in α_0 (induced say by a small temporary shock to unemployment) will not tend to affect the proportions of the cohort which eventually search in equilibrium. However, a large sustained change in the level of unemployment may cause α_0 to cross the critical level of α, causing the proportions of the cohort who eventually search to change and hence the equilibrium rate of unemployment to alter.

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8 That is, it appears reasonable to assume that one of the other principal factors determining the re-employment probability, summarised in Φ, is the level of unemployment.

As such the model predicts that the level of unemployment will tend to show strong mean reverting tendencies in the face of small temporary shocks to unemployment. However, if, on occasion, the economy is subjected to a large (and perhaps sustained) shock, this may induce a new equilibrium rate of unemployment and hence the new level of unemployment to exhibit a high degree of persistence. Such a pattern is an exact caricature of the experience of the UK and other European economies in the post-war period, the explanation of which provided the major stimulus underlying the current literature on hysteresis (eg see Blanchard and Summers 1986, 1987).

Duration Effects

It is possible to consider the implication of duration effects for the model's solutions, by considering a cohort moving into increasingly longer duration categories. Consider first the effect of long-term unemployment on the cost of search. As suggested earlier, it is likely that the cost of search will depend positively on the length of unemployment duration. Such a dependence can be motivated by a variety of arguments. Conventional human capital arguments (eg Blanchard and Summers 1986) suggest that as unemployment duration increases, there is an accumulative decay of a worker's skills stemming from an inability to maintain or update them 'on-the-job'. As such, if the search process requires some form of minimum stock or complement of human capital, one would expect the cost to rise with unemployment duration.

In addition, much of the psychological literature on long-term unemployment (Harrison 1976, Jordan 1975) suggests that, as duration increases, the unemployed become increasingly isolated from their friends and colleagues, with a subsequent fall in their social contact with such people. However, such contacts often play a vital role in disseminating information about current and future job vacancies (Harrison 1976), and hence the loss of such information can be expected to cause the cost of search to rise. Moreover, the literature documents how, after an initial period of optimism immediately following the loss of a job, the accumulation of rejections associated with unsuccessful searches have an increasing psychic cost on the unemployed worker's well being (Warr 1984). These increasing psychic costs can also be expected to cause the cost of search to depend positively on duration.

Consider now the effect of unemployment duration on the re-employment probability. It is well documented (Budd et al 1988a) that an unemployed worker's exit probability declines with duration. However, the exit probabilities commonly discussed in the literature differ from the re-employment probabilities under consideration here, in that they incorporate the reductions in search typically associated with increasing unemployment duration. The re-employment probabilities considered here are independent of search. For q to fall with unemployment duration, it implies that the attractiveness of workers must fall with duration - workers are 'scarred' by increasing unemployment duration.

Since the framework abstracts from variations in the quality of the workforce it can not explicitly incorporate an 'heterogeneity' effect. However, in practice one would expect that another one of the additional characteristics (summarised by Φ) in the re-employment function would be some measure of worker quality (μ) such that:

$$q = q(\mu, \ldots.) \qquad q_{\mu} > 0$$

This implies that, as the cohort moves into longer duration categories, the average quality of the cohort will fall causing q to fall with duration.[9] (A further heterogeneity effect will occur if at some of the duration categories there is an "internal" search solution, such as in case (ii), causing the cohort's average level of α to fall with unemployment duration. This skewing of the α distribution will cause the point of inflection in $p(\alpha)$ to occur at lower levels of α.)[10]

What are the implications of these duration effects? As a purely illustrative exercise consider Figure 1. Suppose that for low duration categories the solution is characterised by case (iii), so the entire cohort is searching. However, as the cohort flows into longer unemployment durations, $c(\alpha)$ shifts

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9 An alternative motivation for the duration dependence of q is provided by the models of Lockwood (1989) and Totcsh (1988), in which a worker's unemployment duration is used as a signal of their quality, causing q to depend negatively on duration.

10 A similar skewing effect occurs if α is interpreted as reflecting a worker's access to an imperfect capital market and this access is assumed to fall with unemployment duration.

up and $p(\alpha)$ shifts down, causing the solution to become characterised by case (ii), with only a proportion of the cohort searching once α_0 passes α^*(ii). As the cohort flows into longer duration categories still, the schedules continue to shift so that this proportion becomes progressively smaller, until the solution is characterised by case (i) in which the entire cohort has chosen to stop searching. **As such the model predicts that as unemployment duration increases, a low or zero search equilibrium becomes increasingly likely.**

The framework now succeeds in providing a formal model of duration-led unemployment hysteresis, based on a microeconomic model of duration dependence. That is, if increases in unemployment are associated with increases in unemployment duration, there are a wealth of forces acting to cause increasing proportions of the long-term unemployed to stop searching and leave the central core of the labour market, thereby causing the equilibrium rate of unemployment to rise.

A number of issues are generated by the above results. First, any model claiming to explain hysteresial effects has to explain the "irreversibility associated with unemployment shocks,.....why (do) temporary shocks have such long run effects?" (Blanchard and Summers 1986). Within the parameters of our model, if a temporary shock to unemployment leads to increased inflows into cohorts in which a large proportion of the unemployed stop searching, there is an array of forces acting to prevent a recovery in labour demand providing a sufficiently powerful impetus to repatriate all the 'discouraged' workers.

When considering the critical duration threshold at which the unemployed cease to search (and as such take an effective part in wage negotiations), the illustration discussed above highlights that there is not a single or unique duration threshold one can point to. Duration effects will occur in varying degrees at different duration thresholds.

While space precludes a full discussion, it can perhaps be seen intuitively that the model has a variety of other applications. For example, by explicitly defining the Φ variables on which $p(\alpha)$ and $c(\alpha)$ schedules are dependent, the model can be used to explain why the likelihood of long-term unemployment tends to vary across sub-cohorts defined in terms of skill and age (Hughes and Hutchinson 1986a 1986b).

SECTION 4 CONCLUSIONS AND FURTHER RESEARCH

This paper was motivated by the perceived importance of duration effects in explaining unemployment hysteresis, and the absence, this far, of a formal framework in which to analyse these effects. The model presented here, by developing a model of duration dependence, succeeds in providing a formal model of "duration-led" hysteresis. In addition, the model also provides a number of insights into how the existing empirical (time series) modelling of duration effects could be developed and improved. In particular, the model stresses that more attention should be paid to the existence of multiple duration effects occurring at varying duration thresholds, rather than the concentration on a single 'magical' threshold that tends to characterise the current empirical literature.

The objective of the model presented here was to capture the effect the problems associated with long-term unemployment had on an unemployed worker's incentive to search. As such, the model concentrates largely on the supply side aspects of long-term unemployment. However, there are clearly important demand side considerations to be taken into account, captured within the concept of 'scarring', whereby the worker who has experienced lengthy unemployment durations becomes less attractive to a firm. The framework presented here, whilst incorporating these effects, does not explicitly model why they may occur. Clearly an important extension of this model lies in its development to explicitly model these effects as well.

As suggested in the introduction, it is possible to encompass this model within the general insider-outsider framework. Within any insider-outsider model, the distinction between insiders and outsiders is determined by the existence of certain costs. In the Lindbeck and Snower models (1986,1987), insider power stems from the assumption that firms exchanging current, fully-fledged employees for unemployed workers face significant turnover costs, and hence the insider-outsider distinction is defined (broadly) in terms of employed and unemployed. In contrast, the model presented here suggests insider power stems from the costs faced by the long-term unemployed (the outsiders), in terms of the increasing costs (and diminishing expected gains) associated with searching. As such, the insider-outsider distinction is defined according to unemployment duration rather than employment or union status.

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APPENDIX 1

The model is generalised here to allow for both the competitive wage level and the re-employment probability to depend on the proportions searching.[11] In particular we assume:

$$w = w(\alpha) \qquad w_\alpha > 0$$

$$q = q(\alpha) \qquad q_\alpha > 0$$

As the equilibrium level of α increases it implies that a decreasing proportion of the unemployed workers are searching. This reduction in search activity may be expected to reduce the downward pressure on wages. Furthermore, it implies there is less competition for the existing jobs and so we may expect the re-employment probability to rise.[12]

This implies:

$$\tilde{p}(\alpha) = f\left(q(\alpha) \int_\alpha^1 g(\alpha)\, d\alpha \right) \tilde{k}(\alpha) \qquad \text{(A1)}$$

where $\tilde{k}(\alpha) = w(\alpha) - b$

Let $\tilde{p}(\alpha) = f(\tilde{t})\, \tilde{k}(\alpha)$ (A2)

where $\tilde{t}(\alpha) = q(\alpha) \int_\alpha^1 g(\alpha)\, d\alpha$

Consider the slope of $\tilde{p}(\alpha)$:

$$\tilde{p}_\alpha = \tilde{k}(\alpha)\, [f_{\tilde{t}}\, \tilde{t}_\alpha] + f(\tilde{t})\, \tilde{k}_\alpha \qquad \text{(A3)}$$

where

$$\tilde{t}_\alpha = q(\alpha)\, I_\alpha + \int_\alpha^1 g(\alpha)\, d\alpha\, q_\alpha$$

$$I_\alpha = d/d\alpha \int_\alpha^1 g(\alpha)\, d\alpha$$

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11 The generalised functions are denoted by a tilda (~) superscript.

12 Although not modelled here, one would not expect these two effects to be independent of each other.

and $\tilde{k}_{\alpha} = \tilde{k}_{w}\, w_{\alpha}$

Therefore:

$$\tilde{P}_{\alpha} = \tilde{k}(\alpha) \left[f_{\tilde{t}} \{ q(\alpha)\, I_{\alpha} + \int_{\alpha}^{1} g(\alpha)\, d\alpha\, q_{\alpha} \} \right] + f(\tilde{t})\, \tilde{k}_{w}\, w_{\alpha} \qquad \text{(A4)}$$

$$\tilde{P}_{\alpha} = \tilde{k}(\alpha)\, f_{\tilde{t}}\, q(\alpha)\, I_{\alpha} + \tilde{k}(\alpha)\, f_{\tilde{t}} \int_{\alpha}^{1} g(\alpha)\, d\alpha\, q_{\alpha} + f(\tilde{t})\, \tilde{K}_{w}\, w_{\alpha}$$

Let $f_{\tilde{t}} = \sigma > 0$, $\tilde{k}_{w} = \Omega > 0$

$$\tilde{P}_{\alpha} = [\sigma\, \tilde{k}(\alpha)\, q(\alpha)]\, I_{\alpha} + [\sigma\, \tilde{k}(\alpha) \int_{\alpha}^{1} g(\alpha)\, d\alpha]\, q_{\alpha} + [\Omega\, f(\tilde{t})]\, w_{\alpha} \qquad \text{(A5)}$$

By definition: $I_{\alpha} < 0$, $w_{\alpha} > 0$, $q_{\alpha} > 0$

Implying:

$$P_{\alpha} \gtreqless 0 \quad [\sigma\, \tilde{k}(\alpha)\, q(\alpha)]\, I_{\alpha} \lesseqgtr [\sigma\, \tilde{k}(\alpha) \int_{\alpha}^{1} g(\alpha)\, d\alpha]\, q_{\alpha} + [\Omega\, f(\tilde{t})]\, w_{\alpha} \qquad \text{(A6)}$$

Without introducing specific assumptions about the schedules, it is not possible to assign a value to $\tilde{p}_{\alpha}$. Instead we will consider a number of possible outcomes and their implications for the model.

One possibility is that the "search effect" I_{α} dominates, ie:

$\tilde{P}_{\alpha} < 0 \quad \forall\, \alpha.$

In this case the generalised model will generate solutions of a very similar form to the more restrictive model analysed in the main text.

In contrast, a second possibility is given by the wage and re-employment probability effects dominating, ie:

$\tilde{p}_\alpha > 0 \quad \forall \alpha.$

In the low cost case, such a solution implies the expected gain from search always exceeds the cost and hence the entire cohort will search.

In the high cost case, such a solution derives a "cobweb" style equilibrium path about a given internal solution, such that:

$\lvert\tilde{p}_\alpha\rvert < \lvert c_\alpha \rvert$	the equilibrium path converges to the internal equilibrium
$\lvert\tilde{p}_\alpha\rvert > \lvert c_\alpha \rvert$	the equilibrium path explodes to one of the polar points

A third possibility is motivated by the observation that $\lvert I_\alpha \rvert$ will tend to become relatively large in the range of α concentrated about the mode of the α distribution. If q_α and w_α are less sensitive to changes in the value of α, it implies that a possible solution is given by:

$$\begin{aligned} \tilde{\tilde{P}}_\alpha \quad &< 0 \quad \text{for } \bar{\alpha} < \alpha < \bar{\bar{\alpha}} \\ &> 0 \quad \text{for } \alpha < \bar{\alpha},\ \alpha > \bar{\bar{\alpha}} \\ &= 0 \quad \text{for } \alpha = \bar{\alpha},\ \alpha = \bar{\bar{\alpha}} \end{aligned}$$

Where $\bar{\alpha} < \alpha < \bar{\bar{\alpha}}$ is a range of α concentrated about the mode of the α distribution.

Figure 2 indicates the three possible cases for such a solution in the high cost case. Cases A(i) and A(iii) are identical to cases (i) and (iii) (respectively) discussed in the main text.

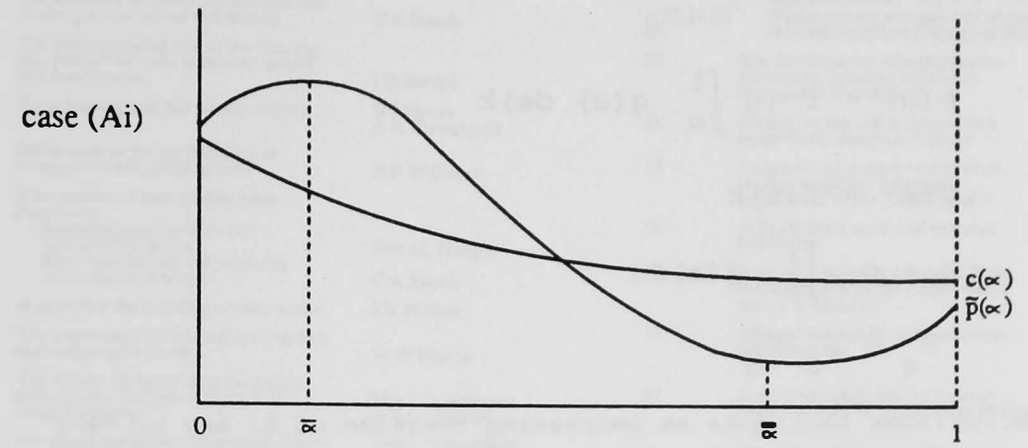
Consider case A(ii). If initial expectations are such that:

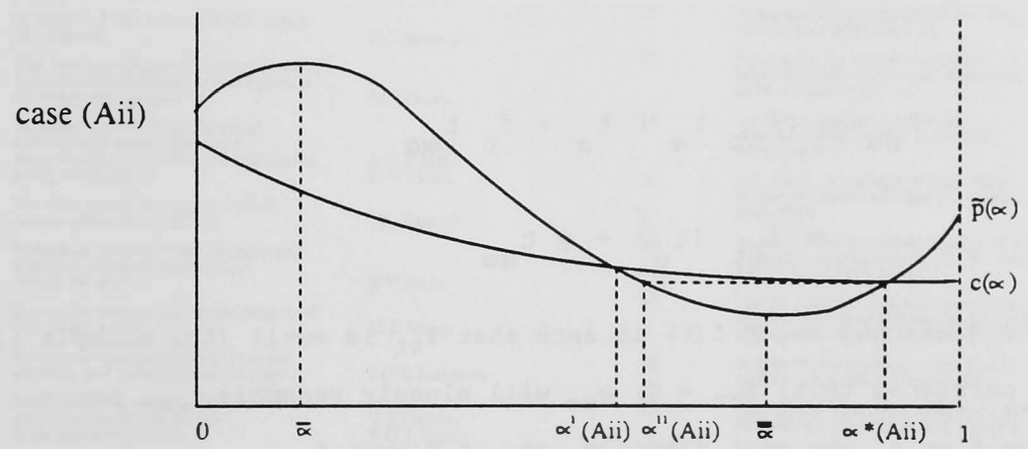
$\alpha_0 < \alpha^{/}$ (Aii), then the entire cohort will search

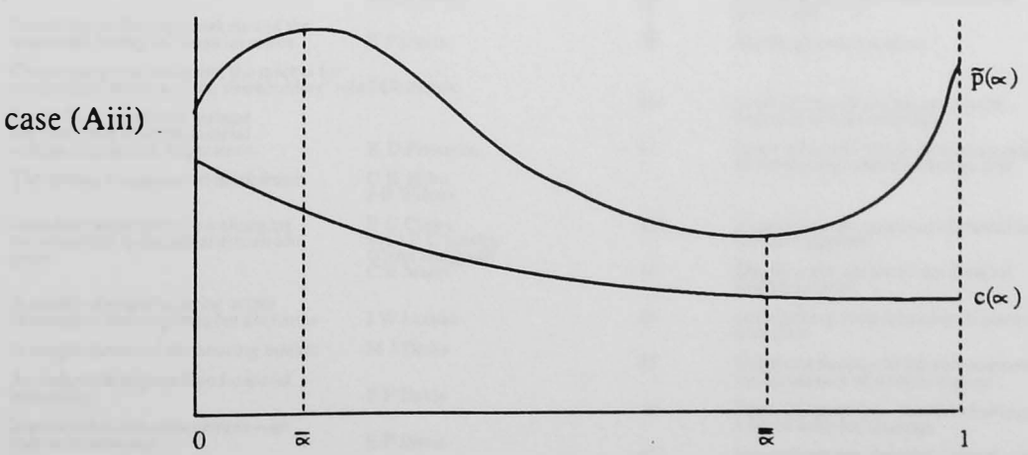
$\alpha_0 > \alpha^{/}$ (Aii), then the equilibrium path will eventually, if not immediately, be given by a cobweb solution. If $|\tilde{p}_\alpha| > |c_\alpha|$ the equilibrium path will converge towards the solution α^*(Aii). However, it can be seen that for various α_0, there is a possibility that the equilibrium path will be "thrown" onto $c(\alpha)$ such that $\alpha < \alpha^{/}$(Aii), in which case the solution will leave the convergent cobweb path about α^*(Aii) and instead converge to a stable equilibrium given by $\alpha(0)$.

If $|\tilde{p}_\alpha| > |c_\alpha|$ then the equilibrium is given by an exploding cobweb solution. However, it can be seen again that, if "thrown" onto $c(\alpha)$ such that $\alpha < \alpha^{/}$(Aii), the solution will leave the exploding cobweb and converge to $\alpha(0)$. Further, if the cobweb path is such that the solution is thrown onto $c(\alpha)$ in the range $\alpha^{/}$(Aii) $< \alpha < \alpha^{//}$(Aii), there is a possibility that it may continuously iterate, neither coming to rest or exploding.

Figure 2


case (Ai)
c(∝)
p̃(∝)
0
∝I
∝II
1


case (Aii)
p̃(∝)
c(∝)
0
∝I
∝'(Aii)
∝''(Aii)
∝II
∝*(Aii)
1


case (Aiii)
p̃(∝)
c(∝)
0
∝I
∝II
1

APPENDIX 2

DERIVING THE P(α) SCHEDULE

$$p(\alpha) = f\left(q \int_{\alpha}^{1} g(\alpha)\, d\alpha\right) k$$

Let $p(\alpha) = f(t)k$

Where $t = q \int_{\alpha}^{1} g(\alpha) d\alpha$

Implying $P_{\alpha} = f_t\, t_{\alpha}$

The model stipulates that $\hat{q}$ is an increasing function of t, say $\hat{q}_t = \phi > 0$

$$P_{\alpha} = \phi\, t_{\alpha}$$

$$P_{\alpha} < 0$$

Consider the second derivative:

$$P_{\alpha\alpha} = (f_{tt}\, t_{\alpha})\, t_{\alpha} + f_t\, t_{\alpha\alpha}$$

$$= f_{tt}\, (t_{\alpha})^2 + \phi\, t_{\alpha\alpha}$$

Hence if the "learning rule" f(t) is such that f_{tt} is small (for example if f is just proportional to t, $f_{tt} = 0$) $p_{\alpha\alpha}$ will closely resemble $t_{\alpha\alpha}$, hence deriving the form of the p(α) schedule used in Figure 1.

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